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2014-15

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IEP-SAC Journal is published yearly by the Institution of Engineers Pakistan, Saudi Arabian Center (IEP-SAC), Riyadh, and distributed to the engineering community in Saudi Arabia. To promote discussion of issues in the field of engineering and ensure coverage of all responsible points of view, conflicting opinions and views may appear, however, IEP-SAC cannot accept any liability for such views nor for any errors or omissions.

Designed By: Omer Khan
(Cell: 055 112 7434)
Email: fanoontamaus@gmail.com

JOIN HANDS WITH IEP-SAC

Dear Engineers

Assalamu Alaikum

More than 160,000 non Saudi engineers have already registered with the Saudi Council of Engineers (SCE) and Pakistani engineers constitute one of the largest group. The Institution of Engineers Pakistan – Saudi Arabian Chapter (IEP-SAC) has three very active sub-centers in Riyadh – Jeddah & Dammam proving technical platforms for the Pakistani engineers to demonstrate their technical and artistic excellences by virtue of presentations and publishing technical articles in our JOURNAL. We need to join hands together across the Kingdom of Saudi Arabia to ensure every Pakistani engineer is registered with its local sub-centre and every major city in Saudi Arabia should have IEP-SAC sub-centre. Let us make special effort to increase our membership and make the year 2014-2015 as the MEMBERSHIP YEAR.

There is a social as well as a business side to our relationship with each other, and the cultivation of the human touch adds to the happiness and contentment of all when engaged in the performance of their various duties. I congratulate the Editorial Board for presenting and promoting this idea. I am confident that this issue will be yet another milestone in the Editorial Board's pursuit of excellence.

With your support and help a large number of needy engineering students get scholarship from IEP-SAC. This is the largest and an impressive scholarship program for engineering students of Pakistani public sector engineering universities. Our steps may be small but they are giant leaps for the needy students.

The absolute volunteer services of the council members at the three regions—Central, Eastern, and Western—is the vehicle for making this success a possibility. Without their sheer hard work and dedication, our programs on the technical and social fronts could not have been held so successfully, and as always, I would like to salute them all.

I call upon the community to come forward and contribute to the objects and purposes of the IEP-SAC. I would highly recommend to all those engineers whose iqama title is not an engineer to change their title as an Engineer and join both professional organizations i.e. IEP-SAC & SCE.

We have the honor of having Prof. Dr. Atta-ur-Rahman, FRS to be our Keynote Speaker on "Higher Education, Science and Technology – Imperatives for the Socio-Economic Development" at our annual seminar. This is our 41st Technical seminar to be held in Riyadh. Finally, I would like to remind Pakistani community and especially the engineers that we have a very special relationship with Saudi Arabia therefore we should also develop an excellent relationship with our Saudi Engineers by means of quality of our performance, dedication and professionalism. Let us remember that for us good is not good enough; we have to be the best.

Engr S M Jaleel Hasan, Chairman

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From The AMBASSADOR

AMBASSADOR

It gives me great pleasure to felicitate the Institute of Engineers Pakistan-Saudi Arabian Center (IEP-SAC) on publication of its annual journal for the year 2014-15. IEP-SAC deserves credit for its services to the community of engineers and the profession of engineering. Through its publications and seminars, the Institution provides excellent service to engineers from the brotherly countries of Saudi Arabia and Pakistan.

I have always been proud of the quality and caliber of Pakistani engineers, architects and town planners who have generated immense good will for their motherland with their standards of professionalism and excellence. I am confident that the IEP and Pakistani engineers will continue to discharge their professional duties in the Kingdom in an admirable manner, thus contributing to the technical know-how and expertise of the two countries.

The Embassy of Pakistan stands with the community of engineers in its pursuit of professional excellence. I also applaud its philanthropic activities and noble endeavors such as awards of scholarships to deserving and needy students studying in Pakistani Engineering Colleges and Universities.

I wish the Institute of Engineers Pakistan, Saudi Arabia Centre complete success in their future endeavours.

Naeem.

(Muhammad Naeem Khan)
Ambassador

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From The President of IEP

On behalf of the Council of The Institution of Engineers, Pakistan it gives me immense pleasure to congratulate The Institution of Engineers, Pakistan (IEP) Saudi Arabian Chapter, Riyadh for organizing seminar on "Higher Education, Science and Technology – Imperatives for the Socio-Economic Development". The Magazine is also being published on this occasion.

I am confident that this Seminar will give an opportunity to highlight the progress made in recent years for promoting and disseminating the knowledge in respect of the theme of this Seminar to the local and expatriate engineers working in the Kingdom of Saudi Arabia.

We appreciate the efforts made by The Institution of Engineers Pakistan (IEP) Saudi Arabian Chapter for their untiring efforts to bring together so many local and expatriate engineers working in KSA to share their ideas and expertise. An event of this magnitude is a substantial undertaking and the IEP will reap extensive benefits from their efforts. The sharing of knowledge and building professional ties among the professional engineers and scientists is vital to the advancement of the profession and the continued level of excellence in Engineering.

We are proud that from its inception, IEP Saudi Arabian Centre has been working exceptionally good for the Engineers and Engineering Community in KSA, specially through well reputed journal "The Engineers", they have been able to serve the engineering community in a great way.

We wish IEP Saudi Arabian Chapter, Riyadh great success in organizing the upcoming Seminar and publication of the new edition of the magazine and are confident that such efforts would be hailed by the engineering fraternity working in KSA.

Engr. Syed Jamshed Ali Rizvi
President,
The Institution of Engineers Pakistan

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From The Secretary of IEP

It gives me immense pleasure to know that the Institution of Engineers, Pakistan (IEP) Saudi Arabia Local Centers (Riyadh, Dammam & Jeddah) are organizing seminars under patronage of Pakistan Embassy/Consulate. "IEP-SAC Journal 2014-15" is also being published on this occasion.

I am confident that these Seminars shall be very useful in sharing the technical knowledge, know how and expertise with all local and expatriate Engineers in the Kingdom of Saudi Arabia. This Seminar will also give an opportunity to highlight the progress made in the recent years for promoting and disseminating the knowledge.

The importance of natural resources in today's competitive environment cannot be ignored. Resources are generally defined as stock of capital, labor, land, and mineral wealth, the level of education, knowledge and technology. The proper and planned use of these resources for the mankind requires a proper environment conductive for the development of natural resources.

I being the Secretary General of The Institution of Engineers Pakistan would like to appreciate and congratulate The Institution of Engineers, Pakistan Saudi Arabia Local Centers for their efforts for the advancement of Engineering Knowledge and welfare of Engineering Community working in Saudi Arabia.

I pray that upcoming seminar / workshop and new edition of "IEP-SAC Journal 2014-2015" would be a great success and shall be hailed especially by the engineering fraternity.

Engr. Mian Sultan Mahmood
Secretary General,
The Institution of Engineers, Pakistan

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الهيئة السعودية للمهندسين
SAUDI COUNCIL OF ENGINEERS

The role of an engineer is to solve societal matters technologically, to increase productivity and the development of any country. There is tremendous potential of development in Kingdom and as a result, there will be enormous employment growth in all disciplines.

The vision of Saud Council of Engineers is to promote engineering profession, facilitate engineers and engineering establishments to reach ideal solutions, enhance the level of performance, and encourage innovation and creativity to achieve an internationally recognized position

Saudi Council of Engineers is a professional body that aims to promote the engineering profession and do whatever may be necessary to develop and upgrade its standards and practices. The objective is to build outstanding engineering efficiencies that effectively contribute to the economic growth of Saudi Arabia, to creating conducive environment for innovation, development, and creativity that serve the requirements of the society and to encourage Saudi engineering firms and Saudi engineers to develop their competitive abilities.

The main responsibilities of the Council are setting criteria and standards of practicing and developing this profession including licensure terms and conditions; prescribing necessary rules, regulations, and examinations for professional degrees; preparation and publication of studies and researches; organization of Engineering courses, conferences, seminars, workshops and symposiums related to the profession. Around 160,000 engineers have been registered so far.

The contributions by Pakistan engineers to the development of Saudi Arabia through the past decades are well recognized by SCE. Therefore, Pakistan – Saudi Arabian relationship is a special one, indeed at all levels. For example, another Memorandum of understanding (MOU) has been signed between SCE and IEP on February 3, 2013, addition to the one which was signed in year 2008, by which both parties wishes to develop an active relation through the development of professional services in the fields of engineering accreditation, continuous development training programs, engineering events, and exchange of expertise and knowhow between the two brotherly Islamic countries.

Engr. Hamad Nasser Al Shagawi

Chairman, Board of Directors
Saudi Council of Engineers








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الهيئة السعودية للمهندسين
SAUDI COUNCIL OF ENGINEERS

Engineers play key role to increase productivity and the development of any country. As a result, the overall engineering employment is expected to grow by 10 percent per annum over the next decade.

With the current financial crisis and expected recession, overall job opportunities in engineering discipline are still expected to be good, and indeed, prospects will be excellent in certain specialties. The trend for this future demand of engineers that will continue even during economic slowdowns will be on research engineers, high-tech engineers, electronics and aerospace engineers. Therefore, the engineering-discipline development through organizations such as SCE or IEP is an important issue, because the value of engineers depends not only on their knowledge of the latest technology, but also on their interaction, cooperation and networking under the umbrella of such NGOs. The role of such professional societies is important and vital to meet the needs of 21st century.

Saudi Council of Engineers is a professional body that aims to promote the engineering profession and do whatever may be necessary to develop and upgrade its standards and practices.

The main responsibilities of the Council are setting criteria and standards of practicing and developing this profession including licensure terms and conditions; prescribing necessary rules, regulations, and examinations for professional degrees; preparation and publication of studies and researches; organization of Engineering courses, conferences, seminars, workshops and symposiums related to the profession. Promoting engineering profession in the KSA is the main goal of the Council.

The contributions by Pakistan engineers to the development of Saudi Arabia through the past decades are well recognized by SCE. Therefore, Pakistan – Saudi Arabian relationship is a special one, indeed at all levels. For example, another Memorandum of understanding (MOU) has been signed between SCE and IEP on February 3, 2013, addition to the one which was signed in year 2008, by which both parties wishes to develop an active relation through the development of professional services in the fields of engineering accreditation, continuous development training programs, engineering events, and exchange of expertise and knowhow between the two brotherly Islamic countries.

Dr. Ghazi S. Al Abasi

Secretary General
Saudi Council of Engineers

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FROM THE GENERAL SECRETARY

As a General Secretary of IEP-SAC, I feel pleasure to brief you about our activities during 2013-2014.

Gentlemen,

We have always emphasized that with the advent of high technology in Engineering profession and its impact on socio-economic issues in the human life, the need of development of the human intellectual capital has become indispensable. However, to avoid being an empty promise, the technology must be part of comprehensive professional learning system, aligned to the standards for professional learning and implemented within a cycle of continuous improvement. I would also like to add that although the real motive force which would impel us to observe the canons of success would be emphasis on science and engineering but within the sanction of moral values.

At this stage, I would like to quote the saying of Hasan al-Basri (RH.U.A), He said, "The creative spirit demands persistence. Seeking knowledge at an young age is like engraving on a stone". Unquote.

In this context, IEP-SAC offers exceptional opportunities for education and professional growth and development. Our scholarship program for the needy students in the public sector engineering universities of Pakistan and Azad Kashmir has been developed to attain the same objectives and by Grace of Al-mighty Allah, it has attained a respectable position. Our Technical Seminars, publication of Technical Papers, interaction with other professional Organizations, especially with Saudi Council of Engineers (SCE) and other Techno-social activities have been some of our achievements. A global report of our activities for the year 2013-2014 is as following:

SEMINARS AND ANNUAL CONVENTION:

Being a professional body, our Seminars are planed to enhance the professional knowledge and foster awareness of new technology to meet the challenges in practical Engineering profession. In this regard IEP-SAC organized its annual Convention and 39th Technical seminar on June 06, 2013. The topic of the seminar was, "Energy Security interest of Pakistan." The presentation was made by a well known Pakistan scientist, Dr. Samar Mubarak MAND (NI, NI, SI), member (science and technology), planning commission, Government of Pakistan.

This seminar provided some valuable and encouraging information about the large deposits of coal in THER area of Sindh, and its potential use in generating electric power upto 5000 MW/day. for 500 years? Audience were extremely excited and applauded the speaker for his encouraging information for a glowing future in Pakistan's energy sector.

40th Technical seminar was organized on Dec. 20, 2013, the topic was, "Development of High efficiency Micro-inventor for solar PV application." Presentation was given by Eng. Hadeed Ahmed, a PhD. Candidate in Elec. Dept. of King Saud University in Riyadh. Presentation was well received by the audience.

ANNUAL ENGINEERING JOURNAL:

On the occasion of the annual convention and seminar on June 06, 2013, IEP-SAC published its annual Journal featuring technical papers and directory of Pakistani Engineers working in KSA. Such publications serve to promote the technical knowledge and exchange of experience. I am confident that our new Journal for 2014-2015 will qualify your expectation. Publication committee and its convener deserve full appreciation for their hard work.

SCHLORSHIPS:

It is a matter of great satisfaction that our scholarship program for the needy but brilliant students in eleven public engineering universities and colleges in all provinces of Pakistan and Azad Kashmir is expanding and progressing every year. During 2013-2014 session, IEP-SAC provided 88 scholarships for full academic year. Our scholarship committee remains busy round the year to ensure that scholarship amount is delivered to all concerned universities and colleges well in time. It would be worth mentioning that our scholarship program is primarily funded through individual donations and sponsorships. This could not be possible without

untiring efforts, devotion, dedication and determination of our Council members. We are endeavored to expand this program further for which we are actively seeking funding sources. From this platform, I invite all the Pakistani Engineers working in KSA and those who believe in progress of science and technology to please come forward and give donation for our noble objectives.

FAMILY PICNIC:

Our largely attended social event is our Annual Family picnic which was organized this year on Feb. 14, 2014. This event has played a pivotal role in energizing the spirit of brotherhood among Pakistani engineers and their families. More than 400 guests including Engineers and their family members enjoyed the full day in a relaxing and entertaining environment. Indoor and outdoor games for children, men and women were very well organized and executed. Our literary program and a new format of "QUIZ" program was very much appreciated. Prize and Raffle gifts distribution kept all participants enthusiastic and motivated till the end of the program. More than 100 Raffle gifts including Air-ticket for Umrah, computer printer, washing machine, kitchen appliances, books on Islamic literature and many more valuable gifts were distributed. All Council members, particularly social activities committee, reception committee, sponsorship committee and responsible for various assignments remind committed to exercise their effort to make the event successful.

AWARDS AND CERTIFICATES:

IEP-SAC special awards were presented to the co-sponsors in recognition of their contribution for the promotion of our scholarship program. Certificates of appreciation were presented to the authors of Tech. papers, published in the previous year's IEP-SAC Journal.

Special certificates were also presented to all attendees of the seminar in recognition of their commitment to engineering profession.

IEP-SAC Web-site:

I am pleased to announce that IEP-SAC web-site is now functional. You may visit to www.iep-sac.org to get the updated program, directory of Engineers in KSA, previously published papers and photos of our events. Your suggestions are invited for any improvement of our web-site. In this regard you may contact the responsible of web-site Engr. Asim Siddiqui.

ACITVITIES OF SUB-CENTRES:

During 2013-2014, IEP-SAC sub-centres in Dammam and Jeddah organized several seminars and symposiums on very interesting and knowledge oriented topics. A brief report of their activities is included in this Journal.

ACTIVITIES OF SUB-CENTRES:

IEP-SAC sub-centers in Eastern region (Dammam) and Western region (Jeddah) remained very active during this period and arranged several Techno-social events which were attended by a large numbers of Engineering & other professionals. A brief repot of their activities is included in this Journal.

GRATITUDES

IEP-SAC expresses its gratitude to the Custodian of the two Holy Mosques, King Abdullah Bin Abdul Aziz and the Government of the Kingdom of Saudi Arabia for facilitating Pakistani Engineers, Architects and Town planners to contribute their share in the development of our brotherly country, KSA.

We are thankful for the continued patronage and support of HE the Ambassador of Pakistan and Pakistan Embassy in exercising the aims and objectives of IEP-SAC.

I am thankful to our Council members for their tireless efforts and cooperation in achieving the objectives set by IEP-SAC. I wish to extend my deep appreciation to all brother Engineers, sponsors, advertisers, press and media personnel's, photographers and all guests for their cooperation and support. Our sincere admiration and appreciation is due to sub-centre in Dammam for its valuable contribution in upholding our scholarship program. In this regard, the role of Engr. Rizwan Ahmed, the Chairman of Eastern sub-centre is of prime importance.

Finally my personal appreciation is due to Chairman Engr. Jaleel Hasan and all Council members for their continued support and encouragement.

We wish and hope to receive your valuable suggestions and contributions to make our program more vibrant and useful.

Thank you all,

Engr. S.M.H. Kirmani
(General Secretary IEP-SAC)

AWARDS AND SCHOLARSHIPS COMMITTEE

لَيْسَ الْبِرَّ اَنْ تُوَلُّوْا وُجُوْهَكُمْ قِبَلَ الْمَشْرِقِ وَالْمَغْرِبِ وَلٰكِنَّ الْبِرَّ مَنْ اٰمَنَ بِاللّٰهِ وَالْيَوْمِ الْاٰخِرِ وَالْمَلٰٓئِكَةِ وَالْكِتٰبِ وَ
النَّبِيّٖنَ ۚ وَاٰتَى الْمَالَ عَلٰى حُبِّهٖ ذَوِي الْقُرْبٰى وَالْيَتٰمٰى وَالْمَسٰكِيْنَ وَابْنَ السَّبِيْلِ ۙ وَالسَّآئِلِيْنَ وَفِي الرِّقَابِ ۚ .... ﴿۱۷۷﴾

اِنْ تُبْدُوا الصَّدَقٰتِ فَنِعِمَّا هِيَ ۚ وَاِنْ تُخْفُوْهَا وَتُؤْتُوْهَا الْفُقَرَآءَ فَهُوَ خَيْرٌ لَّكُمْ ۭ وَيُكَفِّرُ عَنْكُمْ مِّنْ سَيِّاٰتِكُمْ ۭ وَاللّٰهُ
بِمَا تَعْمَلُوْنَ خَبِيْرٌ ﴿۲۷۱﴾

"But Al-Birr (righteousness, piety) is the quality of one who believes in Allah, and the Last Day, and the Angels, and the Book, and the Prophets and distributes his wealth, in spite of love for it, to the kinsfolk, and to the orphans, and to the needy, and to the wayfarer, and to those who ask, and to the ransom of prisoners." (Al-Baqarah-177)

" If you disclose your (acts of) charity, it is well, but if you conceal it, and give it those (really) in need, that is better for you; it will remove from you some of your (stains of) sins and Allah is well acquainted with what you do." (Al-Baqarah-271)

By the grace of Allah the Almighty, the IEP-SAC scholarship program for needy and academically sound students in the Engineering Universities and Colleges of Pakistan was launched 18 years ago in the year 1996. With the joint efforts of IEP-SAC Local Council members, it has been expanding ever since and presently a number of students from the listed below 11 public-sector universities and colleges are being benefited from this program.

1. University of Engineering and Technology, Lahore
2. University of Engineering and Technology, Taxila
3. University College of Engineering and Technology (Baha'uddin Zakariya University), Multan
4. Institute of Chemical Engineering and Technology (University of the Punjab), Lahore
5. Dawood College of Engineering and Technology, Karachi
6. NED University of Engineering and Technology, Karachi
7. Mehran University of Engineering and Technology, Jamshoro
8. Quaid-e-Awam University of Engineering Sciences and Technology, Nawabshah
9. NWFP University of Engineering and Technology, Peshawar
10. Balochistan University of Engineering and Technology, Khuzdar
11. Mirpur University of Science and Technology (Must), Mirpur (AJ&K)

This scholarship program serves all the four provinces of the Islamic Republic of Pakistan and the State of Azad Jammu and Kashmir. The rules and regulations, selection criteria and application forms can be accessed and printed from IEP-SAC website (http:/www.iep-sa.org). By the blessings of Allah the Almighty, 16 batches have been completed so far and 17th batch will be launched in September 2014, benefiting meritorious/needy students from this scholarship program who have been serving the humanity and our homeland after graduation.

The continuity of IEP-SAC scholarship program is not only maintained during last 18 years, but it has also been expanding gradually with the help of financial contributions from various philanthropists, individuals, and organizations in Saudi Arabia. I take the opportunity to offer the readers of these lines in general and the Pakistani community and engineers in particular to join hands with us in this noble and just cause. It is a great service to the humanity in Pakistan. Let us put our maximum efforts in contributing and expanding the scholarship program to the needy engineering students. Your suggestions to improve the program further will be most welcomed. Please do not hesitate to contact any of the members of IEP-SAC Awards and Scholarships Committee or Local Council for any suggestion or information.

Engr Shaikh Akhtar Hussain, Convener
IEP-SAC Awards and Scholarships Committee

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39th IEP–SAC Annual Technical Seminar, Energy Security Interest of Pakistan by Dr. Samar Mubarak Mand NI,HI,SI, on Thursday 6th June 2013, at Prince Salman Social Centre Riyadh

SCENES FROM IEP–SAC **Activities**

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39th IEP–SAC Annual Technical Seminar, Energy Security Interest of Pakistan by Dr. Samar Mubarak Mand NI,HI,SI, on Thursday 6th June 2013, at Prince Salman Social Centre Riyadh

SCENES FROM IEP–SAC **Activities**

CENTRAL REGION

40th IEP–SAC Mid Term Technical Seminar, Harnessing Solar Energy–Current Purspective and future Challenges by Engr. Hadeed Ahmed Sher, Friday 20th Dec 2013, at Marhaba Banquet Hall Riyadh

SCENES FROM IEP–SAC **Activities**

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SCENES FROM IEP–SAC **Activities**

CENTRAL REGION

Family Picnic, 14th February 2014, Istraha Rushd












SCENES FROM IEP-SAC **Activities**

CENTRAL REGION

Family Picnic, 14th February 2014, Istraha Rushd












FROM EASTERN REGION

Engineers keep on researching, developing and upgrading their knowledge to construct and reconstruct human needs with a view improving the living conditions of the mankind. Sharing information about new technologies for multifaceted engineering activities, networking and assisting engineering graduates for their career development is a passion of IEP-SAC-EP.

Technical Seminars, Awarding Scholarships to competent engineering students in need, assisting fresh graduates to place them in the industry & guiding other engineers for their respective needs is the continued mission of IEP-SAC-EP.

IEP-SAC-EP interacts with Saudi Council of Engineers and maintains a close and strong relationship with them.

We actively participated in 26th FEIIC (Federation of Engineering Institutions of Islamic Countries) Council Meeting & 12th FEIIC General Assembly meeting held in Madinah Munawwarah from 23rd to 25th Dec, 2013.Motto was “Driving for Strategic Change”. A very positive interaction was held with Arch. Hamad N. A. Al-Shagawi, Chairman, Board of Directors, Saudi Council of Engineers, Dr. Ghazi S. Al Abasi, Secretary General, Mr. Ibrahim Saleh Al-Dhobaie, Deputy Secretary General, Dr. Saleh Al-Mogrin, Director of Eng. Chapters and Arch. Adnan A. Alsahhaf Advisor of Saudi Council of Engineers during the above seminars / meetings and useful thoughts were exchanged with these dignitaries

Technical Seminar entitled “The Hope for Pakistan`s Future - Energy” was held by IEP-SAC-EP at Dhahran International Hotel Al-Khobar on 7th June, 2013.

Dr. Samar Mubarakmand, Nishan-E-Imtiaz, Hilal-E-Imtiaz, Sitara-E-Imtiaz – One of the leading nuclear scientists in the Islamic World was the Keynote Speaker. Mr. Mutlaq M. Naba Al-Qahtani, President & CEO of the Jubail based NABA International Group was the Chief Guest of this event. He is also the Chairman of Jubail Chamber of Commerce & Industry – Business committee.

Dr. Mubarakmand highlighted that - Pakistan has immense, indigenous energy and mineral resources quite sufficient to take it out of the current economic imbroglio. The need is to tap and exploit these resources properly, scientifically and economically. Dr. Mubarakmand said that Thar Coal can play a pivotal role in meeting the current energy crisis, both in long and short term. Spread over 9,000 Kms, the reserves are to the order of 175 billion tons of lignite coal. By using this indigenous resource, Pakistan could generate electricity at RS 8 per unit as compared to the average cost of RS 14/15 per unit being incurred currently.

Dr. Mubarakmand then elaborated on the Underground Coal Gasification (UGC) project that was undertaken at the Thar coal reserves. The abundant gas produced through the simple underground coal gasification process, could help generate not only electricity, gas and diesel, but also herald Pakistan into petrochemical products such as methanol and ammonia fertilizer.

At the end of the presentation the audience gave a standing ovation to Dr. Mubarakmand.

Another Technical Seminar held on 12th Jan, 2014 entitled: “The Emerging Shale Oil & Gas Revolution” was organized at Al-Khobar. The Keynote Speaker at this occasion was Mr. Syed Rashid Husain, Global Energy Analyst and renowned Energy columnist of Arab News and Saudi Gazette and other local news papers. He is also Vice President of Al-Azzaz Est. Al-Khobar.

Arch. Hamad N. A. Al-Shagawi, Chairman, Board of Directors, Saudi Council of Engineers was supposed to grace this occasion as the Chief Guest. Due to his last minute travelling plans, Engr. Kamal A. Al-Hammed, General Manager Eastern Province Branch of SCE was the honourable Chief Guest.

In his presentation, Rashid Husain highlighted the role of technology in bringing this resource to the fore, though People had known of shale resources for a long time.He emphasized that – The shale revolution unravelling before our very eyes is impacting the entire global energy equation.

Shale resources were known long time back when there was no dearth of resources but the issue was how to exploit this resource. Two major developments helped the engineers crack these formations – horizontal drilling and the hydraulic fracturing (fracking).

These two technologies made exploiting shale resources feasible. Indeed with crude market prices staying in three digits figures, for some time now, it also helped extracting this resource as an alternative economically viable energy source

IEP-SAC/Engineers are playing major role in the development of Kingdom of Saudi Arabia and it is proud to note that Saudi Arabia is placed at the 20th Rank in the 148 Global Competiveness Index 2013-14 as also 15th Position among the world`s leading economies in credit worthiness according to S & P Capital`s IQ survey. The Kingdom has also maintained its 14th Position among low-risk credit markets on a list of 76 countries.

IEP-SAC-EP is pleased to acknowledge continued support of the Kingdom of Saudi Arabia.

IEP-SAC-EP Executive Council is totally committed and engaged in promoting the technical activities, sharing knowledge and technological advancements through seminars, conferences, and workshops in different fields of engineering.

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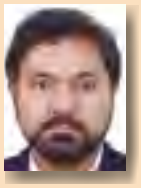

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FROM WESTERN REGION

The role of engineers is evident in every society. Pakistani Engineers in Kingdom have always been active in all fields of engineering. The Institution of Engineers Pakistan / Engineers Welfare Forum provide a platform for Pakistani Engineers community to share knowledge and ideas. IEP / not only presented seminars, also helped students at home and needy Pakistani students in schools of Kingdom.

On 6th June 2013, Institution of Engineers Pakistan (IEP) / Engineers Welfare Forum (EWF) organized with Jeddah Chamber of Commerce (JCCI) a workshop on " Energy Production by Natural Resources" in Shk. Ismail Abo Dawood Auditorium of JCCI. The key note speaker was world renowned scholar and scientist Dr. Samar Mubarakmund who specially came for the event, another renowned scientist Dr. Shahid Munir also came from Pakistan. Consul General Aftab Ahmad Khokher presided

Dr. Samar Mubarakmund said the tough challenge to be faced by new government will be to tackle issues e.g. terrorism, corruption, energy crisis which requires integrated, urgent and concrete measures. He said Pakistan's 90% of wealth lies underground which we must have to work and invest to explore. Referring to Thar coal and Recodec Gold mines projects which he is working since 2007 can change the fate of the nation from third world nation to a developed nation. Thar coal reserves is worth over 12 trillion dollar and if we use it to produce 100,000 MW (five times of present country demand), it will work for 500 years. He is also working on Recodec gold mines project. Both projects are totally managed by Pakistani expertise.

One of the landmark achievement was signing of Memorandum of Understanding (MOU) on January 2nd 2014; with Jeddah Chamber of Commerce & Industry (JCCI) at it's head quarter for the establishment of First joint Vocational Training Institute (VTI) to support the Saudisation program of the Kingdom and also help Pakistani workers to improve their skills. Dr. Abdul Aleem Khan thanked to Consul General and all the Guests who gathered on very short notice. He said the concept of Training to Saudis was originally discussed with Engr. Talal Samar Qandi, Head Engineering Committee of JCCI which was endorsed by Mr. Mazen Batterjee who extended full contribution for this project. He said there will be 15 Trades in which VTI will work. He also praised Custodian of Two Holy Mosques King Abdullah bin Abdul Aziz and Crown Prince Salman Bin Abdul Aziz for supporting Pakistanis in kingdom.

On 31st January 2014, IEP / EWF organized a Lecture by world renowned scientist and educationist Dr. Ataur Rahman (ex-Federal Minister of Education) at Spinzer restaurant. This was also attended by Mr. Mazen Batterjee vice chairman of Jeddah Chamber of Commerce and industry (JCCI). Pakistani Consul General Aftab Ahmed Khokher presided the event. The function started with the recitation of Quran by Qari Abdul Majeed, Engr. Masroor Elahi, secretary general of EWF conducted the event, who paid tribute to Dr. Ataur Rahman for an excellent work done during his tenure in which Pakistan took revolutionary measures in higher education and IT profession.

There was good motivation in membership registration of the Institute of Engineers Pakistan. Engr. Asif Butt took the lead of this activity and last year 120 Engineers registration was accomplished. IEP encourages all professional engineers in the region to become members of IEP which will enhance professional activities of the Forum.

Formal by laws of EWF was finalized and published which will put forth legitimacy for future activities of the forum.

Social worker team organized wheel chairs and other support facilities to Hundreds of Hajis in need of assistance. Over 50 volunteers handled this at the last haj. IIftar/ dinner were organized for Engineers families which gave opportunity for socializing with religious fervor. EWF also extended Pakistani consul general's support fund for needy students of Pakistani school in Jeddah

Dr. Abdul Aleem Khan

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The contracting sector has witnessed various developments. The contracting concept was no longer limited to the constructions activities only. Nowadays the contracting has been more specialized with the rapid increase & diversification of the business. In this context many big companies has come to the field such as A. S. Husseini & Partner Contracting Co. Ltd which was established in 1975 as an individual establishment in the name of Abdulsalam Al Husseini and has started its business in the electrical contracting then in the eighty (1980's) it has developed to company which has engaged, in addition to the electrical business, in the civil & mechanical works. Later it has specialized in industrial works as it was being able to construct integral factories and has been approved by (IBSF) company in Riyadh which is specialized in building of steel hangers for factories & warehousing.

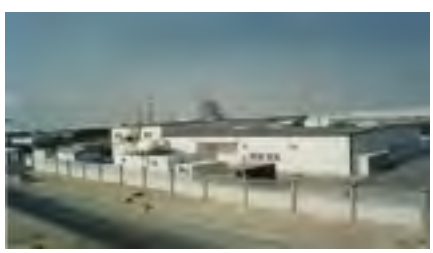
During the last forty (40) years, being the business life of the company, which coincided with the KSA economic boom,

The company has achieved many jobs in the activities such as the construction of chicken slaughter house for Faqih Poultry in Abha and another one for Arasco in Riyadh, Paper Factory for Obaikan in Riyadh, Medium Voltage Power Transmission Towers for the Aluminum Factory in Ras Alkhair under the supervision of Bechtel Co.

The above business was in addition to the several power plants (9) constructed by the company in Jeddah, Tabuk, Tehama, Jizan, Buraidah & Najran. That is because the company is approved at the Saudi Consolidated Electric Co. (SCECO) in addition to Aramco, Sabic & Bechtel.

It is to be mentioned that the company is planning to upgrade the electric Division as a separate in order not to be only constructions but to include power plant inspection & operation.

Finally, I would like to have a word to the Saudi youths that working & employment in the private sector companies is a wide space with promising future. I, therefore, advise them to enter this field but they should qualify themselves properly.



Global Warming And Climate Change

Extent of human impact and mitigation required

By

S.M.H. KIRMANI

Abstract

Climate change, also known as global warming, is one of the most important and profound environmental issue facing the planet. The topic covers the changes in climate across the entire planet including shifting pattern of precipitation, drought, desertification, sand storms, extreme weather events, shrinking glaciers or accelerated Sea level rise.

According to the international panel on climate change, "most of the observed increase in global average temperature since the mid-20th century is very likely (over 90%) due to the observed increase in anthropogenic (human caused) green house gas concentration. The potential threats are serious and actions are required to mitigate climate change risks.

This paper covers the brief history and causes of climate change, the role of different Green house gases and their global warming potential, effects of global warming and climate change, future prediction and efforts required to safeguard the prosperity of our planet and its people.

INTRODUCTION:

Climate change is a long term shift in the statistics of the weather. For example, it could show up as a change in climate normals (expected average values of temperature and precipitation) for given place and time of year, from one decade to the next. Climate change is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, Ocean and land as well as changes in the amount of solar radiation reaching the earth.

A number of indicators suggest that global warming due to increased levels of green house gasses (GHGs) has become a major issue of national and international policy. The last decades of 20th century and the beginning of the 21st century have been the warmest period in the entire global instrumental temperature record, starting in the mid 19th century. The fourth and fifth Assessment Report of the International panel on climate change (IPCC) concludes that, "Most of the observed increase in the global averaged temperature since the mid 20th century is very likely due to the observed increase in anthropogenic green house gas concentrations."

BRIEF HISTORY OF CLIMATE CHANGE:

The origins of climate science go back to the late 18th century and 19th century. In 1770 a Swiss scientist, Horace – Be'ne'djet de Saussure, suggested that the atmosphere is like a green house, protecting both the earth surface and those who live on it, from extreme temperature. Later John Tyndall, one of the great British scientists of the 19the century, was the first person to do experiments that confirmed the green house effect. However, the Swiss scientist Louis Agassiz is considered the "real inventor of the idea of climate". In 19th century, Louis Agassiz gave the theory that the growth and recession of glaciers over eons of time had sculpted the Alps in Europe, the Great Lakes in North America and other terrestrial formation. He also poised the idea that the earth had experienced shifts in temperature and climate conditions.

Charles David Keeling (April 20, 1928 – June 20, 2005) was an American scientist who's recording of carbon dioxide at the Mauna Loa observatory in Hawaii, first alerted the world to the possibility of anthropogenic contribution to the "green house effect" and global warming [1]. Modern satellite imaging and computer modeling has confirmed the idea of global warming. These models also suggest that human activities played a significant role in causing such change by releasing CO_2 into the atmosphere through combustion of hydrocarbons. A mile stone in the history of climate change debate occurred in 1988, when the international panel on climate change (IPCC) was established. This international network of scientists from around the world issues regular reports that synthesize current science research. Today, the discussion around climate change has shifted from "is it happening?" to "what is the extent of human impact?" and "what should we do about it."

Causes of climate change:

Two Major factors are responsible for the changes in the state of the Earth's climatic system:

i) Extraterrestrial factors (change in solar radiation, variation in Earth's orbital characteristics).

ii) Internal variations in the Earth's climatic system (changes in the concentrations of atmospheric gases, mountain, building, volcanic activity and changes in incident light reflected by the surface or atmosphere.

It is verified that only a limited number of factors are primarily responsible for most of the past episodes of climate change on the Earth. These factors include:

- Atmospheric carbon dioxide variations
- variation in the Earth's orbital characteristics

- variation in solar output
- Acidification of Sea water
- volcanic eruption

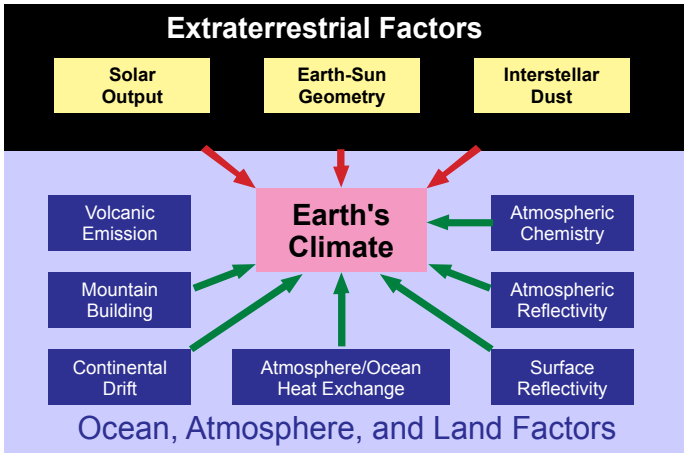


Fig-1: Factors that influence the Earth climate

Atmospheric carbon dioxide variations – Green House Effect:

Studies of long term climate change have discovered a connection between the concentrations of carbon dioxide in the atmosphere and mean global temperature. Carbon dioxide is one of the more important gases responsible for the "GREEN HOSUE EFFECT." "Green house effect" is the term used to describe the retention of heat in the Earth's lower atmosphere (troposphere) due to concentrations of trace gases (CO_2, methane & Nitrous oxide) and water vapour in the atmosphere. These gases are known as green house gases (GHGs).

The green house effect itself occurs when short-wave solar radiation, which is not impeded by the green house gases, heat the surface of the Earth, and energy is radiated back through the Earth's atmosphere as heat, with a longer wave length.

(See Fig-2).

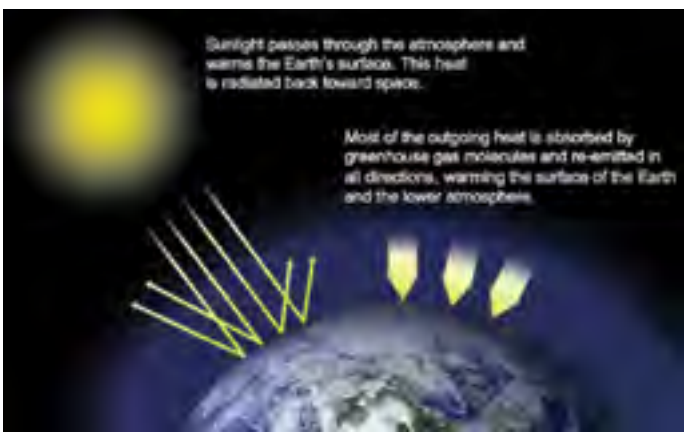
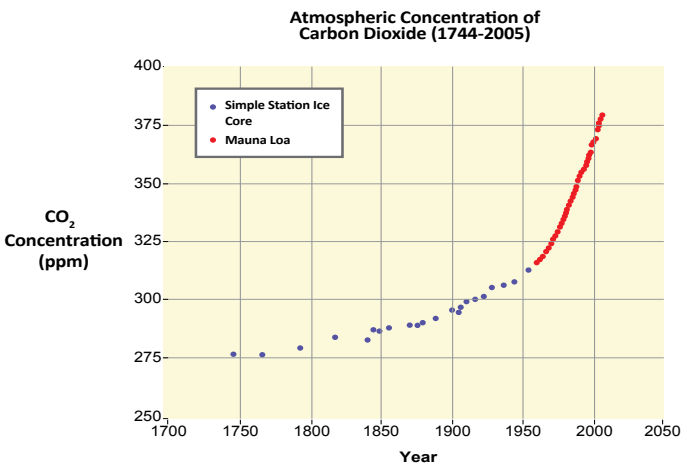


Fig-2: GREEN HOUSE EFFECT

In the wavelengths 5-30 µm a lot of this thermal radiation is absorbed by water vapour and carbon dioxide, which in turn radiate it, thus heating the atmosphere and land and ocean surface. This is natural green house effect and what keeps the Earth habitable. Without green house effect overnight temperatures would plunge and the average surface temperature would be about -18°C, about the same as on the moon, which lacks the shroud of our atmosphere.

In respect to enhancing the green house effect, or the likelihood of anthropogenic global warming (AGW), the particular issue is focused in the 8-18 µm bands where water vapour is a weak absorber of radiation and where the Earth's thermal radiation is greatest. increased concentrations of CO_2 and other radiative gases here mean that less heat is lost to space from the Earth's lower atmosphere, and temperature at the Earth's surface are therefore likely to increase [2].

Over the past three centuries, the concentration of CO_2 has been increasing in Earth's atmosphere because of human influences (Fig-3). Human activities like burning of fossil fuels, conversion of natural prairie to formland, and deforestation have caused the release of CO_2 in to the atmosphere. From early 1700, CO_2 has increased from 280 parts per million to 390 parts per million in 2005. Most computer climate model suggest that the globe will warm up by 1.5-4.5°C if CO_2 reaches the predicted level of 600



part per million by the year 2050.

Fig-3: Rise in atmospheric CO_2, exponential during 1744-2005

The role of different GHGs in total emissions:

Estimates of the individual contribution of particular gases to the green house effect, their global warming potential (GWP), are broadly agreed (relative of carbon dioxide=1) as reflected in Table no. 1.

Table No. 1

Green house gas	Concentration change, 1800s to 2010	Anthropogenic source	100-year GWP * (Global warming potential)	Proportion of total effect apart from water vapour
Carbon dioxide	280-390 ppm	Fossil fuel burning, Deforestation	1	60%
Methane	0.75-1.75 ppm	Agriculture, fuel leakage	25	20%
Halocarbons	0-0.7 ppb	Refrigerants	1100 to 11000	14%
Nitrous oxide	275-310 ppb	Agriculture, combustion	298	6%
Ozone	20-30 ppb	Urban pollution		

[* IPCC Third Assessment report, CO_2 information Analysis centre, ORNL, 2013].

Although water vapour has a major influence on absorbing long-wave thermal radiation, its GWP is not calculated since it's concentration in the atmosphere varies widely and mainly depends on air temperature. Also its residence time is only about nine days, compared with years of CO_2 and methane.

Countries contributing major emissions of GHGs.

Which countries have the longest and which are the current major contributors to total GHGs are evident from Fig-4. Accordingly, United States of America as a single country was major emitter of GHGs, during the period 1850-2004 while following 2004, China has played leading role in contributing GHGs to atmosphere.

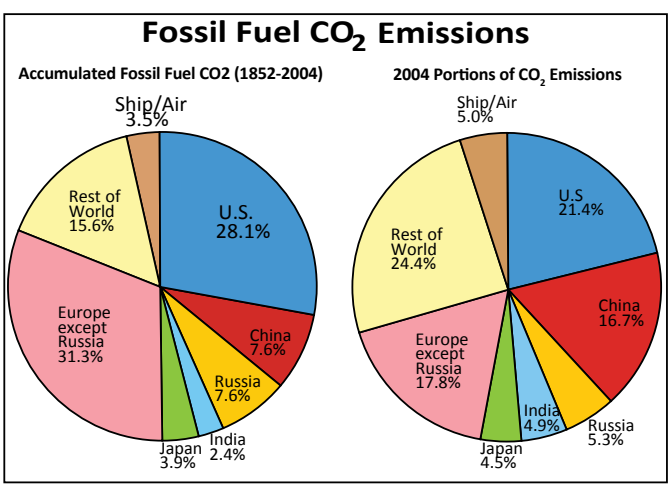


Fig-4: Factors that influence the Earth climate

Annual Green house Gas Emission by sector is indicated by Fig-5. Accordingly power sector (21.3%) is the main contributor of GHGs, following by industrial process (16.8%) and Transportation fuel (14.0%) are the major emitters of GHGs.

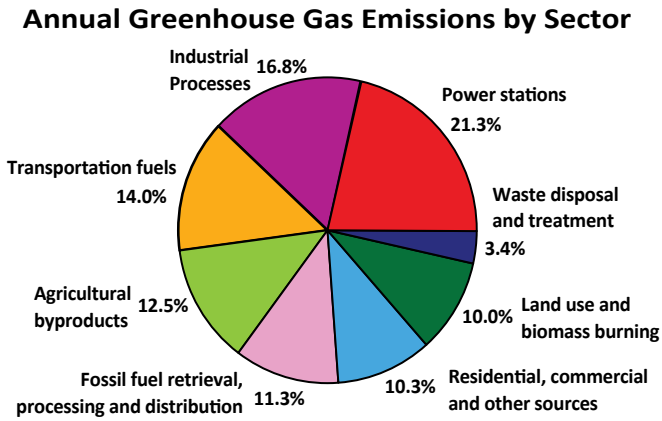


Fig-5: Factors that influence the Earth climate

Ocean Acidification:

Scientific coordinator of the European project on Ocean Acidification, Jean-Pierre Gattuso [4] estimated that around 10 giga tonnes of CO_2 are released by human activity every year, of which 25% is absorbed by the Oceans. As the Oceans absorbs excess CO_2 produced by humans, they are becoming more acidic, which affects the biology of marine ecosystems. The net effect of this trend of lower pH may be lower levels of dimethyl sulphide, a by product of plytoplankton ecosystem, released into the air. As dimethyl sulfide plays an important role in seeding clouds, lower atmospheric levels of the chemical could mean fewer clouds reflecting the Sun's energy and, therefore, a hotter earth. This means that humanity's CO_2 emission could warm the Earth by the additional 0.5°C by 2100 [4].

Variation in Solar output:

Many scientists were of the opinion that the Sun's output of radiation only varied by a fraction of a percent over many years. However, measurements made with the help of radiometers in 1980s and 1990s suggested that the Sun's energy output may be more variable than was once thought. The measurement made during the early 1980s showed a decrease of 0.1 percent in the total amount of solar energy reaching the Earth over just an 18 months time period. If this trend continued over several decades, it could influence global climate. Numerical climatic models predict that a change in solar output of only one percent per century would alter the Earth's average temperature by between 0.5 to 1.0° Celsius [5].

Variation in the Earth's orbital characteristics:

The Milankovitch theory [3] suggests that normal cyclical variations in three of the Earth's orbital characteristics (Eccentricity, change in orbital timing and obliquity of Earth's axis) is probably responsible for some past climate change. The basic idea behind this theory assumes that over time these cyclic events vary the amount of solar radiation that is received on the Earth's surface.

Eccentricity controls the shape of the Earth's orbit around the Sun. The orbit gradually changes from being elliptical

to being nearly circular and then back to elliptical in about 100,000 years. The greater the eccentricity of the orbit, the greater the variation in solar energy received at the top of the atmosphere between the Earth's closet and farthest approach to the Sun.

Effects of global warming and climate change:

There are numerous potential effects of climate change. Extensive research is being done around the year to determine the extent to which climate change is occurring, how much of it is being caused by anthropogenic (man made) forces and it's potential impacts. Potential impacts most studied by researchers include the effects on melting glaciers, increase in Sea level, droughts, hurricanes and changes in local weather.

The fifth Assessment report, 2013 IPCC [6] concluded that the evidence that the human derived green house gas emissions had already had an impact on the climate had strengthened. Furthermore, there was greater confidence in predictions of the impacts of future GHGs emissions.

Findings of the fifth (2013) IPCC report:

- More than half of the observed increase in globally averaged temperatures since the mid-20th century is extremely likely (95% + probability) due to the human influence, notably the observed increase in anthropogenic green house gas concentrations.
- Green house gases contributed a global mean surface warming likely (66% + confidence) to be in the range of 0.5^{o} C to 1.3^{o} C over the period 1951-2010.
- More than 60% of the net energy increase in the climate system was stored in the upper ocean (0-700 m) from 1971 to 2010, and about 30% is stored in the ocean below 700 m.
- Anthropogenic influences likely contributed to the retreat of glaciers since the 1960s and to the diminution of the Green land ice sheet since 1993.
- Multiple lines of evidence support very substantial Arctic warming since the mid-20th century, and anthropogenic influences have very likely contributed to Arctic Sea ice loss since 1979.
- Global average Sea level rose at an average rate of 2.0mm per year over 1971 to 2010. The rate was faster over 1993 to 2010, about 3.2 mm per year.
- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics.
- Widespread changes in extreme temperatures have been observed over the last 50 years. Cold days, cold nights and frost have become less frequent, while hot days, hot nights and heat waves have become more frequent.
- The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1820 ppb in 2011.
- The combined radiative forcing due to increases in carbon dioxide, methane, nitrous oxide and halocarbons is +2.83 W/m^2 and its rate of increase during the industrial era is very likely to have been unprecedented in more than 10,000 years.

Future prediction:

In the fifth IPCC report, four scenarios for the future carbon emission to 2100 ranged from means of 270 GTC, assuming substantial cuts in the emission and corelated with the best case radiative forcing of 2.5 W/m^2, to 1685 GTC correlated with 8.5 W/m^2 radiative forcing. Accordingly, it predicted that based on the range of scenarios, by the end of 21st century, climate change will result in:

- Global surface temperature change is likely to exceed 1.5^{o} C relative to 1850 to 1900 for two scenarios, be about 2^{o} C in one, and approaches 4^{o} C in the other.
- A Sea level rise most likely to be 47-63 cm, due more to thermal expansion than retreating glaciers and Greenland ice cap.
- Arctic summer Sea ice disappearing in second half of century in all but the lowest scenario.
- It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal time scales as global mean temperature increase. It is very likely that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur.
- It is virtually certain that near surface permafrost extent at high Northern latitudes will be reduced as global mean surface temperature increases.

Mitigation of comate change:

The potential threats are serious and actions are required to mitigate climate change risks. However, according to NRC, 2010a, recommendations [7], "Climate research needs to be integrative and inter disciplinary", encompassing many societal components and activities that are profoundly influenced by climate, including fresh water resources, agriculture, fisheries and food production, public health, transportation, the built environment, energy production and use, and economic well-being. Boldest efforts are required to safeguard the prosperity of our planet and its people. Following steps would be necessary:

i) Non-combustion energy sources:

To increase non-carbon electricity generation from 34% (Nuclear; Hydro; Solar thermal; Solar photovoltaic; wind; tidal power) now to 48 to 53% by 2030, along with other measures.

ii) Forest conservations:

What if you did not have to choose between Green and growth? The two concepts should be hand to

hand.

Tropical forests act as the Earth's lungs, absorbing carbon dioxide and releasing oxygen. Forests provide other critical ecosystem services such as filtering water, preventing soil erosion and regulating climate. By developing a REDD+ (Reducing Emissions from Deforestation and Forest Degradation plus conservation, the sustainable management of forests and enhancement of carbon stocks) projects, we can mitigate climate change as well as can provide local communities with financial, social and environmental benefits [8].

iii) Adopting sustainable Green Building Development and LEED Grading [9].

iv) Reduce underlying demand for goods and services that require energy.

v) Improve the efficiency with which energy is used.

vi) Environmental awareness:

By hosting a series of workshops for youth aimed at providing the skills and information that will empower them to educate their communities on the importance of protecting their natural home.

CONCLUSION:

Careful and comprehensive scientific assessments have clearly demonstrated that the Earth's climate is changing in response to growing atmospheric burdens of green house gases (GHGs) and absorbing aerosol particles. A large part of the increase in all green house gases is attributed to human source, that is it is anthropogenic. Over one third of human induced green house gas emissions come from the burning of fossil fuel to generate electricity.

Prospects and options to mitigate the effect of global warming and climate change include, non-carbon electricity generation, forest conservation, environmental awareness, sustainable green building development and sustainable management to improve the efficiency in use of energy.

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عَنْ عَبْدِاللهِ بِنْ قُرْطٍ رَضِیَ اللهُ عَنْهُ قَالَ:
قَالَ رَسُوْلُ اللهِ ﷺ اَوَّلُ مَا يُحَاسَبُ بِهِ الْعَبْدُ يَوْمَ الْقِيَامَةِ الصَّلٰوةُ، فَاِنْ صَلَحَتْ صَلَحَ سَآئِرُ عَمَلِهٖ وَاِنْ فَسَدَتْ فَسَدَ سَآئِرُ عَمَلِهٖ۔ (ترغیب بحوالہ طبرانی)

First thing that will be questioned on the Day of Resurrection will be about Prayer; if someone met this, he will be successful in the remaining actions. If he can't meet, the rest of the deeds will be worse. (ترغیب بحوالہ طبرانی)

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Micro–Inverters – Promising Solutions in Solar Photovoltaics

by

Hadeed Ahmed Sher

Abstract

Micro-inverter technology is an upcoming area of research in the field of photovoltaic (PV) as it enables solar arrays to work as plug and play devices. Most of the research in this field has been based on the arrangement of different DC-DC converters and inverters and the effort is mostly focused towards attaining greater stability, lesser complexity and better performance. A literature survey reveals that most micro-inverters are designed with two stage power conversion techniques and little research exists with single stage power conversion designs. The literature survey also notes that most micro-inverters are designed in the power range of 100-250W with power conversion efficiencies above 90%. There are a variety of applications where the use of micro inverters can be very effective. The research in single stage micro-inverters can offer potential benefits in the field of solar PV. The review of micro-inverter research work can lead to future research and benefits in this area.

I. Introduction

Solar Photovoltaic (PV) based systems are among those renewable energy systems that are now at the top eco-friendly renewable energy solutions for power generation. From powering up a compact fluorescent lamp, the world's leading economies have installed solar PV systems that produce power in the Mega Watt (MW) range (Hoffmann, 2001). Solar PV systems are based on semiconductor wafers and are available in variety of sizes for various applications. Solar cells can be combined to form the solar array which is basic unit for solar power module/panel. Solar systems have low efficiency and are used in assistance with the power electronics based systems for efficient energy harvesting. They can be installed on ground or on roof. In roof top installations they offer good results as far as the energy saving is concerned (Kalkanoglu et al., 2010). Over the years the researchers have seen tremendous potential in PV technology. From the Log Cabin Systems (LCS[1]) to Urban Home Systems (UHS[2]) there have been a variety of technical arrangements (Dumais, 2010). However, if the solar panel gets shaded due to nearby objects, the working of solar PV module is compromised. Therefore, the issue of partial shading forced engineers to design another category of systems with individual DC-DC converters followed by only one main inverter. Here, the DC-DC converters are connected to each panel and are connected to a common DC bus which forms the input to the inverter. It should be noted that for this system there is only one inverter, therefore in case of failure of inverter there is no alternate of energy transfer. For resolving this issue, the idea of string inverters was proposed and implemented. Therefore, instead of having a common DC bus, in these types of systems, each panel supplies AC voltage to the common AC bus. The output of various panels is synchronized with each other for proper operation. This provides better stability and safety against the failure (Haeberlin, 2001). However, the problem of partial shading degrades the performance for such a system as well by lowering power output and if the connection is in shunt then it lowers the input voltage to the converter as well. Therefore for ensuring stable operation, Maximum Power Point Tracking (MPPT) is recommended for each and every module (Kjaer et al., 2002). Even with string inverters, a PV system was not suitable as a plug and play device for domestic applications. Therefore, it was considered desirable to design systems that have inverters inside the PV modules. This type of design was initiated in early 90's under the name of OK4 (Oldenkemp and DeJong, 1998) and is also termed as Micro-Inverter (MI), Module Integrated Converters (MIC) or AC module (Dumais, 2010; Kjaer, 2005; Li and Wolfs, 2006). One researcher defined an MI as "An AC module is an electrical product and is the combination of a single module and a single power electronic inverter that converts light into electrical alternating (AC) power when it is connected in parallel to the network" (Kjaer, 2005). Although the concept of MI is not new, the latest developments in this field classify it as a new concept. With the use of a micro inverter, each PV module produces its own AC power. Therefore in case of failure of any individual module, the power can still be supplied without any interruption.

The average life of MI based systems is about 25 years because of low rise of internal temperature and elimination of bulky electrolytic capacitors. Such systems have a better physical and economical scalability as compared to the string inverters *(Andersen and Alvsten, 1995)*. One important advantage is the savings in term of space, noise and heat in contrast with large string inverters *(Browder, 2005)*. They also offer a highly efficient battery-less PV system using individual tracking of maximum power. They are low cost, have increased reliability, and, reduced risk of arcing because of the use of standard AC wiring *(Kjaer et al., 2002; Oldenkemp and DeJong, 1998; Meinhardt et al., 1999; Walker and Pierce, 2006)*. Some researchers claim that MI is the best choice for building integrated environment because the procedure for their installation is simple *(Oldenkemp and DeJong, 1998)*. Protection functions are integrated within the electronic control of the inverter. However, MI also has some disadvantages. The direct exposures of power electronic devices to extreme

1. A DC system that is used to cater lighting loads for isolated cabins built in remote areas. It works on 12 V DC.
2. These are large systems that contain a lot of solar PV panels. Their output is AC in the range of 2 -10 kW at 120/240 V

environmental conditions like humidity, temperature, lighting etc. reduces the Mean Time to Failure (MTTF). The environmental conditions may have a wide temperature range from -30°C to 70°C and from dry to very humid environment *(Rodriguez and Amaratunga, 2008)*. If an MI system develops a fault as a result of the environmental or technical issues, repairing it can be very difficult. Though the cost is low for an MI system, at mass levels the cost per watt is higher as compared to a string inverter of the same size. Also since MI contains tens of components in a compact space, it becomes obvious that each and every component is a possible point of failure *(Meinhardt et al., 1999; Myrzik and Calais, 2003)*.

MI systems are mostly designed for power rating between 200-700 watts. For better matching of inverter and PV module, they are incorporated with MPPT as the output power of a typical MI system increases by 11% annually if proper MPPT technique is employed *(Andersen and Alvsten, 1995)*. Most of the MI systems have either a single stage or multi stage power conversion process. In the single stage configuration, the inverter is designed to ensure MPPT and in the multi-stage configuration the DC-DC converter is usually employed to ease the implementation of MPPT. Transformers are also used in some multistage configurations for stepping up the voltages. Mostly, MI systems are designed for operating at grid voltages with a desirable power factor of 0.9 and Total Harmonic Distortion (THD) limited in accordance with the IEEE regulations.

I. Microinverter Research

As discussed above, although the first MI was designed during the 90s, yet the research in this field has opened new horizons for power electronics engineers. This section deals with the general design objectives of an MI system followed by various proposed energy conversion configurations. It also gives a glimpse of the MPPT techniques employed.

A. MI Design Objectives

The design of an MI must be such that it is easy to install and can be fitted on the rooftop for domestic applications. To enhance its acceptance in the market it is necessary to make its use feasible for home based installations. The basic challenge is to convert the low voltage output of a solar module to a level compatible with the utility with highest possible efficiency (typically above 90%). The inverter must also be capable of current shaping making it as close to a sine wave form as possible *(Myrzik and Calais, 2003)*. The inverters used for the MI must inherit high conversion efficiency with better optimization for output power, low profile electronic design and multiple AC connections. They must be able to convert even at 5% of the rated power. Furthermore, it is also desired that they possess the property of "Islanding" in a worst case scenario. Islanding techniques are discussed in *(Trujillo et al., 2010)*. Class II isolation for providing special safety measures for PV modules is also a requirement. Galvanic isolation is also recommended in case of utility interfacing for solving the grounding issue *(Kjaer, 2010)*. It can either be provided in the form of a high frequency transformer connected with DC-DC converter; or, with the grid side in the form of low frequency bulky transformer *(Krekes et al., 2009)*. The MI must be tested in accordance with international standard tests for safety compliance *(Islam et al., 2003)*. In case of MI interface with grid, the requirements for current/voltage harmonics and under/over voltage protection must be ensured. The high frequency ripple due to switching must not pose EMI[1] problems in the system. Planer magnetic[2] is recommended for a slim design *(Meinhardt et al., 1999)*. The cost of the AC modules should be less than the string inverter or central inverter based systems and it is a good option to have an integrated monitoring system *(Islam et al., 2006)*, *(Bonn, 2002)*. Based on the temperature profile of the solar PV panel during a sunny day, an MI must withstand a max temperature of 80°C *(Kjaer, 2005)*. It should be noted that the famous Arrhenius law tells us that the life of the device becomes double if temperature decreases by 10K *(Sahan et al., 2008)*. This means that thermal improvements can enhance the life of the MI. Therefore, as a design objective, proper thermal modeling is also required. The reliability and life of a MI is mainly dependent on the life of the components utilized and if there is no other issue they can reach a life of 20 years. Table 1 shows the reliability of MI components.

Table 1: AVERAGE LIFE OF MICROINVERTER COMPONENTS *(Meinhardt et al., 1999)*

Component	% Temperature	% Failure Rate
DC Capacitor	70.7°C	60% 4 Electrolyte capacitors
Control	83.5°C	60% including rest of components
Rectifier	85.8°C	8% diodes
Converter MOSFET	83.9ºC	10% Including transformer
AC filter	86.2ºC	8% including filter capacitor
Sum		100%(≈37.5% failures/106 h)

B. Designed Topologies

The circuit arrangement and design in MI is a promising field of research and development. Technically an MI is composed of the following general components as shown in Fig. 1

- DC-DC converter
- Inverter
- Control circuitry
- Protection scheme
- Utility interfacing transformer

3 EMI (Electromagnetic Interference) is an unwanted signal / disturbance that affect the performance of an electric circuit. All Electrical devices must comply with the rules for passing the standard EMI test.

4 Planner magnetic consists of planar core of magnetic material. The assembly is simple as it has two flat pieces of magnetic material placed above and below the coil. The coil is part of Printed circuit board. The main advantages are high power with small volume compared with the conventional magnetic devices

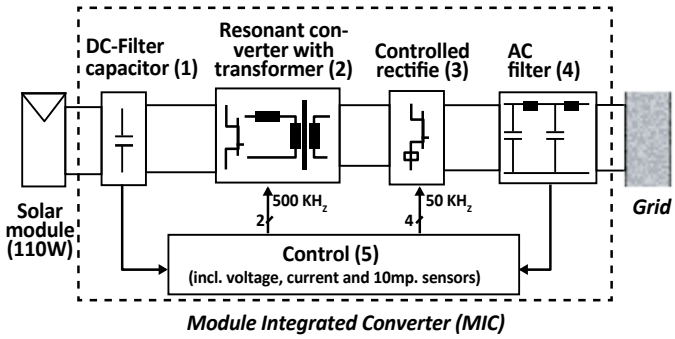

Figure 1 Typical Microinverter (Meinhardt et al., 1999)

Control chips like dsPIC DSC, TMS320C31 UCC28956 TI MSP430F1232,TI TMS320F2812eZ DSP kit, DSP TMS320F28027/2407, DSP1104 from dSPACE and MSP430F147 are generally used to control the power switches and the implementation of the protection schemes along with MPPT (Dumais, 2010; Walker and Pierce, 2006; Rodriguez and Amaratunga, 2008; Krekes et al., 2009; Fang and Ma, 2010; Jain and Agerwal, 2007b; Kasa et al., 2005). Moreover, surface mounted inductors, fast recovery diodes and low ESR capacitors are generally recommended (Walker and Pierce, 2006). The topology of the inverter strongly affects the efficiency. A lot of work has been done based on the inverter topologies and circuit arrangements. For maximizing the efficiency of the system often the designers incorporate MPPT either by a DC-DC converter or by modifying the inverter switching algorithm. The first one is known as multi stage design and the later as single stage design. The designs of (Andersen and Alvsten, 1995; Rodriguez and Amaratunga, 2008; Trujillo et al., 2010; Kjaer, 2005; Kusakawa et al., 1998; Jiang and Pan, 2009; Krishnaswami, 2011; Ho and Chung, 2005) are multi stage and the designs given in (Sahan et al., 2008; Fang and Ma, 2010; Jain and Agerwal, 2007b; Kasa et al., 2005; Chen et al., 2007) are single stage.

C. MPPT for MI

In any Micro-Inverter, it is always desired to have an MPPT applied either through a DC-DC converter or through an inverter. MPPT uses the current and voltage level optimization for obtaining the maximum power. The voltage and current characteristics of a PV panel are generally given by the manufacturer and this helps in defining the operating mechanism of MPPT. It should be noted that a wrong choice of frequency and amplitude of step size can greatly affect the reliability of the system. Thus, following MPPT algorithms are important in this regard *(Kjaer, 2005; Jain and Agerwal, 2007a; Esram and Chapman, 2007)*.

- Hill climbing (Perturb and Observe)
- Incremental conductance method
- Constant voltage method
- Fuzzy logic control
- State based MPPT
- Beta (β) method
- Sweeping algorithm
- System oscillation method
- Ripple correlation method
- Fractional short circuit current MPPT

Three of the above mentioned techniques are considered accurate and are widely used. These are Hill Climbing, Incremental Conductance and beta method. Hill climbing, incremental conductance and constant voltage method can be implemented using analog or digital circuits.

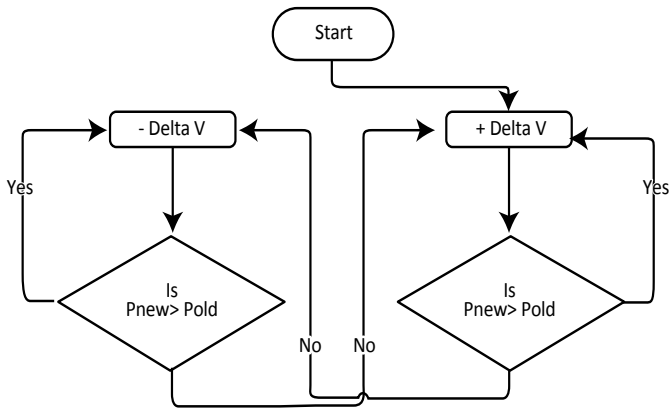

Figure **2**: Basic hill climbing MPPT algorithm

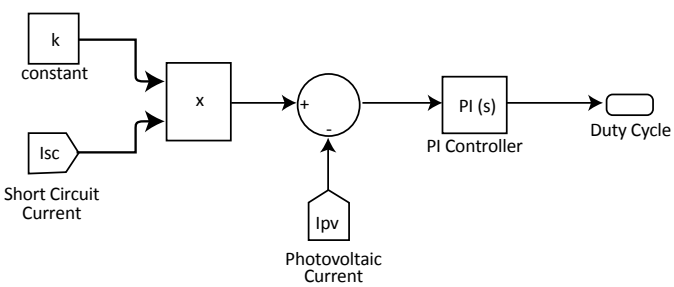

Figure 3: Fractional short circuit MPPT

II. Conclusion

Microinverter technology is an upcoming field and has a lot of scope for research and development. MI with ratings less than 1 kW have been discussed here. These are categorized into single stage and multi stage MI based on their energy conversion stages. The pros and cons of the technology have also been discussed. It seems that single stage MI provides a good room for research and development as it reduces the cost as well as size and increases the reliability and life of the system. This research survey thus provides an outline for future development of MI.

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حدثنا عبدان أخبرنا أبي عن شعبة عن عمرو بن مرة عن سالم بن أبي الجعد عن أنس بن مالك أن رجلا سأل النبي صلى الله عليه وسلم متى الساعة يا رسول الله قال ما أعددت لها قال ما أعددت لها من كثير صلاة ولا صوم ولا صدقة ولكني أحب الله ورسوله قال أنت مع من أحببت

Narrated Anas bin Malik:

A man asked the Prophet "When will the Hour be established O Allah's Apostle?" The Prophet said, "What have you prepared for it?" The man said, "I haven't prepared for it much of prayers or fast or alms, but I love Allah and His Apostle." The Prophet said, "You will be with those whom you love."

صحیح بخاری:جلد سوم:حدیث نمبر ۱۱۲٤

Particle Swarm Optimization

by

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Abstract

Particle swarm optimization (PSO) is an Artificial Intelligence technique used for finding maximum/minimum points in functions. This idea falls under the domain of Swarms intelligence. The underlying idea of particle swarm optimization is that groups can perform better than individuals working alone. The members of a group (or swarm) search the desired optimum point. Every member (particle) gets information from its neighbors and makes a decision based on its previous experience as well as on experience of the neighbor who achieved the best optimum solution. This paper presents a modified particle swarm optimization technique and tests it on four standard benchmark functions. The technique is based on controlling the movement of particles using velocity clamping and penalizing the particles for crossing the speed limits. The algorithm has been implemented in Matlab® and compared with the results of standard particle swarm optimization.

Keywords: Particle Swarm Optimization**,** benchmark functions.

I. Introduction

Particle Swarm Optimization (PSO) is a stochastic optimization technique based on population and was developed by Dr. Kennedy and Dr. Eberhart in 1995. The inspiration behind this technique came from the problem solving capabilities and behavior of social animals. It is a known fact that efficiency of a group increases, as members of group seems to share information among them.

This paper is divided into two parts; first part includes literature review on standard particle swarm optimization and evaluation of implemented standard PSO on four well known benchmark functions. Different values for inertial weight, acceleration constants and maximum velocity have been explored and justification of chosen values has been provided. Second part includes all the steps performed in the implementation of the general PSO, with suggestions on improving the standard PSO. Finally, a comparison has been made between an improved proposed algorithm and the standard PSO.

II. Literature Survey

Swarm intelligence is a term which was introduced by Professor Gerardo Beni and Jing Wang while working on cellular robotics in 1989. The idea is based on the fact that working in a group can give better results. The idea of swarm intelligence and social interaction was used by James Kennedy and Russell Eberhart [1] in 1995 to introduce a new algorithm in which arbitrary particles interact with each other to find a solution of a fitness function. Later on Eberhart and Shi modified the original algorithm and introduced a factor called the inertial weight [2]. More work was further done by other researchers to control the inertial weight and find better results on standard benchmark functions [3] . An assessment has been reported on different variants of the particle swarm optimization in [4]. The three parameters of standard PSO i.e. inertial weight and two acceleration constants have to be chosen very precisely. The approach of linearly decreasing the inertial weight used by [2] has got better results than standard PSO. Maurice and Kennedy have used a new parameter known as the constriction factor with PSO to optimize multi-dimensional functions, which eliminates the need for velocity control to some extent [3]. A lot of research has been done on the different topologies of PSO. Some of them include lbest topology which uses the local best position of the particle to guide it to the global optimum point. Another topology is the gbest topology which uses the personal best as well as the global best position of the swarm to find the optimum point. The variant of PSO known as the Fully Informed PSO uses the approach that every member of the swarm benefits from the experience of every other member i.e. a particle finds the optimum point by using its personal best position as well as the personal best positions of all other particles. This approach is somewhat slow and requires a high computational power. This paper will discuss the use of the general PSO and then a modification inspired by [5] [6] [7] will be used to control the velocity and weights. The approach to avoid stagnation will also be used.

III. Standard Particle Swarm Optimization

PSO is an optimization technique, whose search procedure is population-based in which individuals called “Particles” change their “Position” with time. This algorithm searches through a multi-dimensional space in which each particle has two characteristics: a position and a velocity.

Positions and velocities of particles in a swarm are randomly initialized. Assume a search space is D-dimensional; j^{th} particle position of the swarm can be represented by a D-dimensional vector

$$X_J = (x_{j1}, x_{j2}, x_{j3}, \dots, x_{jD}) \quad 1$$

Similarly, the velocity of this particle is also a D-dimensional vector given as

$$V_J = (v_{j1}, v_{j2}, v_{j3}, \dots, v_{jD}) \quad 2$$

Each particle’s position is passed to fitness function and is evaluated. Based on the result provided by fitness function, global best is assigned. Velocities and positions of each particle would be updated according to the particle’s local best position and the global best.

IV. Implementation of Standard PSO

Matlab® is used as a tool for implementing standard particle swarm optimization. This function has four input arguments: Number of Particles, "ps"=30; Dimensions, "D" = 2 & 30; Function name and Maximum number of function evaluations, "FE=5000*D". This function has two output arguments: "Gbest_position" and "Gbest_value".

The script is evaluated on four well known benchmark functions: Sphere, Ackley, Rastrigin and Rosenbrock. Position and velocity of each particle in a swarm has been randomly initialized resulting in D-dimensional position and velocity vectors. As given by equations 1 and 2. initially each particle's position is the local best position.

For each particle, fitness function is called and evaluated based on particle's current position. If the fitness value is better than the best fitness value of the particle's local best, current value is set to new local best. Global best is updated based on the best fitness function value found by any neighbor of the particle.

Velocity of a particle is updated based on following expression:

$$v_j^i = \left(w * v_j^{i-1}\right) + c_1 * r_1 * \left(p_{best_j}^{\,i-1} - x_j^{i-1}\right) + c_2 * r_2 * \left(g_{best_j}^{\,i-1} - x_j^{i-1}\right) \quad 3$$

w is the inertial weight which controls the momentum of the particle. is the velocity of j[th] particle in i[th] iteration. c_1 and c_2 are cognitive and social acceleration constants. r_1 and r_2 are separately generated uniformly distributed random numbers between 0 and 1. $p_{best_j}^{\,i-1}$ is the particle's local best position and $g_{best_j}^{\,i-1}$ is the global best of a particle within the swarm. New position of particle was updated using the new velocity vector using the following equation:

$$x_j^i = x_j^{i-1} + v_j^i \quad 4$$

In the above expression, x_j^i is the position of j[th] particle in i[th] iteration. As stated above, maximum function evaluations are provided which is used as the stopping criterion for evaluation of fitness function.

V. Parameters of Standard PSO

In order to observe convergence behavior of the standard PSO, inertial weight is a very important parameter. Inertial weight controls the impact of the previous velocity on the current update. Inertial weight is a trade-off between the global and the local abilities of the swarm. If the inertial weight has large value, it will result in facilitating global exploration, i.e. it will help in searching new areas. Similarly, if the inertial weight has small value, it will result in facilitating local exploration, i.e. it will help in fine-tuning the current search area. Initially, in the standard PSO, the value of inertial weight was kept constant but later experimental results showed that it is better to initially start with larger value of and gradually reduce it to lower value.

c_1 and c_2 are acceleration constants and are used to pull each particle towards the local best or the global best position, respectively. If the values of C_1 and C_2 are low, it will result in particles roaming far from the target. Similarly, high values will result in abrupt movement of particles towards or away from the target. According to the past experiments, the acceleration constants are often selected such that they will satisfy $c_1+c_2 \leq 4$. If this constraint is not satisfied, then PSO does not usually converge [Eberhart 2000].

r_1 and r_2 are uniformly distributed random numbers in the range and are used to maintain the diversity of the population.

VI. Modified PSO

The approach used in this paper to modify the standard PSO is to adjust the velocity of particles so that it does not get out of bounds of the function. Along with this the weightage also decreases linearly. The velocity penalizing algorithm has also been used so that after velocity clamping, if the new position of the particle is outside the search space, the particle is penalized and its velocity is given a value of 0. Another feature of this algorithm is that it tries to avoid stagnation to some extent and thus keeps searching for a better global best position until the stopping criterion is met.

The weightage is linearly decreased from one iteration to the next one. Two different parameters are being defined which are w_{max} and w_{min}. The following relation is used for weightage control:

$$w = w_{max} - \left(\frac{w_{max} - w_{min}}{FE}\right) * i \quad 5$$

In the above relation, is the current function evaluation. The value of and has been optimized to achieve the best results. Constriction factor has also been introduced in this paper as a modification made by [2]. The constriction factor is calculated as follows.

$$chi = \frac{2}{phi - 2 + \sqrt{phi^2 - 4 * phi}} \quad 6$$

Where This constriction factor is used to modify weightage factor. Following control is incorporated in the weightage factor.

$$w = chi * \left(0.0005 + w * \left(\frac{FE - (i - 30)}{FE}\right)\right) \quad 7$$

FE is the maximum number of functional evaluations which in our case is the termination criteria. The value of phi as originally used by the author in [2] was equal to the sum of two acceleration constants c1 and c2 and should be greater than 4. Here we have preset the value of phi as constant and equal to 4.1.

Velocity clamping has been achieved in a loop which

checks every element of the velocity vector to be inside the search space. This loop also penalizes the particle as described above. Here, two more parameters, i.e. V_{max} and $V_{min,}$ have also been defined. These parameters are obtained as below:

$$V_{max} = lemda * (Max_{SS} - Min_{SS}) \quad 8$$

$$V_{min} = lemda * (Min_{SS} - Max_{SS}) \quad 9$$

In these relations, Max_{SS} and Min_{SS} are the maximum and minimum limits of the search space and have unique values for every function.

$$\begin{cases} V_{i,D} > Vmax \ \ then \ V_{i,D} = Vmax \\ V_{i,D} < Vmin \ \ then \ \ V_{i,D} = \ Vmin \end{cases}$$

Where $V_{i,D}$ is the velocity of i^{th} particle in the D^{th} dimension. The penalizing algorithm works as follows:

$$\begin{cases} V_{i,D} + P_{i,D} > Max_{SS} \ \ then \ V_{i,D} = 0 \\ V_{i,D} + \ P_{i,D} < Min_{SS} \ \ then \ \ V_{i,D} = \ 0 \end{cases}$$

In the above expression $P_{i,D}$ is the position of the i^{th} particle in the D^{th} dimension. After penalizing, update the particle position using the standard PSO position update expression given by equation 4.

After updating the particle position, it is again checked to see if the $P_{i,D}$ is outside the search space limits, otherwise $P_{i,D}$ is set to where $G_{j,D}$ is the global best position during the j^{th} iteration in the D^{th} dimension. Following relation is used for this purpose:

$$\begin{cases} P_{i,D} > Max_{SS} \ \ then \ P_{i,D} = G_{j,D} \\ P_{i,D} < Min_{SS} \ \ then \ \ P_{i,D} = G_{j,D} \end{cases}$$

Another modification was made to the modified PSO, which checks the stagnation. The loop performs the stagnation check for constant value for some iterations and then randomizes the velocity. Hence if the particles fall inside a local minimum it simply gives them a push to get out of there and find a better optimum point. In this way the algorithm searches throughout the time and ends when the termination criterion is met.

VII. Benchmark Functions:

Benchmark functions are widely accepted as problems for testing algorithms. They vary from simple uni-modal functions like Sphere to very complex multimodal problems e.g. Rastrigin. For the sake of this study, four well known benchmark functions were used to test the standard PSO as well as the modified PSO. These functions include

- Sphere
- Ackley
- Rastrigin
- Rosenbrock

These functions are generalized for any number of dimensions. This paper presents the behavior of the standard and modified PSO algorithm on 2 and 30 dimensional versions of these functions. The complexity of functions increases with the number of dimensions.

Table 1: Benchmark Functions

Function	Equation $f(x_i)$	Range
Sphere	$\sum_{i=1}^{D} x_i^2$	[-100,100]
Ackley	$-20\exp\left(-0.02\sqrt{n^{-1}\sum_{i=1}^{D} x_i^2}\right) - \exp\left(n^{-1}\sum_{i=1}^{D} cos(\pi x_i)\right) + 20 + \exp(1)$	[-32,32]
Rastrigin	$10n + \sum_{i=1}^{D}[x_i^2 - 10\cos(2\pi x_i)]$	[-5.12,5.12]
Rosenbrock	$\sum_{i=1}^{D-1}[\,(100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2]$	[-10,10]

VIII. Simulation Setup:

For the purpose of simulation, the following initial conditions were imposed:

Table 2: Initial Conditions

Parameter	Value
No. of Particles (PS)	30
Dimensions (D)	2 and 30
Termination Criterion	Maximum Function Evaluations = 5000*D

Results

This section discusses the results obtained by simulating the standard and the modified PSO. First the results of standard PSO are presented and later the results of modified PSO are included.

PSO with Constant Weightage Factor and No Velocity Control

Initially, the simulation of standard PSO was performed on four well known benchmark functions with a constant weightage factor and uncontrolled velocity algorithm.

Table 3 Standard PSO, constant w and without velocity clamp

Function	2 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	2.87E-11	5.31E-11	2.87E+00
Sphere	1.34E-21	3.44E-21	2.63E+00
Rosenbrock	2.04E-07	3.67E-07	2.71E+00
Rastrigin	0	0	2.71702

Table 3 shows the descriptive statistics of the standard PSO when D=2. Table 4 shows the descriptive statistics of the standard PSO when D=30.

Table 4 Standard PSO, constant w and without velocity clamp,

Function	30 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	3.43E-12	8.55E-12	43.816646
Sphere	4.39E-24	1.00E-23	38.634477
Rosenbrock	91.2226	174.236	41.436479
Rastrigin	34.923	10.6382	42.581176

PSO with linearly decreasing inertial weight and no velocity control

These simulation results were obtained after inertial weight is linearly decreased according to the information available in the literature. The slight improvement in inertial weight is made in the standard PSO. Table 5 represents the results of standard PSO with decreasing inertial weight when D=2. A linearly decreasing inertial weight means that particles will initially be involved in global search and with time will start to focus on a local area containing the optimum point.

Table 5 Standard PSO, linearly decreasing w and without velocity clamp, D=2

Function	2 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	0	0	2.99E+00
Sphere	9.83E-75	2.22E-74	2.83E+00
Rosenbrock	2.90E-09	4.68E-09	2.84E+00
Rastrigin	0	0	2.83E+00

It can be seen from Table 4 and Table 5 that the results of Sphere and Ackley have improved but all the other benchmark functions got worse by just decreasing the inertial weight linearly. The reason is that the particles get stuck in the local minima.

Table 6 represents the results of standard PSO with linearly decreasing inertial weight when D=30.

Table 6 Standard PSO, linearly decreasing w and without velocity clamp, D=30

Function	30 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	1.04E-14	3.37E-15	45.456836
Sphere	9.15E-48	1.87e-47	40.73665
Rosenbrock	312.1166	504.8463	43.505973
Rastrigin	56.9115	15.4195	44.612146

Modified PSO with inertial weight control and velocity clamping

Standard PSO is modified in such a way that if the particle velocity in the D^{th} dimension is greater than the maximum set velocity, then particles' velocity in D^{th} dimension is set to the maximum set velocity. Similarly, if the velocity is less than the minimum set velocity, then it is set to the minimum set velocity. This clamping will limit the particle within the search space.

After modifying the velocity of the particle in the D^{th} dimension, it is checked that if sum of particles position in the D^{th} dimension and particles velocity in the D^{th} dimension exceeds the search space limits, then particle is penalized and its velocity in the D^{th} dimension is set to 0.

After all the modifications, particle's new position is calculated and it is checked if its position in the D^{th} dimension still lies outside the search space; then particle's position in the D^{th} dimension is set to global best position.

Table 7 shows the results obtained with modified PSO. It can be seen that there is a slight increase in simulation time, but results obtained are better as compared with the previous two experiments.

Table 7 Modified PSO, with Inertial Control, Velocity Clamping and Penalizing, D=2

Function Name	2 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	0	0	5.07E+00
Sphere	5.56E-82	1.69E-81	3.30E+00
Rosenbrock	4.40E-08	1.27E-0.7	3.10E+00
Rastrigin	0	0	3.21E+00

Table 8 Modified PSO, with Inertial Control, Velocity Clamping and Penalizing, D=30

Function Name	30 Dimensions		
	Mean	Standard Deviation	Time for 10 replications (seconds)
Ackley	1.07E-14	3.35E-15	62.760532
Sphere	1.15E-51	3.37E-51	53.483193
Rosenbrock	19.6859	26.0738	54.126309
Rastrigin	48.3549	18.5024	56.318203

Table 8 represents the results of modified PSO when D=30.

It is obvious from the above tables that results are very improved in modified PSO. There is a slight compromise between the simulation time and the accuracy. Figure 1 shows the result of 2 dimensional Ackley function. It can be seen that convergence is very rapid

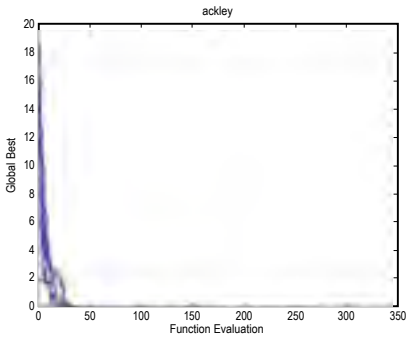

Figure 1: Ackley in 2D with modified PSO

Figure 2 represents the result of Ackley function when D is set to 30 and modified PSO is used. It is clear from this figure that convergence is achieved within specified function evaluations i.e. within 500D to 700D.

Figure 3 and Figure 4 represent the results of 10 replications for Sphere function with modified PSO when the Dimension is set to 2 and 30 respectively.

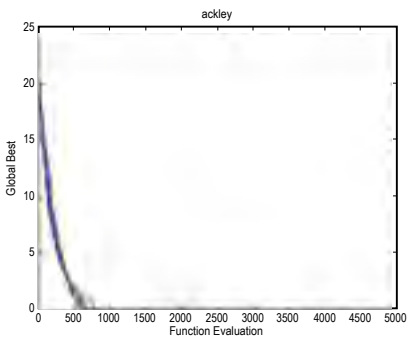

Figure 2: Ackley in 30D with modified PSO

The Sphere function shows the best results. It converges very rapidly in both 2 Dimension and 30 Dimension.

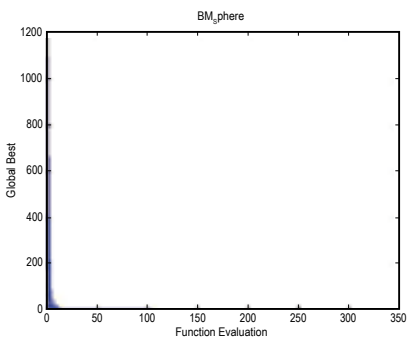

Figure 3: Sphere in 2D with modified PSO

When simulated with standards PSO, the convergence is achieved after 1000D function evaluations while with modified PSO, convergence is obtained within 500*D.

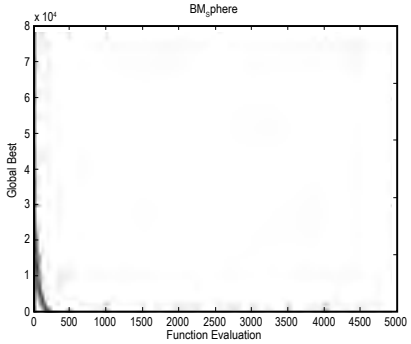

Figure 4: Sphere in 30D with modified PSO

Figure 5 shows results of Rastrigin function when modified PSO is used. When Dimension is set to 2, Rastrigin converges to 0 after only 50 evaluations in 90% of the cases.

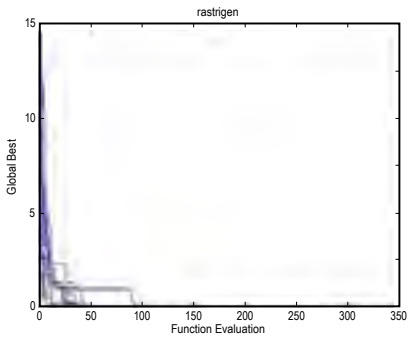

Figure 5: Rastrigin in 2D with modified PSO

Figure 6 shows the results of 30 dimensional Rastrigin function when modified PSO is used. There is slight improvement in Rastrigin function with modified PSO but convergence is more or less same for both the algorithms.

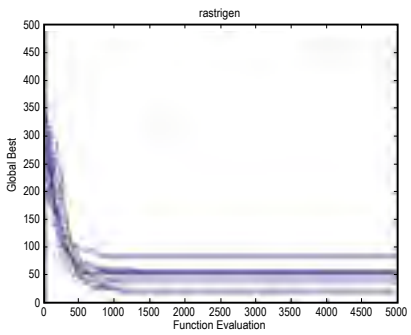

Figure 6: Rastrigin in 30D with modified PSO

Figure 7 gives the result of 2 dimensional Rosenbrock function when modified PSO is used. Rosenbrock converges very rapidly but stagnates near.

Figure 8 shows the result of 30 dimensional Rosenbrock function. Convergence is very rapid as compared to the standard PSO.

In standard PSO, Rosenbrock converges to global best between function evaluations but for modified PSO, it converges very rapidly to a better result as shown below.

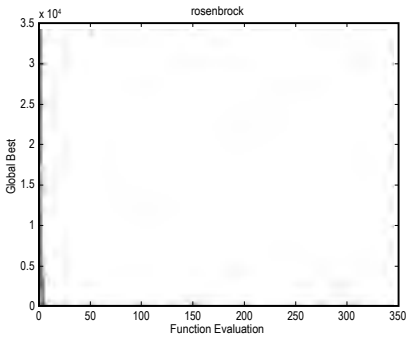

Figure 7: Rosenbrock in 2D with modified PSO

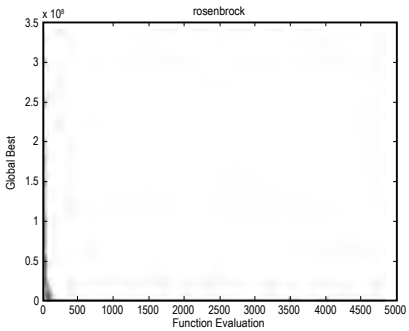

Figure 8: Rosenbrock in 30D with modified PSO

9. Conclusion:

When Standard PSO is implemented with constant inertial weight but without clamping the velocity, results were better than the linearly decreasing inertial weight. Standard PSO is modified in such a way to make a compromise between all the benchmark functions in order to obtain optimum results. From these results, it can be concluded that with the modified PSO, there is a little trade-off between simulation times and accuracy. After comparing the standard PSO with the modified PSO, it is clear that the modified PSO is better than the standard PSO in terms of convergence and in terms of better results.

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وَوَصَّيْنَا الْإِنسَانَ بِوَالِدَيْهِ حُسْنًا ۖ وَإِن جَاهَدَاكَ لِتُشْرِكَ بِي مَا لَيْسَ لَكَ بِهِ عِلْمٌ فَلَا تُطِعْهُمَا ۚ إِلَيَّ مَرْجِعُكُمْ فَأُنَبِّئُكُم بِمَا كُنتُمْ تَعْمَلُونَ (٨) العنكبوت

We have enjoined upon man kindness to his parents, but if they exert pressure on you to associate with Me in My Divinity any that you do not know (to be My associate), do not obey them. To Me is your return, and I shall let you know all that you have done.

Securing Critical Infrastructure:
Industrial Control Systems – Risks and Mitigation:

by
Mian Abdul Hamid

Abstract

Industrial Control Systems (ICS) are typically used in industries such as electric, water & wastewater, oil & gas, chemical, transportation, pharmaceutical, pulp & paper, food & beverage, and discrete manufacturing (e.g., automotive, aerospace, and durable goods.) These control systems are critical to the operation of infrastructures that are often highly interconnected and mutually dependent systems. The operational and risk differences between ICS and IT systems create the need for increased sophistication in applying cyber security and operational strategies to ICS . While security solutions have been designed to deal with security issues in typical IT systems, special precautions must be taken when introducing these same solutions to ICS environments. In some cases, new security solutions are needed that are tailored to the ICS environment alone. Major problem is; most security people do not understand the ICS and security language is Chinese to control engineers. This paper will explain the components of ICS (specially SCADA) and highlight the points for ICS specific Risks and countermeasures. This paper will be equally useful for both, security experts and control engineers.

1. Introduction:

Information or Cyber Security is no more a technical issue but it is a business issue now. Of course businesses operate to make money, not just to be secure, but most businesses depend now upon information and communication technologies. Lack of security measures may cause; the loss of reputation and customer base after a database of credit card numbers is compromised, loss of thousands of dollars in operational expenses from a new computer worm, loss of proprietary information as a result of successful company espionage attempt, loss of confidential information from a successful social engineering attack but the most devastating is the loss of human life, critical infrastructure and national security, which would be the result of compromised critical systems in which Industrial Control Systems are top of the list.

Industrial Control Systems (ICS) are typically used in industries such as electric utilities, water & wastewater, oil & gas, chemical, transportation, pharmaceutical, pulp &paper, food & beverage, and discrete manufacturing (e.g., automotive, aerospace, and durable goods.) These control systems are critical to the operation of infrastructures that are often highly interconnected and mutually dependent systems

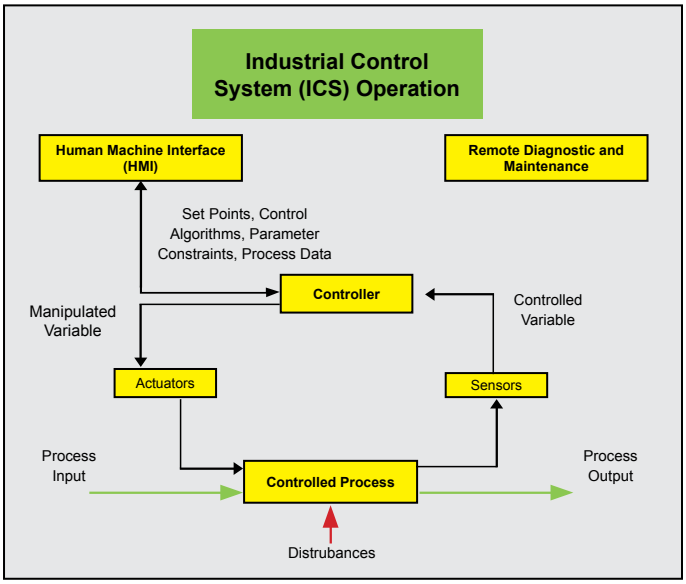
Business initiatives demand real-time information from Industrial Control Systems which drive more interconnections between control systems, corporate IT networks, Internet and extranets (third party connections) continuously. Interconnection delivers important business benefits, but without appropriate security measures, it can compromise control system availability and cause service disruptions, blowup, even destruction. Although some characteristics are similar, ICS also have characteristics that differ from traditional information processing systems. Many of these differences stem from the fact that logic executing in ICS has a direct effect on the physical world. Some of these characteristics include significant risk to the health and safety of human lives, serious damage to equipment and environment, serious financial issues such as production losses, negative impact to a nation's economy, and compromise of proprietary information. Here, we will highlight the security issues pertaining specifically to Industrial Control Systems (ICS).

Since the advent of microprocessors, ICS were isolated systems, with proprietary hardware and software. Initially, ICS had little resemblance to traditional information technology (IT) systems. Now, Microsoft Windows based Operating Systems and widely available, low-cost Internet Protocol (IP) based communication devices have replaced proprietary solutions which increases the possibility of cyber security vulnerabilities and incidents. As ICS are adopting IT solutions to promote corporate business systems connectivity and remote access capabilities, and are being designed and implemented using industry standard computers, operating systems (OS) and network protocols, they are starting to resemble IT systems. This integration supports new IT capabilities, but it reduces isolation of ICS from the outside world, creating a greater need to secure these systems.

While security solutions are being designed to deal with typical IT systems, special precautions must be taken when introducing these same solutions to ICS environment. In some cases, new security solutions are needed that are tailored to the ICS environment specifically.

Originally, ICS implementations were susceptible primarily to local threats because many of their components were in physically insecure areas and the components were not connected to IT networks or systems. However, the trend toward integrating ICS systems with IT networks provides significantly less isolation for ICS from the outside world, creating a greater need to secure these systems from remote, external threats. Also, the increasing use of wireless networking exposes ICS implementations to greater risk from adversaries who are in relatively close physical proximity but do not have direct physical access to the equipment.

Threats to control systems can come from numerous sources, including hostile governments, terrorist groups, disgruntled employees, malicious intruders, complexities, accidents, natural disasters as well as malicious or acci-



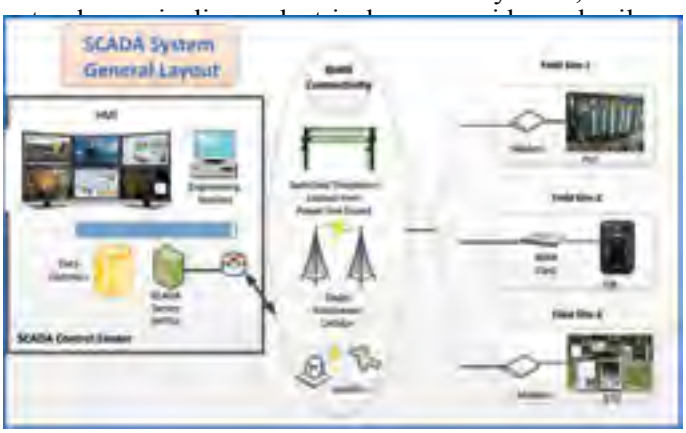
dental actions by insiders. ICS security objectives typically follow the priority of availability, integrity and confidentiality. To understand the security issues of ICS, it is prudent to at the typical components and their working.

2. Industrial Control Systems:

Industrial control system (ICS) is a general term that encompasses several types of control systems, including supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other control system configurations such as skid-mounted Programmable Logic Controllers (PLC) often found in the industrial sectors and critical infrastructures. Actual implementations of ICS may be hybrids that blur the line between DCS and SCADA systems.

2.1 SCADA Systems:

SCADA systems are highly distributed systems used to control geographically dispersed assets, often scattered over thousands of square kilometers, where centralized data acquisition and control are critical to system operation. They are used in distribution systems such as water distribution and wastewater collection systems, oil and



2.2 Distributed Control Systems (DCS):

DCS are used to control industrial processes such as electric power generation, oil refineries, water and wastewater treatment, and chemical, food, and automotive production. DCS are integrated as a control architecture containing a supervisory level of control overseeing multiple, integrated sub-systems that are responsible for controlling the details of a localized process. Product and process control are usually achieved by deploying feedback or feed forward control loops whereby key product and/or process conditions are automatically maintained around a desired set point. To accomplish the desired product and/or process tolerance around a specified set point, specific Controllers are employed in the field and proportional, integral, and/or derivative settings on the Controllers are tuned to provide the desired tolerance as well as the rate of self-correction during process upsets. DCS are used extensively in process industries.

2.3 Programmable Logic Controls (PLCs):

PLCs are microprocessor based devices that control industrial equipment and processes. While PLCs are control system components used throughout SCADA and DCS systems, they are often the primary components in smaller control system configurations used to provide operational control of discrete processes such as automobile assembly lines and power plant auxiliaries e.g. emergency shutdown systems etc. PLCs are used extensively in almost all industrial processes.

3. Key ICS Components

Following are the key ICS components that are used in control and networking. Some of these components can be described generically for use in SCADA systems, DCS and PLCs, while others are unique to one.

3.1 Control Components:

Major control components of an ICS are listed and described in this section:

The current control systems are based on microprocessors and support chips that allow fast processing of data and communication over the networks for integrated monitor-

ing and control of process plants.

3.1.1 Controller

The heart of the modern day control system is a microprocessor based controller responsible for executing mission-critical applications for process control. In a typical controller, the process applications may include the following functions:

- Data acquisition
- Boolean logic
- Continuous (PID) control
- Logic and timing functions
- Process point database storage
- Process point sensor/limit checking
- Process point alarm processing
- I/O interface
- Communications interface

3.1.2 Standard Controller Functions

a. Control Execution

The Controller is capable of simultaneously executing multiple process control tasks each running at a predefined speed. Each control task is comprised of I/O process point input scan, the control scheme execution followed by an output scan. Individual processes are user-assigned to one of these tasks, allowing control execution loop times to be appropriate for the functions being controlled.

b. Control Scheme

A typical control scheme executed by the Controller may be defined by control modules using an extensive set of standard algorithms developed specifically for the process. The control modules, also referred to as control sheets, provide the basis for execution, documentation, and automatic creation of control tuning diagrams that assist users during the commissioning and optimization of the control scheme. The controller can execute hundreds of control sheets but are limited by the processing power of the processors.

c. Sequence of Events

Sequence of Events (SOE) monitoring is an essential part of any controller to determine the cause of the process failure. Currently, the SOE recording is an Integral capability of the controller which is achieved by the specialty digital input module and the controller software. The SOE subsystem records the sequence in which a user-defined set of digital input conditions occurred. The usual resolution of the SOE is one millisecond, In addition to the higher resolution time tag, the SOE points are usable in control schemes like any other digital input including limit checking and alarming.

d. Alarm Processing

Based on each process point database definition, the Controller performs all of the limit and alarm processing functions typically associated with a data acquisition during the input scan associated with the control execution. The status (including alarm status) of all points in the controller are updated and broadcast to the HMI or to the workstations on the Network.

Extensive information is included within the status information broadcast. For example, the status may indicate that a point has either:

- Exceeded the range of the sensor
- Exceeded the user-defined limits
- Changed state
- Crossed an incremental limit

The Controller may include the capability to report multiple independent alarm thresholds, defined as:

- High limits
- Low limits
- Incremental limits

The HMI has the capability to sort alarms based on a user-selected alarm significance level.

e. Operator Interface Processing

The Controller performs the entire limit and alarm processing based on the database configuration of each point. The HMI has the capability that allows these functions to be suspended as necessary by the process state or operator action which is also logged. These functions include removal of point from scan, alarm cutout, enter valve, alarm and limit checking suspension

3.1.3 Control Server:

The control server hosts the DCS or PLC supervisory control software that communicates with lower-level control devices. The control server accesses subordinate controllers over an ICS network.

3.1.4 SCADA Server or Master Terminal Unit (MTU):

The SCADA Server is the device that acts as the master in a SCADA system. Remote Terminal Units(RTU) and PLC devices located at remote field sites usually act as slaves.

3.1.5 Remote Terminal Unit (RTU):

The RTU, also called a remote telemetry unit, is a special purpose data acquisition and control unit designed to support SCADA remote stations. RTUs are field devices often equipped with wireless radio interfaces to support remote situations where wire-based communications are unavailable. Sometimes PLCs are implemented as field devices to serve as RTUs; in this case, the PLC is often referred to as an RTU.

3.1.6 Programmable Logic Controller (PLC):

The PLC is a small industrial computer originally designed to perform the logic functions executed by electrical hardware (relays, switches, and mechanical timer/counters). PLCs have evolved into controllers with the capability of controlling complex processes, and they are used substantially in SCADA systems and DCS. Other controllers used at the field level are process controllers and RTUs; they provide the same control as PLCs but are designed for spe-

cific control applications. In SCADA environments, PLCs are often used as field devices because they are more economical, versatile, flexible, and configurable than special-purpose RTUs.

3.1.7 Intelligent Electronic Devices (IED):

An IED is a "smart" sensor/actuator containing the intelligence required to acquire data, communicate to other devices, and perform local processing and control. An IED could combine an analog input sensor, analog output, low-level control capabilities, a communication system, and program memory in one device. The use of IEDs in SCADA and DCS systems allows for automatic control at the local level.

3.1.8 Human-Machine Interface (HMI):

The HMI is software and hardware that allows human operators to monitor the state of a process under control, modify control settings to change the control objective, and manually override automatic control operations in the event of an emergency. The HMI also allows a control engineer or operator to configure set points or control algorithms and parameters in the controller. The HMI also displays process status information, historical information, reports, and other information to operators, administrators, managers, business partners, and other authorized users. The location, platform, and interface may vary a great deal. For example, an HMI could be a dedicated platform in the control center, a laptop on a wireless LAN, or a browser on any system connected to the Internet.

3.1.9 Data Historian:

The data historian is a centralized database for logging all process information within an ICS. Information stored in this database can be accessed to support various analyses, from statistical process control to enterprise level planning.

3.1.10 Input/output (IO) Server:

The IO server is a control component responsible for collecting, buffering and providing access to process information from control sub-components such as PLCs, RTUs and IEDs. An IO server can reside on the control server or on a separate computer platform. IO servers are also used for interfacing third-party control components, such as an HMI and a control server.

3.2 Network Components

There are different network characteristics for each layer within a control system hierarchy. Network topologies across different ICS implementations vary with modern systems using Internet-based IT and enterprise integration strategies. Control networks have merged with corporate networks to allow control engineers to monitor and control systems from outside of the control system network. The connection may also allow enterprise-level decision-makers to obtain access to process data. The following is a list of the major components of an ICS network, regardless of the network topologies in use:

3.2.1 Fieldbus Network:

The fieldbus network links smart sensors and actuators and other devices to a PLC or other controller. Use of fieldbus technologies eliminates the need for point-to-point wiring between the controller and each device. The devices communicate with the fieldbus controller using a variety of protocols. The messages sent between the sensors and the controller uniquely identify each of the sensors.

3.2.2 Control Network:

The control network connects the supervisory control level to Controllers, RTU's PLCs etc.

3.2.3 Communications Routers:

A router is a communications device that transfers messages between two networks. Common uses for routers include connecting a LAN to a WAN, and connecting MTUs and RTUs to a long-distance network medium for SCADA communication.

3.2.4 Firewall:

A firewall protects devices on a network by monitoring and controlling communication packets using predefined filtering policies. Firewalls are also useful in managing ICS network segregation strategies.

3.2.5 Modem:

A modem is a device used to convert between serial digital data and a signal suitable for transmission over a telephone line to allow devices to communicate. Modems are often used in SCADA systems to enable long-distance serial communications between MTUs and remote field devices. They are also used in SCADA systems, DCS and PLCs for gaining remote access for operational and maintenance functions such as entering commands or modifying parameters, and diagnostic purposes.

3.2.6 Remote Access Points:

Remote access points are distinct devices, areas and locations of a control network for remotely troubleshooting, configuring control systems and accessing process data. Examples include using a personal digital assistant (PDA) to access data over a LAN through a wireless access point, and using a laptop and modem connection to remotely access an ICS system.

4. Risks Pertaining to ICS:

An ICS may face the following incidents in case of any threat agent exploits a vulnerability related to a control and/or network component of ICS .

- Blocked or delayed flow of information through ICS networks, which could disrupt ICS operation
- Unauthorized changes to instructions, commands, or alarm thresholds, which could damage, disable, or shut down equipment, create environmental impacts, and/or endanger human life

- Inaccurate information sent to system operators, either to disguise unauthorized changes, or to cause the operators to initiate inappropriate actions, which could have various negative effects
- ICS software or configuration settings modified, or ICS software infected with malware, which could have various negative effects
- Interference with the operation of safety systems, which could endanger human life.

5. Incidents Examples:

5.1 Siberian Pipeline Explosion:

This is the first known cyber-security incident involving critical infrastructure. In 1982, intruders planted a Trojan in the SCADA system that controls the Siberian Pipeline. This caused an explosion equivalent to 3 Kiloton of TNT.

5.2 Bellingham, WA Gas Pipeline

In June 1999, 237,000 gallons of gasoline leaked from a 16" pipeline into a creek that flowed through Whatcom Falls Park in Bellingham, Washington. About 1 ½ hours after the rupture , the gasoline ignited and burned approximately 1 ½ miles along the creek causing 3 deaths and 8 documented injuries. The pipeline failure was exacerbated by control systems not able to perform control and monitoring function. While not technically an attack, the loss of human life in this incident illustrates the dangers of nay type of failure in a critical infrastructure system.

5.3 Chevron Emergency Alert System:

A fired employee of Chevron's emergency alert network disabled the firm's alert system by hacking into computers in New York and San Jose, California, and reconfigured them so they would crash. The vandalism was not discovered until an emergency arose at the Chevron Refinery in Richmond, California and the system could not be used to notify the adjacent community of the release of a noxious substance. During the ten-hour period in 1992 when the system was down, thousands of people in twenty-two states and six unspecified areas of Canada were put at risk.

5.4 CSX Corporation:

In 2003 a virus named SOBIG was reported to have shut down train signaling System in Florida, US. It shut down the signaling , dispatching and other systems at SCS Corporation; on of the largest transportation suppliers in the US. While there were not major incidents caused by this case trains were delayed.

5.5 Stuxnet (2010)

In June 2010, it was discovered that a worm dubbed Stuxnet had struck the Iranian nuclear facility at Natanz. Stuxnet used four "Zero-day-vulnerabilities" (vulnerabilities previously unkown,so there has been no time to develop and distribute patches). The work employes Siemen's default password to access Windows operating system that run WinCC and PCS7 program. The Farora Paya in Iran and Vacon in Finland. Therse drives were used isotope. Stuxnet altered the frequency of the electrical current to the drives causing them to switch between high and low speeds for which they were not designed. This switching caused the centrifuges to fail at a higher than normal rate.

6. Potential consequences of an ICS incident

Following list shows the potential consequences of an ICS incident. This is not an independent list. In fact, one incident can lead to another. For example, release of hazardous material can lead to injury or death.

- Impact on national security—facilitate an act of terrorism
- Reduction or loss of production at one site or multiple sites simultaneously
- Injury or death of employees
- Injury or death of persons in the community
- Damage to equipment
- Release, diversion, or theft of hazardous materials
- Environmental damage
- Violation of regulatory requirements
- Product contamination
- Criminal or civil legal liabilities
- Loss of proprietary or confidential information
- Loss of brand image or customer confidence.

Undesirable incidents of any sort detract from the value of an organization, but safety and security incidents can have longer-term negative impacts than other types of incidents on all stakeholders—employees, shareholders, customers,

and the communities in which an organization operates.

7. How to secure the ICS:

This section will provide the main areas which needs to considered when making an ICS security program:

7.1 Governance:

The most important part to secure any ICS system is the Governance which includes policies, procedures, standards adaptation and implementation , Risk Assessment, risk management , monitoring, auditing and management decisions.

7.2 Access Controls:

The ICS should use a network topology that has multiple layers, with the most critical communications occurring in the most secure and reliable layer. All kind of network traffic and access should be prevented and/or controlled passing directly between the corporate/Internet/Extranet and ICS networks. A separate authentication mechanisms and credentials should be used for users of the corporate/external and ICS networks.

7.3 Physical access control and security of ICS network and components:

Unauthorized physical access to components could cause serious disruption of the ICS's functionality. A combination of physical access controls should be used, such as , data center, specialized racks, locks, card readers, biometrics and/or guards.

7.4 Protecting individual ICS components from exploitation:

This includes deploying operating system security patches in as expeditious manner as possible, after testing them under simulated conditions; disabling all unused ports, peripheral and services; restricting ICS user privileges to only those that are required for each person's role; tracking and monitoring audit trails; and using security controls such as antimalware software and file integrity checking software where technically feasible to prevent, deter, detect, and mitigate malware.

7.5 Business Continuity and Disaster Recovery Planning:

This involves designing the ICS so that each critical component has a redundant counterpart. Additionally, if a component fails, it should fail in a manner that does not generate unnecessary traffic(traffic storm) on the ICS or other networks, or does not cause another problem elsewhere, such as a cascading event. A verified and tested plan should be in pace in case of any disaster.

7.6 Incident Management:

Incidents are inevitable and an incident response plan is essential. A major characteristic of a good security program is how quickly a system can be restored after an incident has occurred.

7.7 Social Engineering:

Unnecessary information about the system should not be disclosed through any mean including, RFPs, public websites, social media, and projects.

8. ICS Security Program Guideline:

Due to the criticality and sensitivity of ICS systems, organizations must adapt a Defense-in-depth strategy. This means that organization has to analyze the risk at each level of ICS architecture and put a control for each gap identified for respective layer. A security program based upon Defense-in-Depth strategy can be developed by using below given guidelines:

8.1 Strategic Planning Guideline:

- Developing and applying security policies and procedures specifically to the ICS.
- Adaptation and implementation of security standards for ICS
- Developing training program, providing educational and awareness material and workshops.
- Addressing security throughout the lifecycle of the ICS from architecture design to procurement to installation to maintenance to decommissioning.
- Conduct risk analysis and use the result in making strategy, acquiring and maintaining countermeasures.
- Research and continuously monitor the laws and regulations pertaining to ICS security which needs to be complied by your organization.
- Implementing a network topology for the ICS that has multiple layers, with the most critical communications occurring in the most secure and reliable layer.

8.2 Tactical Planning Guideline:

- Prepare procedure, acquire expertise and tools for vulnerability and threat management.
- A strong internal audit procedure should be in place and practice.
- Develop special procedure for scrutinizing the staff as well as secure hiring and firing practices.
- Ensuring that critical components are redundant and are on redundant networks.
- Designing critical systems for graceful degradation (fault tolerant) to prevent catastrophic cascading events.
- Develop and test a Business Continuity and Disaster Recovery Plan.

8.3 Operational Planning Guideline:

- Considering ICS security policies and procedures based on the Threat Level provided by security advisory bodies, deploying increasingly heightened security postures as the Threat Level increases.
- Providing logical separation between the corporate/external and ICS networks
- Employing a DMZ network architecture (i.e., prevent direct traffic between the corporate/external

and ICS networks).

- Disabling unused ports and services on ICS devices after testing to assure this will not impact ICS operation.
- Restricting physical access to the ICS network and devices.
- Restricting ICS user privileges to only those that are required to perform each person's job (i.e., establishing role-based access control and configuring each role based on the principle of least privilege).
- Considering the use of separate authentication mechanisms and credentials for users of the ICS network and the corporate network (i.e., ICS network accounts do not use corporate network user accounts).
- Using modern technology, such as smart cards for Personal Identity Verification (PIV).
- Implementing security controls such as intrusion detection systems, antimalware software and file integrity checking software, where technically feasible.
- Applying security techniques such as encryption and/or cryptographic hashes to ICS data storage and communications where determined appropriate.
- Expeditiously deploying security patches after testing all patches under field conditions on a test system if possible, before installation on the ICS.
- Tracking and monitoring audit trails on critical areas of the ICS.
- Physical access to all components must be controlled by using purpose built data center, specialized racks, locks, card readers, biometrics and/or guards etc.

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Temperature Rise Test for Prefabricated Substations

by

Muhammad Hanif

Abstract

This paper discusses temperature rise test on prefabricated substations according to IEC 62271-202 standard. This standard is successor of IEC 61330 Edition 1, published in 1995. It establishes operating conditions, nominal values, general design requirements, measurement methods and temperature rise test methods for prefabricated substations with rated voltage above 1 kV to 52 kV at 50 to 60 Hz. The main purpose of the standard is to increase the general safety level. This can be achieved when the substation fulfils the specified characteristics and ratings which are proven by type test and routine test. The paper also discusses temperature rise test conditions, test method and temperature rise limits.

INTRODUCTION

The prefabricated substations as well as other equipment with the respective protection and measurement devices are usually used for transformation of power form primary distribution system to domestic, commercial and industrial consumers or for power transmission from photovoltaic, wind, biogas or other type of power plants to the network.

The initial properties of an insulation are frequently more than adequate but effects of thermal aging and environment may degrade the insulation rapidly to the point of failure. Electrical insulation degradation processes are usually accelerated by increased temperature. Under the influence of heat and other agents such as oxygen and moisture, insulating materials undergo chemical alterations with time. Thermal, mechanical, electrical and physical properties of the insulation are deteriorated so resulting in aging and reduced life time of the insulating materials. Arrhenius, Montsinger, Fabre, Transformer Working Group of CIGRE and other researchers have done valuable work on laws of aging of insulating materials.

For most of the organic materials as well as parts and equipment it follows that by increasing the temperature by about 6 degree Kelvin, the life time is reduced by a half. This statement does not apply exactly to all materials and systems; it can be used informatively only. On this basis, relationships are conducted through accelerated life or thermal aging tests.

The temperature rise test is a mandatory type test to prove the temperature rise of the main components contained in a prefabricated substation. Its purpose is to check that the design of prefabricated substation enclosure operates correctly and does not impair the life expectancy of the substation components. Their life expectancy will not be influenced if the acceptable limits of deterioration of insulation through thermal effects are not exceeded.

The IEC standard 62271-202 gives the basic design and test requirements for a prefabricated substation but local additional requirements have to be taken into consideration as well. These may vary considerably from region to region. Such additional requirements will normally be given by the utility, based on local, regional, national or even international regulations or directives.

The main components used in the substation like medium and low voltage switchgear as well as transformer shall be type tested. The use of design parameters given in the standard, combined with type and routine testing will lead to safe and reliable product and provide reliable and safe operation of the substations.

TEMPERATURE RISE TEST

The purpose of temperature rise test of prefabricated substation is to:

- Determine enclosure class,
- Verify if the temperature of individual parts of the prefabricated substation including external enclosure parts accessible to touching does not exceed defined temperature limits,
- Ensure guaranteed life time of the device insulation system, and thereby the safety and reliability of substation during the period of operation.

The temperature rise test confirms that design and construction of prefabricated substation is appropriate. Poor enclosure construction and then overheating of substation may have a major impact on the life time of the components.

TEST CONDITIONS

The substation enclosure shall be complete with its components positioned for service. The doors shall be closed and cable access points sealed to represent service conditions. Figure 1, shows a 1500kVA, 13.8/0.4kV compact substation which is to be tested. The power losses of the transformer should be those correspond to the rated maximum power of the substation. The rated maximum power of the substation is given by the maximum rated power of the transformer for which the substation has been designed. The maximum rated losses of transformer (P_{k75} and P_o) shall be taken from routine test results of transformer which is carried out before the temperature rise test.

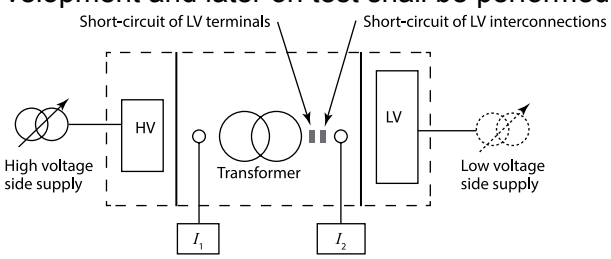
The temperature rise test focuses mainly on the temperature measurement of the transformer insulation system and windings and low voltage switchgear and controlgear. The temperature rise test of the HV switchgear is not required because it operates at much lower current than the rated current. Therefore, HV interconnections can be excluded from test and sensors may be utilized in the LV connections starting from transformer LV bushings up to LV outgoing feeders covering complete current circuit and all critical locations. Temperature rise test on Transformer, HV and LV interconnections and low-voltage equipment should be performed simultaneously.

The ambient air temperature of the test room shall be maintained less than 40 °C with a variation not exceeding 1 K in a 1 hour during the measurement test period. The environment shall be considerably free from air currents, except those generated naturally by heat from the equipment under test. Normally, this condition is reached when the air velocity does not exceed 0.5 m/s.

Figure 1 – Substation in the test room prepared for temperature rise test.

TEST METHOD

The temperature rise test on the substation shall be performed as per circuit diagram shown in the Figure 2. The substation manufacturer can perform test at his premises of test facilities are available during development and later on test shall be performed in an independent certified laboratory like KEMA and CESI for product certification as per standards.



I_1 Sufficient current to generate the total rated transformer losses

I_2 Low voltage rated current of the transformer

Figure 2 – Diagram of the temperature rise test on compact secondary substation

The test equipment and thermocouples (heat sensors) used during the test shall be calibrated from certified laboratory. The heat sensors shall be installed at most critical locations where maximum temperature is expected as per Table 1.

Figure 3 – Sensor installed on the LV busbar

Figure – 4 Generator connections

The CT secondary of protection relay for the tee-off shall be shorted if available to avoid tripping during the test. The temperature readings shall be taken after every one hour interval and during the last quarter of test period, after every 30 minutes. Estimated saturation time may be approximately 10 - 12 hours which can be calculated by the following formula:

Estimated saturation time, $t = 5 \text{ x } T_0$

When, $T_0 = [(5\ M_T + 15M_0) / P_T] \text{ x } (\Delta\Theta / 60)$

Where, T_0 = Thermal constant, M_T = Mass of the transformer in Ton, M_0 = Oil mass in Ton

$\Delta\Theta$ = Estimated oil temperature rise in K and P_T = Total transformer loss in kW

CONNECTION OF SUPPLIES & APPLICATION OF TEST CURRENTS

The transformer and HV switchgear with its tee-off (fuses with correct rating or circuit breaker) shall be connected and the low-voltage outgoing terminals of the transformer shall be short-circuited. The generator supply shall be connected to the incoming high-voltage switchgear terminals as shown is Figures 2 and 4.

The low-voltage switchgear shall be isolated from the transformer, as close as practicable to the transformer terminals. At a convenient point adjacent to the transformer terminals, short-circuit shall be applied to the connections between the transformer and the

low-voltage switchgear. The current shall be applied to the low-voltage switchgear via the outgoing feeders as shown in Figure 2.

The transformer is supplied with sufficient current to generate the total rated power losses of the transformer, at its reference temperature, using either method defined in IEC 60076-2 or IEC 70076-11. This test will require a small percentage of current above the rated current flowing through the complete circuit so as to compensate for the transformer's no-load losses. During the test, the resistance will vary according to the temperature of the transformer. Therefore, the generator current should be varied correspondingly to maintain the generated losses constant and equal to the total transformer losses throughout the test.

The low-voltage circuit is supplied with the rated low-voltage current of the tested transformer. The distribution of this supply current at the low-voltage outgoing feeders shall be selected to be the worst case in respect of heat generation.

MEASUREMENTS

AMBIENT AIR TEMPERATURE

The ambient air temperature is the average temperature of the air surrounding the substation. It shall be measured during the last quarter of the test period by means of at least four thermocouples or thermometers equally distributed around the substation at about the average height of its current carrying parts and at a distance of about one meter from the substation. In order to avoid indication errors because of rapid temperature changes, the thermocouples or thermometers can be put into small bottles containing about half a liter of oil.

During the last quarter of the test period, the change of ambient air temperature shall not exceed I K in 1 hour. The ambient air temperature during test shall be more than +10 °C but less than +40 °C. No correction of the temperature-rise values is required for ambient temperatures within this range.

TRANSFORMER, LV AND HV SWITCHGEAR & CONTROLGEAR

The top oil temperature rise for liquid-filled transformers shall be measured as given in IEC 60076-2. The average winding temperature rises for dry-type transformers shall be measured as given in IEC 60076-11. The low-voltage switchgear and controlgear temperature rises shall be measured as given in IEC 61439-1.

It is not necessary to repeat the temperature-rise test, when other configurations different from the tested one are used, unless the losses in the LV side are higher than in the tested configuration. The air temperature in the HV and LV compartments where electronic equipment are installed shall be measured. The temperature rise of the HV interconnections and their terminals is not required.

Table 1 - Temperature measuring points

Number of sensor	Location
S1-S4	Ambient air around substation
S5	Transformer top oil
S6-S8	Transformer LV bushing terminals
S9-S12	Transformer cooling fins
S13	Air, transformer compartment
S14-S16	LV main circuit breaker upper terminals
S17-S19	LV main circuit breaker lower terminals
S20-S22	LV vertical busbars, L1-L3
S23-S24	LV horizontal busbar L1
S25-S26	LV horizontal busbar L2
S27-S28	LV horizontal busbar L3
S29	Air, LV Switchgear
S30	Handle, LV switchgear
S31	Air, LV compartment, instrument level
S32-S34	Outgoing circuit breaker X, upper terminals
S35-S37	Outgoing circuit breaker X, lower terminals
S38-S40	Outgoing circuit breaker Z, upper terminals
S41-S43	Outgoing circuit breaker Z, lower terminals
S44	Ammeter, metering door
S45	Air, HV compartment

CLASS OF ENCLOSURE

The class of enclosure is the difference between the temperature rises of the transformer inside the enclosure and outside the enclosure. A temperature rise

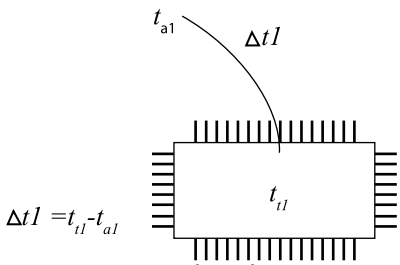


Figure 5 - Measurement of transformer temperature rise in air: $\Delta t1$

test without enclosure shall be carried out before the temperature rise test with the enclosure.

Where t_{a1} is the ambient air temperature of the test room; t_{t1} are the transformer temperatures measured according to IEC 60076-2 and IEC 60076-11 and Δt_1

is the temperature rise of transformer outside an enclosure.

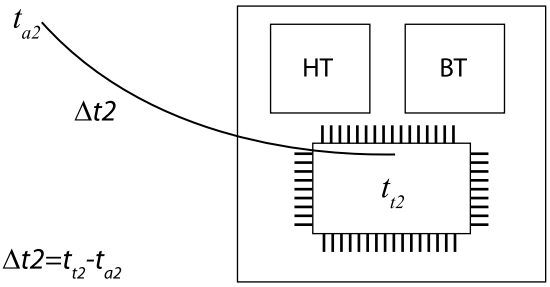


Figure 6 - Measurement of transformer temperature rise in an enclosure: Δt_2

Where t_{a2} is the ambient air temperature of the test room; t_{t2} are the transformer temperatures measured according to IEC 60076-2 and IEC 60076-11, Δt_2 is the temperature rise of transformer inside an enclosure and Δt is class of enclosure and is equal to $\Delta t_2 - \Delta t_1$.

AMBIENT TEMPERATURE AND TEMPERATURE RISE LIMITS

The ambient temperature declared for the substation varies from one customer to another. In tropical countries it may be specified from 50 to 55 °C. The reference temperature (ambient temperature) mentioned in the IEC Standards for medium voltage switchgear and power transformers is 40 °C. Whereas for low voltage switchgear, IEC 61439-1 is mentioning reference temperature 35 °C and IEC 60947-1 and IEC 60947-2 are mentioning 40 °C. The circuit breaker manufacturers are mentioning reference temperature 35 °C or 40 °C with a degree of protection up to IP31 for temperature performance of circuit breaker. All these factors shall be considered by the user for appropriate application.

For defining temperature rise limits of a sample prefabricated substation, let us assume oil and winding temperature rise for the transformer are 35 K and 40 K respectively, ambient temperature is 40 °C and substation enclosure class is 10 K. The expected temperature rise at 40 °C ambient temperature at various locations shall remain within the limits as in Tables 2, 3 and 4. When the substation is designed for service where the temperature of the cooling air exceeds from 40 °C, the temperature rise limits shall be reduced by the same amount as excess.

Table 2 – Temperature Rise Limits for Prefabricated Substation

Description	Temperature Rise above Ambient
Temperature rise of top oil	45 K
Temperature rise of HV winding	50 K
Temperature rise of LV winding	50 K
RMU HV interconnection temperature	Not required
Transformer HV interconnection temperature	Not required
Transformer LV bushing terminal temperature	80 K

Table 3* – Temperature rise limits for low voltage switchgear and controlgear

Parts of Assemblies-Description	Temperature Rise Limits	Temperature Limits (starting from T_A=40°C)
Terminal for external insulated connections (IEC 60439-1)	65 K	105 °C
Manual operating means:		
of metal	10 K	50 °C
of insulating material	20 K	60 °C
Accessible external enclosures and covers:		
metal surfaces	25 K	65 °C
insulating surfaces	35 K	75 °C

* The reference temperature in Table 6 of IEC 61439-1 is 35 °C. The Table 3 is modified form of Table 6 of IEC 61439-1 at 40 °C reference temperature.

Table 4 – Temperature rise limits for low voltage switchgear and controlgear as per IEC 60947-1 and IEC 60947-2.

Description of Parts	Temperature Rise Limits	Temperature Limits (starting from T_A=40°C)
Terminal for external connections (IEC 60947-2)	80 K	120 °C
Manual operating means: (IEC 60947-1)		
metallic	15 K	55 °C
non-metallic	25 K	65 °C
Parts intended to be touched but not hand-held: (IEC 60947-1)		
metallic	30 K	70 °C
non-metallic	40 K	80 °C
Parts which need not to be touched for normal operation: (IEC 60947-1)		
metallic	40 K	80 °C
non-metallic	50 K	90 °C
Manual operating means: (IEC 60947-2)		
metallic	25 K	65 °C
non-metallic	35 K	75 °C

Parts intended to be touched but not hand-held: (IEC 60947-2)		
metallic	40 K	80 °C
non-metallic	50 K	90 °C
Parts which need not to be touched for normal operation: (IEC 60947-2)		
metallic	50 K	90 °C
non-metallic	60 K	100 °C

ACCEPTANCE CRITERIA

The prefabricated substation shall be considered to have passed the temperature rise test if:

i. The transformer temperature rises do not exceed the corresponding temperature rises measured on the same transformer without an enclosure by more than the temperature class of the substation. For example, for class 10 enclosure, $\Delta t \leq 10$ K. If $\Delta t >$ 10 K then class of enclosure will be considered next higher class.

ii. The temperature rises and temperature of low-voltage interconnections and low-voltage switchgear do not exceed the requirements of IEC 61439-1, IEC 60947-1 and IEC 60947-2.

CONCLUSIONS

The accumulation of heat in an enclosure is potentially damaging to electrical and electronic devices in the substation. Overheating can shorten the life expectancy of electrical components and lead to failure. Therefore, substation enclosure shall be designed such that all the component shall operate safely within specified limits as per standard. The aging acceleration factor due to temperature for all components in the substation shall have a value of 1.0 for continuous transformer operation at rated winding hot spot temperature. The insulation rate of aging is expected to double for every 6 K rise in insulation hottest spot temperature.

Among the type tests listed in the IEC 62271-202 standard, the temperature rise test is one of the major test used to validate the thermal design and performance of prefabricated substation. The reference temperature mentioned in the IEC standards for MV switchgear, LV switchgear and transformer is not similar. Also, the LV switchgear manufacturers are mentioning different reference temperature in their catalogue. There shall be common reference temperature in the IEC standards for better understanding.

Loading tests on the substation demonstrate that temperature rise of the transformer inside the enclosure does not exceed more than temperature class of prefabricated substation and temperature rises of low voltage interconnections and low voltage switchgear remain within limits specified in IEC Standards.

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يَٰٓأَيُّهَا ٱلَّذِينَ ءَامَنُواْ ٱتَّقُواْ ٱللَّهَ وَلۡتَنظُرۡ نَفۡسٞ مَّا قَدَّمَتۡ لِغَدٖۖ وَٱتَّقُواْ ٱللَّهَۚ إِنَّ ٱللَّهَ خَبِيرُۢ بِمَا تَعۡمَلُونَ ١٨
وَلَا تَكُونُواْ كَٱلَّذِينَ نَسُواْ ٱللَّهَ فَأَنسَىٰهُمۡ أَنفُسَهُمۡۚ أُوْلَٰٓئِكَ هُمُ ٱلۡفَٰسِقُونَ ١٩ لَا يَسۡتَوِيٓ أَصۡحَٰبُ ٱلنَّارِ
وَأَصۡحَٰبُ ٱلۡجَنَّةِۚ أَصۡحَٰبُ ٱلۡجَنَّةِ هُمُ ٱلۡفَآئِزُونَ ٢٠ سورة الحشر

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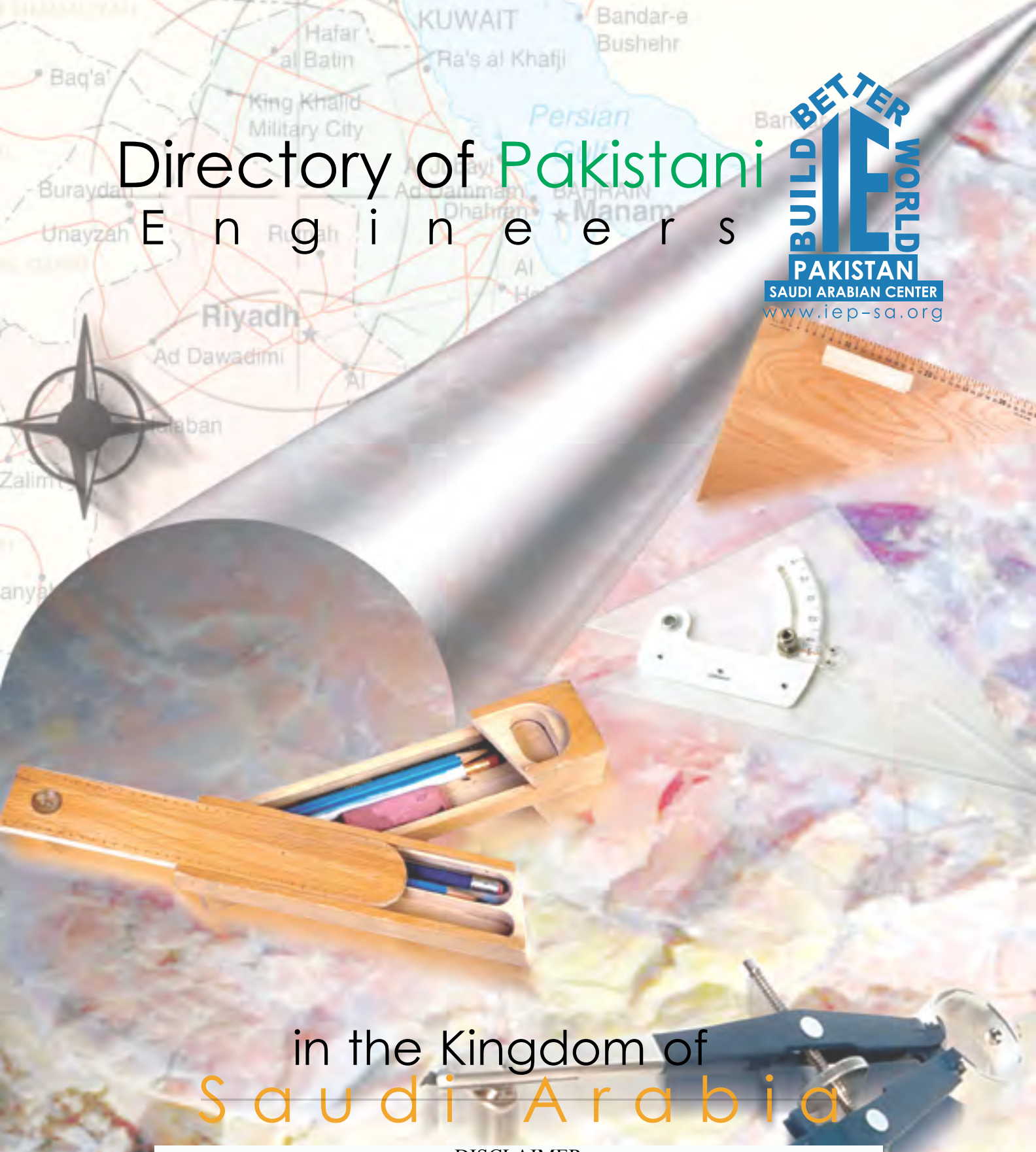

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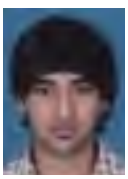

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MAJOR SOURCES OF RADIATION EXPOSURE TO THE PUBLIC

Natural Radiation

Radon in Indoor Air. Small amounts of radon-222, a radioactive gas, seep from uranium that is widely distributed in the Earth's crust. On average, radon trapped in homes accounts for 55 percent of the radiation to which Americans are exposed -- approximately 200 millirem every year.

The Human Body. About 11 percent of the average person's total exposure -- an average of 39 millirem per year -- comes from the human body itself. Potassium-40 and other radionuclides found in air, water and soil are incorporated into the food we eat, then into our bodies' own tissues.

Rocks and Soil. Rocks and soil account for about 8 percent of the public's exposure to radiation from all sources, or 28 millirem per year. The exposure comes from the Earth's crust and from building materials derived from soil and rocks. Brick and cinder-block homes expose the public to more radiation than do wooden homes. Granite used to build large structures, such as Grand Central Station in New York City, also exposes the public to small amounts of radiation.

Cosmic Rays. The average person receives about 8 percent of his total exposure -- 28 millirem per year -- from cosmic radiation from outer space. Actual exposures vary, since cosmic radiation increases with altitude, roughly doubling every 6,000 feet. A resident of Denver (one mile high) receives an average dose of about 50 millirem per year from cosmic radiation; those in Leadville, Colorado., at an altitude of two miles, get a cosmic ray dose of about 125 millirem per year; while a resident of Florida (at sea level) receives about 26 millirem per year from this source. Similarly, a passenger in a jet airliner at 37,000 feet (seven miles) may receive 60 times as much cosmic radiation in a given time as does someone at sea level.

Man-Made Radiation

Medical Procedures. The average American receives about 15 percent of his exposure to radiation from X-rays and nuclear medicine procedures -- an average of 45 millirem per year. A typical chest x-ray results in a 10 mrem dose.

Consumer Products. The average American receives about 3 percent of his total exposure to radiation from consumer products, or approximately 9 millirem per year. Radon in natural gas used in cooking ranges contributes about five millirem per year. Smaller exposures can come from some smoke detectors, which use americium-241, and television sets. The use of lawn fertilizer can also expose an individual to radiation. Fertilizer contains potassium, of which a tiny amount is potassium-40, a naturally radioactive material.

Nuclear Power and Other Sources. Individuals are exposed to tiny amounts of radiation -- less than 1 percent of their total exposure -- from a variety of other activities. This includes radiation exposure from nuclear power plant operations, exposure due to fallout from past atmospheric testing of nuclear weapons, and from the generation of electricity from coal-fired and geothermal power plants. The average Nuclear power plant operations do not expose people living near the plants to more than tiny amounts of radiation. Extensive epidemiological studies of cancer in populations living near nuclear power plants indicate no long term effects that could be attributed to radiation exposure from nuclear plant operations.

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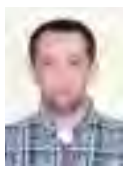

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Change

"Progress is impossible without change, and those who cannot change their minds cannot change anything."
- George Bernard Shaw

"The greatest discovery of all time is that a person can change his future by merely changing his attitude."
- Oprah Winfrey

"He who rejects change is the architect of decay. The only human institution which rejects progress is the cemetery."
- Harold Wilson

"Consider how hard it is to change yourself and you'll understand what little chance you have in trying to change others."
- Jacob M. Braude

"You must be the change you wish to see in the world."
- Mahatma Gandhi

"No change of circumstances can repair a defect of character."
- Ralph Waldo Emerson

"Only the wisest and stupidest of men never change."
- Confucius

"Change the changeable, accept the unchangeable, and remove yourself from the unacceptable."
- Denis Waitley

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- The constitution of Pakistan has yet to be framed by the Pakistan Constituent Assembly. I do not know what the ultimate shape of this constitution is going to be, but I am sure that it will be of a democratic type, embodying the essential principle of Islam. Today, they are as applicable in actual life as they were 1,300 years ago. Islam and its idealism have taught us democracy. It has taught equality of man, justice and fairplay to everybody. We are the inheritors of these glorious traditions and are fully alive to our responsibilities and obligations as framers of the future constitution of Pakistan. In any case Pakistan is not going to be a theocratic State to be ruled by priests with a divine mission. We have many non-Muslims — Hindus, Christians, and Parsis — but they are all Pakistanis. They will enjoy the same rights and privileges as any other citizens and will play their rightful part in the affairs of Pakistan.

  (Broadcast to the people of the United States of America on Pakistan, February 1948)
- You are free to go to your temples, you are free to go to your mosques or to any other place of worship in this State of Pakistan. You may belong to any religion or caste or creed. That has nothing to do with the business of the State.

  (Presidential address to the first Constituent Assembly of Pakistan, Karachi, 11 August 1947)
- I have one underlying principle in mind: the principle of Muslim democracy. It is my belief that our salvation lies in following the golden rules of conduct set for us by our great lawgiver, the Prophet of Islam.

  (In 1948, Address to Sibi Darbar)
- I cannot understand the logic of those who have been deliberately and mischievously propagating that the Constitution of Pakistan will not be based on Islamic Sharia. Islamic principles today are as much applicable to life as they were 1300 years ago.

  (Address to Karachi Bar Association in January 25, 1948)
- Pakistan not only means freedom and independence but Muslims ideology which has to be preserved which has come to us a precious gift and treasure and which we hope, others will share with us.

  (Address to Frontier Muslim Students Federation on 18th June 1945)
- I have full faith in my people that they will rise to every occasion worthy of our past Islamic history, glory and traditions.

  (Message to the Nation on first Anniversary of Pakistan on 14th August, 1948)

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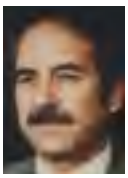

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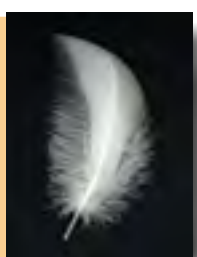
FEATHERS ..... An Engineering Marvel

The extraordinary gift of feathers has given birds a magic carpet which will sail virtually anywhere. This marvel of engineering design provides strong and flexible flight feathers that furnish the lift and thrust of flight whenever needed. Soon after birth, birds are presented with expensive down-lined jackets that are carefully fitted to cover their entire bodies except for their feet and legs, and part of their faces. The down in these jackets is, likewise, guaranteed to keep the body warm in cold w eather and is adjustable to keep the body comfortable in warm weather. This special coat has an outer covering of contour feathers that the designer has made beautiful as well as functional. When the wind blows, it serves as an excellent windbreaker; when it rains, the jacket is water proof. The thickness and strength of this coat protects the body thermally and mechanically. Besides all this, birds are given a magic carpet which is a marvel of engineering design. The flight feathers on the wings are strong and flexible, which give birds flight whenever they want it. The key to water repellency of feathers is the feather structure and feather network, not the natural oil. The micro-structure of the wide flat part of feathers involves interlocking barbules that may number up to one million in a single feather. The zipper effect gives strength to the web, but also traps air, helping to make the feather water tight. Through all of history, men have marveled at the splendor of feathers and have attempted to duplicate their beauty. It seems fitting that birds as rulers of the sky have brilliant feathers to match their position.



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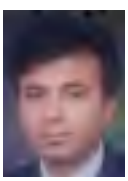

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Courage

"It takes courage to grow up and turn out to be who you really are."
- E.E. Cummings
"Courage is what it takes to stand up and speak. Courage is also what it takes to sit down and listen."
- Winston Churchill
"Courage is grace under pressure."
- Ernest Hemingway
"Courage is being scared to death but saddling up anyway."
- John Wayne
"It is curious that physical courage should be so common in the world and moral courage so rare."
- Mark Twain
"Mistakes are always forgivable, if one has the courage to admit them."
- Bruce Lee
"Success is never final. Failure is never fatal. It's courage that counts."
- John Wooden
"Faced with what is right, to leave it undone shows a lack of courage."
- Confucius

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Spirograph

Spirograph is a geometric drawing toy that produces mathematical roulette curves of the variety technically known as hypotrochoidsand epitrochoids. It was developed by British engineer Denys Fisher and first sold in 1965.

The mathematician Bruno Abakanowicz invented the spirograph between 1881 and 1900. It was used for calculating an area delimited by curves.[1] Drawing toys based on gears have been around since at least 1908, when The Marvelous Wondergraph was advertised in the Sears catalog.[2][3] An article describing how to make a Wondergraph drawing machine appeared in the Boys Mechanic publication in 1913.[4] The Spirograph itself was developed by the British engineer Denys Fisher, who exhibited at the 1965 Nuremberg International Toy Fair. It was subsequently produced by his company. US distribution rights were acquired by Kenner, Inc., which introduced it to the United States market in 1966 and promoted it as a creative children's toy.

The original US-released Spirograph consisted of two different-sized plastic rings, with gear teeth on both the inside and outside of their circumferences. They were pinned to a cardboard backing with pins, and any of several provided gearwheels, which had holes provided for a ballpoint pen to extend through them to an underlying paper writing surface. It could be spun around to make geometric shapes on the underlying paper medium. Later, the Super-Spirograph consisted of a set of plastic gears and other interlocking shape-segments such as rings, triangles, or straight bars. It has several sizes of gears and shapes, and all edges have teeth to engage any other piece. For instance, smaller gears fit inside the larger rings, but also can engage the outside of the rings in such a fashion that they rotate around the inside or along the outside edge of the rings.

A Spirograph is formed by rolling a circle inside or outside of another circle. The pen is placed at any point on the rolling circle. If the radius of fixed circle is R, the radius of moving circle is r, and the offset of the pen point in the moving circle is O, then the equation of the resulting curve is defined by:

$$x = (R+r)*\cos(t) - (r+O)*\cos(((R+r)/r)*t)$$

$$y = (R+r)*\sin(t) - (r+O)*\sin(((R+r)/r)*t)$$

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MONTE CARLO SIMULATION

Risk analysis is part of every decision we make. We are constantly faced with uncertainty, ambiguity, and variability. And even though we have unprecedented access to information, we can't accurately predict the future. Monte Carlo simulation (also known as the Monte Carlo Method) lets you see all the possible outcomes of your decisions and assess the impact of risk, allowing for better decision making under uncertainty.

What is Monte Carlo simulation?

Monte Carlo simulation is a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making. The technique is used by professionals in such widely disparate fields as finance, project management, energy, manufacturing, engineering, research and development, insurance, oil & gas, transportation, and the environment.

Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities—the outcomes of going for broke and for the most conservative decision—along with all possible consequences for middle-of-the-road decisions.

The technique was first used by scientists working on the atom bomb; it was named for Monte Carlo, the Monaco resort town renowned for its casinos. Since its introduction in World War II, Monte Carlo simulation has been used to model a variety of physical and conceptual systems.

How Monte Carlo simulation works

Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values.

The advent of spreadsheet applications for personal computers provided an opportunity for professionals to use Monte Carlo simulation in everyday analysis work. Microsoft Excel is the dominant spreadsheet analysis tool.

Please Write for YOUR Journal

IEP–SAC Journal is published every year at the occasion of its Summer Annual Technical Seminar. The Editorial Board welcomes articles for publication which could further the Journal's mission to keep professional engineers abreast of current trends and practices in engineering sciences and technology and to promote exchange of scientific and technical knowledge. Articles should be written in a serious but not overformal academic style at a level informative to other workers in the area and also accessible to engineers active in other fields of engineering.

The Editorial Board solicits manuscripts of the following types from prospective authors:

a. "Review" type papers suitable for reading by practicing engineers to give a first–class introduction to a subject with which they are not familiar.

b. Articles presenting key features of some new technology or system that is of general engineering interest.

c. Articles taking a new look at old problems readable by those outside the field.

d. Articles for the specialist recording an advance in the field, but readable by non–specialists also.

Scope

Broad interest articles pertinent to any discipline of engineering or related fields.

Manuscript Requirements

1. Papers can be 3000 words in length excluding diagrams and tables.
2. A short abstract of 150 words should be provided.
3. Manuscript may typically include five or six illustrations. These along with captions should be inserted at the appropriate places within the manuscript.
4. SI units should be used throughout except those allowed by consensus within the scientific and engineering community, namely, minute (symbol min), hour (h), and day (d) for time; degree (°), minute (′), and second (″) for plane angle; liter (l, L) for volume; and tonne (t) for mass; electron volt (ev), unified atomic mass unit (u), baud (Bd) and bit (bit) and certain other highly specialized units are acceptable. Please note that such non–SI units as nautical mile, knot, angstrom (Å), are (a), hectare (ha), barn (b), bar (bar), gal (Gal), curie (Ci), roentgen (R), rad (rd, rad), rem (rem), kilo–, mega–, giga– etc bytes are acceptable to the scientific community only temporarily.

Refereeing

Acceptance of manuscripts is subject to peer review by the Editorial Board or other reviewers and conditional upon revisions made in light of comments from the review process. Authors are nevertheless responsible for the accuracy of statements made in the paper. Where applicable, authors are also responsible for obtaining clearance from their employers.

Due Dates

Articles should be submitted to the members of the Editorial Board electronically no later than 31 March 2015. Please ensure that IEP–SAC acknowledges with the receipt of the manuscript.

Acceleration in Aviation: G-Forc

Human beings are adapted to live and survive within the ever-present, accelerative force of gravity. While on earth, this is a constant, and we live and function with it from the day we are born until the day we die. As an infant learning to walk, we learn very quickly that a misstep will ultimately lead to a painful gravity-induced incident with the ground that we call "a fall." As we develop and start to solve problems, we learn that a cookie jar falling off the counter will accelerate all the way to floor with shattering results. Many hours of our youth are spent determining the results of gravity on spherical objects of various shapes and sizes to our advantage in competition. We became accustomed to gravity at the standard 1 "G-force." When we pilot an aircraft, all that we have learned about gravity and have become comfortable with suddenly changes. Flight—in its purest definition—is overcoming gravity to ascend through the air. Just as when we were learning to walk, a primary goal of every flight should be to avoid painful, gravity-induced incidents with the ground. These encounters are called aircraft accidents and mishaps, and they can be destructive, even fatal.

What Goes Up Must Come Down

The force of gravity on earth causes a constant acceleration of 32 feet-per-second squared. An object in freefall will accelerate at an ever-increasing speed toward earth until it impacts the earth or reaches terminal velocity—the point at which the force of aerodynamic drag acting on the object overcomes theforce of acceleration induced by gravity. Acceleration is described in units of the force called "Gs." A pilot in a steep turn may experience forces of acceleration equivalent to many times the force of gravity. This is especially true in military fighter jets and high-performance, aerobatic aircraft where the acceleration forces may be as high as 9 Gs. Air race pilots in a tight pylon turn also experience high G-forces, but the important thing to remember is that any aircraft operated in a maximum-performance profile will subject the pilot to acceleration that is greater than the 1 G acceleration encountered on the ground. Pilots need to understand this in to successfully master flying.

Types of Acceleration

There are three types of acceleration. These types are Linear, Radial, and Angular Acceleration.

Linear Acceleration—reflects a change of speed in a straight line. This type of acceleration occurs during take-off, landing, or in level flight when a throttle setting is changed.

Radial Acceleration—is the result of a change in direction such as when a pilot performs a sharp turn, pushes over into a dive, or pulls out of a dive.

Angular Acceleration—results from a simultaneous change in both speed and direction, which happens in spins and climbing turns.

G Forces

During flight, a pilot may experience a combination of these accelerations as a result of input to the flight controls. These accelerations induce G-forces on the body that may be described as Gx, Gy, and Gz.Gx—is described as force acting on the body from chest to back; +Gx is experienced, for example, during the take-off roll as the throttle is advanced. This is the force that pushes the pilot back into the seat as the aircraft accelerates. –Gx is described as force from back to chest, and it is encountered during landing as the throttle is closed. This force pushes the pilot forward into the shoulder strap.Naval pilots flying from aircraft carriers feel the extremes of this type of G force. During a catapult launch, the aircraft accelerates to 160-plus mph in just under two seconds. During landing, the aircraft will decelerate to a complete stop in just a few feet. Carrier pilots have adapted and successfully functioned with these extreme Gs for decades. Gy—is a lateral force that acts from shoulder to shoulder, and it is encountered during aileron rolls. Aerobatic pilots routinely encounter this type of G force and can still safely and precisely maneuver their aircraft. Gz— is a gravitational force that is applied to the vertical axis of the body. If it is experienced from head to foot, it is termed (positive) +Gz. This happens when a pilot pulls out of a dive or pulls into an inside loop. –Gz (negative) travels from foot to head, and it is experienced when a pilot pushes over into a dive.

Aviators need to respect G acceleration just as they respect other aspects of flight. Proper flight planning will take a number of things into account, such as weather, fuel, distance, and time. A smart aviator will also include consideration of the G forces for the aircraft and all aboard when it comes to flight planning. A healthy respect, training, and planning will help to avoid possible encounters with the ground.

Physiological Effects of High G Forces

Human beings are adapted for life at 1 G on the surface of the earth. In the aviation environment, any maneuver has the potential to expose the human body to more than 1+ Gz of acceleration force. This can be particularly hazardous for pilots in the Gz axis. This is a G force that acts from head to toe in the case of +Gz and from toe to head in the case of –Gz. As an aircraft enters into a high-speed, coordinated turn or begins the pullout from a steep dive, the pilot experiences +Gz. The heart and cardiovascular system must respond quickly to G acceleration to keep blood flowing to the brain and maintain consciousness. Physiological response to +Gz causes the heart to beat harder and faster with an increased

What Does This Mean to Me?

Any aircraft, civilian or military, can expose the pilot, crew, and passengers to forces in excess of 1 G. During steep turns and unusual attitude recovery, civil aviation pilots can experience high G forces that may take them by surprise unless they are prepared. Subsequently, all aviators need to understand what makes their body more resistant to the effects of G acceleration. Conversely, aviators need to understand those conditions that will make their body more susceptible to the effects of G forces. The bottom line is that G tolerance for each individual aviator may fluctuate from day to day, and this can lead to disastrous consequences in flight. This is one of the reasons that military pilots do a "G warm-up" maneuver prior to flying high-performance aircraft—it allows them to assess their own body and how well they will be able to tolerate the high-G environment.

IEP-SAC MEMBERSHIP APPLICATION FORM

1) Category of membership requested:
   - ☐ Honorary Fellow
   - ☐ Corporate member
   - ☐ Member
   - ☐ Associate member

Space to attach 2cm x 2cm photo

2) Present IEP membership status, if applicable
   - ☐ Fellow
   - ☐ Life member
   - ☐ Corporate member
   - ☐ Associate member

Membership No.

……

Since: ……..
(DD/MM/YYYY)

3) Personal Data:

3.1) Full Name: .....
(As appearing in Passport)

3.2) Date of Birth: .....

3.3) Pakistan ID No: ..... , valid up to .....

3.4) Saudi Iqama No: ..... , valid up to .....

3.5) Home address: .....

3.6) E-mail: ..... , 3.7) Mobile # : ….....

3.8) Work Address: ..... , 3.9) Work phone # : ….....

4) Academic Qualifications:
   - ☐ 4-years bachelor's degree in Engineering
     Name of University ……., year of passing……
   - ☐ 4-years bachelor's degree closely related to Engineering or Technology
     Name of University ……., year of passing……
   - ☐ 4-years B. Tech
     Name of University ……., year of passing……
   - ☐ 3-years B. Tech (pass)
     Name of University ……., year of passing……
   - ☐ 3-years Diploma in Engineering
     Name of University ……., year of passing……
   - ☐ Post graduation/M.Sc.,/Ph.D. (In Engineering subjects)
     Name of University ……., year of passing……
   - ☐ Any other post graduation Diploma or certificate
     Name of University ……., year of passing……

5) Professional Experience:
Give brief description of job title, name of the employer in chronological order. Use separate sheet if necessary.

6) Employer's recommendations:
Needed for the category of membership as stipulated in Clause 5.2 of Appendix-'B'. Use separate sheet
(**N.B:** Photocopies of all Degrees, Diplomas & experience certificates should be attached)

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7) For IEP-SAC office use only.

7.1) Recommendations of IEP-SAC liaison committee:

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Signature_____Date_____

7.2) Approval by IEP-SAC Council:

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3. NIC Number _____-_____-_____

4. Permanent Address _____
5. Present / Postal Address _____
6. Telephone Number Office: _____ Residence: _____
   Mobile: _____ E-mail: _____
7. BASIC EDUCATION _____ Year _____
   Certificate/Degree Obtained _____
   College & University _____
8. ENGINEERING EDUCATION _____ Year _____
   Degree Obtained _____
   College & University _____
9. POST-GRADUATE EDUCATION
   Degree Obtained _____ Year _____
   College & University _____
10. PROFESSIONAL TRAINING & NAMES OF ORGANIZATIONS WHERE OBTAINED _____
11. MEMBERSHIP(S) OF OTHER PROFESSIONAL BODIES, IF ANY. _____
12. PRACTICAL EXPERIENCE _____

Sr. No.	Organization	Position Held	From	To	Total Years
1.					
2.					
3.					
4.					
5.					
6.					
7.					
				TOTAL YEARS	

PLEASE ATTACH A COPY OF DETAILED BIO-DATA

13. Class of membership in which admission is sought:

☐ Chartered Engineer ☐ Fellow ☐ Member ☐ Associate ☐ Affiliate ☐ Subscriber

Current Membership Number _____

PEC Registration Number _____

_____
Applicant's Signature

Proposer's Name (in block letters)	Signature	Date	Class of Membership

Seconder's Name (in block letters)

Grade of Membership General Requirements	Transfer Fee Fellow to Chartered Engineer	Age (Minimum) Years	Entrance Fee	Transfer Fee Member to Fellow	Life Fee	Life Membership fee for Pakistan Engineer Readers Club	Annual Sub-Scription	Diploma / Certificate Fee	Total
	Rs.		Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
1. **Chartered Engineer** (A) Must be a Fellow of IEP (B) Must be holding, or must have held in the past, positions of high responsibility in the Engineering profession, for a minimum of 20 years.	--	45	--	--	2000/-	1500/-	--	200/-	3700/-
2. **Fellow** Must have all the qualifications of a Member and must be holding or must have held, in the past, position(s) of high responsibility in the Engineering profession for a minimum of 10 years. The applicant must have at least one technical paper (published in a journal of repute) to his credit. *Please enclose four hard copies and one soft copy of the technical paper for IEP's record.*		40	--	1000/-	2000/-	1500/-	--	150/-	4650/-
3. **Member** Must be in possession of: (A) Section A & B of IE (Pak), or (B) Degree in Engineering from any recognized University, or (C) Any other qualifications exempting the applicant from the above.		21	150/- 150/-	--	-- 1100/-	1500/- 1500/-	100/- --	100/- 100/-	1850/- 2850/-
4. **Affiliate** Must be an engineer, or a person, or a body of persons not belonging to other categories of corporate membership, whose interests are related to engineering profession by virtue of his/her occupation.		25			2000/-	1500/-	--	150/-	3650/-
5. **Subscriber** Any Business Enterprise, Company, Government Department, Registered Film or individual not eligible for Fellow, Membership, Affiliate Membership or students Membership who wishes to be so attached with IEP.		30 (For Individual)	--	--	5000/-	1500/-	--	150/-	6650/-

N.B.: 1. Proposer & Seconder must be Corporate Members of IEP.

2. This Application Form must be properly filled in and signed by the applicant, proposer and seconders & submitted to the H.Q. Office through the Local Centre concerned, together with attested copies of the Matriculation Certificate, Engineering Degree & CNIC Copy.

3. Please enclose a bank draft or crossed cheque in favor of IEP HQ for:
   a) Life Membership Fee
   b) Subscription for IEP Journal "The Pakistan Engineer"
   c) Fee for Life Membership of Readers Club to receive monthly Journal of IEP as and when published.
   d) Diploma Fee

4. When applying for fellowship of I.E.P. please quote current Membership Number.

5. Only Members of IEP are eligible for Fellow Membership.

If the applicant is not already a member of the Readers' Club.

THANK YOU ADVERISERS

	AB Contracting	39		Habib Rafiq	45
	AETCON	9		Ittefaq Steel	1
	Al-fanar	19		Kirby	62
	Al-Manara	31		Mehran	23
	Aquarious	C 3		Naba Int'l	7
	A.S. Hussaini & Partner	5		OCC	63
	Ather Technology Pvt. Ltd.	11		Qahtani Pipe Coating	C 2
	Foundation	15		Riyadh Cables	2
	FUCHS	37		Swary	C 4
	GEC	13			

The Institution Of Engineers Pakistan Saudi Arabian Center

DIRECTORY REGISTRATION FORM

Please Cross (X) the applicable:

☐ New Entry ☐ Data already sent is correct ☐ Amendment (Please write only Name, Branch, and Amendment)

Name .....

Branch (e.g. Civil, Electrical) .....

TWO PHOTOGRAPHS 1.75" X 2.25"

(PASTE 1, STAPLE 1)

Are you a member of IEP? ☐ Yes ☐ NO

If the answer to the above question is "Yes" then please fill up the following:

a) Grade (Fellow, Member etc.)
b) Membership No.
c) Year
d) Center that granted membership

Qualifications (Please begin with Engineering Degree and list up to the highest qualification)

Degree	Institution	Year

Present Designation .....

Present Employer .....

Present Address .....

Telephone Office ..... Telephone Residence .....

Mobile ..... Fax .....

Email-1 ..... Email2 .....

Permanent contact in Pakistan or elsewhere (with country, area, and postal code)

City ..... County .....

Telephone Residence ..... Fax .....

Please register my particulars in the next edition of IEP-SAC Directory of Pakistani Engineers in Saudi Arabia

You can insert Signature

Signature: ..... Date: .....

Please hand in the completed form to any member of the IEP-SAC Local Council.

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