



# **Engineering Research Division Report**

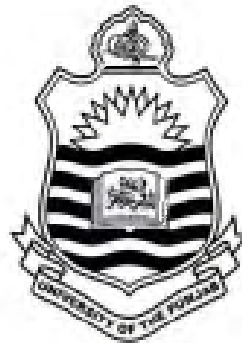


**Engineering Research Division  
Institute of Chemical Engineering & Technology  
Faculty of Engineering & Technology**

**UNIVERSITY OF THE PUNJAB  
Quaid-e-Azam Campus, Lahore**

## **Progress Report**

**From July 2005 to June 2007**



**Engineering Research Division**  
**Institute of Engineering and Technology**  
**FACULTY OF ENGINEERING & TECHNOLOGY**  
**University of the Punjab, Quaid-i-Azam, Lahore.**

## PREFACE

Universities must lead a nation. The University is a place to develop human resources in terms of mindset, attitudes, motivation and values required for the achievement of civil society needs and material goals. The two important role of a University is high quality teaching and outstanding research. It will not be proper if we talk just about research only, because good researchers are the product of high quality teaching. The Strength in basic sciences in Chemistry, Physics and Mathematics are must to have a sound base of teaching in science and engineering. There is need to upgrade education system from the grass root, the school system, colleges and polytechnics which are the building . blocks of education system.

The research especially in the field of engineering discipline is non existent in the country. Due to lack of research activities the country has to spend huge money on the import of not only high end products but also consumer items. Moreover there is need to develop expertise for the optimum production of value addition product which can meet local needs and fetch more foreign exchange.

The research cluster in the country cannot be developed unless there is change of mindset at the decision and administrative level. The goals for research should be set at national level. The Planning Commission, Ministry of Science & Technology, Ministry of education and Higher Education Commission alongwith stake holders like Universities, Chambers of Commerce and Industry and R&D organizations should define the national goals. To achieve these goals, conducive environment should be produced especially in the public sector Universities.

The Engineering Research Division at the Faculty of Engineering, University of the Punjab was created with the objective to develop a cluster of research for the production of highly educated and well trained human resources in engineering sciences & technology and to catalyze the creation of knowledge based economic resources by strengthening University-Industry interaction.

The report of this division is hereby presented which reflects the achievements with meager resources and also highlights the needs to develop indigenous resources for trained human power and economic uplift of the country. I appreciate the efforts of core team of engineering research division and the researchers. I am indebted to Dean Faculty of Engineering & Technology and Vice-Chancellor Prof. Dr. Muhammad Arif Butt who whole-hearted supported the research activities. I acknowledge the financial support of Punjab University, and higher education commission.

Lahore, November 19, 2007

Prof. Dr. Arshad Chughtai

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## Brief History

The Institute of Chemical Engineering & Technology is the pioneer institution of chemical engineering in the country. Since partition, thousand of engineers and technologists have passed through the portals of the University and the Institute is proud of their contribution towards the progress and advancement of Pakistan in the industrial realms. The standards achieved by the Institute in education and research in the field of Chemical Engineering and Technology have received due recognition at home and abroad. Today, practically almost whole of the chemical and process industry in the country is being manned by the graduates of this Institute. The alumni of the Institute have contributed significantly to the industrial growth and economic development of the management of many important chemical plants, petroleum refineries, natural gas companies and a number of industrial units. They are holding highly responsible positions in Pakistan Atomic Energy Commission, Pakistan Council of scientific and Industrial Research, Chemical and Process Industries both in the private and public sector, Defense Organizations, Universities and Government Departments etc.

Considering the enormous scope or requirement of Research & Development work for the nation, the Vice-Chancellor of the University of the Punjab allowed to create an Engineering Research Division in 2004. From the grant provided by the Higher Education Commission and University of the Punjab, analytical and corrosion research laboratories were established. The postgraduate students and research scholars conducted research under the supervision of highly qualified senior faculty members and research advisors. A significant number of publications have been made in national and international journals. The Engineering Research Division also held a number of conferences and workshops. The University-Industry interaction is another important area of achievement of the Engineering Research Division as reflected in this report. Future plans in the form of conceptual "School of Process Engineering Research" are also highlighted as a PC-I project. This research school will ultimate become the centre of excellence in process engineering research.

## Research & Development Needs in Engineering

For self reliance of engineering and technology the basic task is the development of infrastructure for research in engineering and technology and creating conducive atmosphere for R&D activities. To create research environment the following are essential requirements.

- **Scope of R&D:** The scope of R&D should be well defined. The R&D work should be based as far as possible on the problems referred by the industry and on brain storming to uplift national economy vide utilizing indigenous resources. The research should aim at self reliance in technology and address the latest changes in global economy. To fix the targets for purposeful research, the top down approach is essential. The Planning Commission in collaboration with Ministry of Science & Technology and Higher Education Commission along-with Universities and chambers of commerce and industry should identify the research areas and integrated approach involving Universities, R & D organization & private sector should be well defined. The research fields should be well defined keeping in view the country needs. These should address not only the current needs but also address the forthcoming requirements, and cutting edge technologies. The following sectors may be considered; biotechnology, technical textiles, advanced materials including biomaterials, specialty chemicals, pharmaceuticals, electronics, machinery design and fabrication, enhancement of agricultural output, energy sources (exhaustable and renewable), environmental science and engineering. Moreover in particular areas where acceptable expertise is available, crash programme of R&D linked with industry must be actively initiated. For example in case of materials developments, GIK, NUST, Pinstech, Punjab University, Bahauddin Zakariya University and University of Engineering and Technology Lahore should make a joint programme. Similarly the country has strong infrastructure in biological sciences. In this regard NIBGE, Punjab University cluster in biology (Centre for Advanced Molecular Biology, School of Biological Sciences, Department of Molecular Biology & Genetic Engineering, Institute of Biochemistry & Biotechnology) and Agricultural University Faisalabad should make headway for biotechnology and agriculture sectors.
- **Resource Persons:** The highly qualified and experienced faculty is the backbone of R & D activities. This need can be materialized by employing qualified and well motivated faculty. Since there is an acute shortage of resource persons, this can be partially

overcome by engaging retired professors, researchers and expatriate persons of relevant qualification. The faculty development programme of Higher Education Commission will also be useful in this regard, moreover the HEC programme of indigenous Ph. D may be effectively utilized for raising experienced faculty.

- **Modern and Updated Laboratory Facilities:** To conduct R&D work in science and engineering the updated laboratories are essential ingredient of research infrastructure. To carry out research work the latest analytical and characterization equipments beside well designed & fabricated experimental setup are essential. The maintenance of these laboratories and retrofits, require a well equipped workshop containing the sections in Mechanical, Electrical and Glass Blowing facilities.
- **Supporting Staff/Technicians:** It has been observed in the past that non availability of technicians and maintenance engineers for expensive instruments had detrimental effect on the smooth functioning of the research laboratories. The presence of a team of experienced engineers and technicians is another important requirement for the sustenance of experimental work. To attract and retain good technicians their service structure should be well defined as practiced in PAEC.
- **Researchers and Postgraduate Students:** With the availability of required resources like experienced supervisors and well equipped and well maintained laboratories there should be enough recurring grant available for the employment of research scholars and research fellows and availability of scholarships for postgraduate students. The amount of scholarship for postgraduate students should be reasonably linked to match the salary of a graduate engineer/scientist working in the industry. This facility will attract able students to join M. Sc. (Engg) and Ph. D. (Engg) Programmes.
- **Literature & Online Information Sources:** For acquaintance with the latest knowledge and technical information, there should be easy access to these resources. There has been considerable improvement in this regard and this generosity of Higher Education Commission should be continued. The Universities should be consulted for subscribing the information sources.
- **Good Governance and Accountability:** The allocation of funds for the higher education has increased, however capacity enhancement of universities has not been increased proportionally. The mindset in administration and accounts departments have

not been reformed to match the current needs. These departments must be reformed to support research and development requirements. The qualified, experienced and well motivated managers be appointed to handle bottlenecks for research and development needs. With the availability of budget, the stipulated time for recruitment procedure for a person should be six months and purchase of equipment may take maximum six months for imported item and far less time for local supply. The professor/ research group leader should be given authority to purchase item with single quotation upto Rs.100,000. The good governance should also be assured in all academic departments of a University. The role of all faculty members should be well defined and monitored. They are bound to deliver quality teaching and participate in research activities. Moreover an independent project director with experience in project management must be appointed for all mega projects, who should be responsible for timely execution of projects. Professors must be empowered to hire people upto certain grade, purchase quickly consumables, equipments and necessary components. They must have a say in policies regarding engineering education, setting up new industry (energy sector, petrochemicals, biotechnology, machinery design etc) and averting problems effecting the industry.

- **Strengthen Public Sector Engineering Institutions:** The engineering universities and institutions have played significant role for producing quality graduates. The services of these engineering graduates have been recognized nationally and internationally. These universities and institutions require heavy and sustained funding to undertake market driven research. There should be rationale in funding to ten foreign engineering universities, and public sector engineering universities and institutes. The public sector universities have potential which should be strengthened. The impediment to progress at public sector universities is lack of good governance, accountability and shortage of competent faculty. The suggestions for improving governance have already been made. There is need to strengthen faculty by employing additional faculty members on attractive salaries and assigned targets of research. This move is bound to give outstanding results by creating entirely conducive environment for research. This probable success will be great impetus to others to take up research assignments.
- **Priorities Indigenous PhD Programme:** The indigenous programme of PhD in engineering disciplines is almost non existent. To develop confidence in research this has

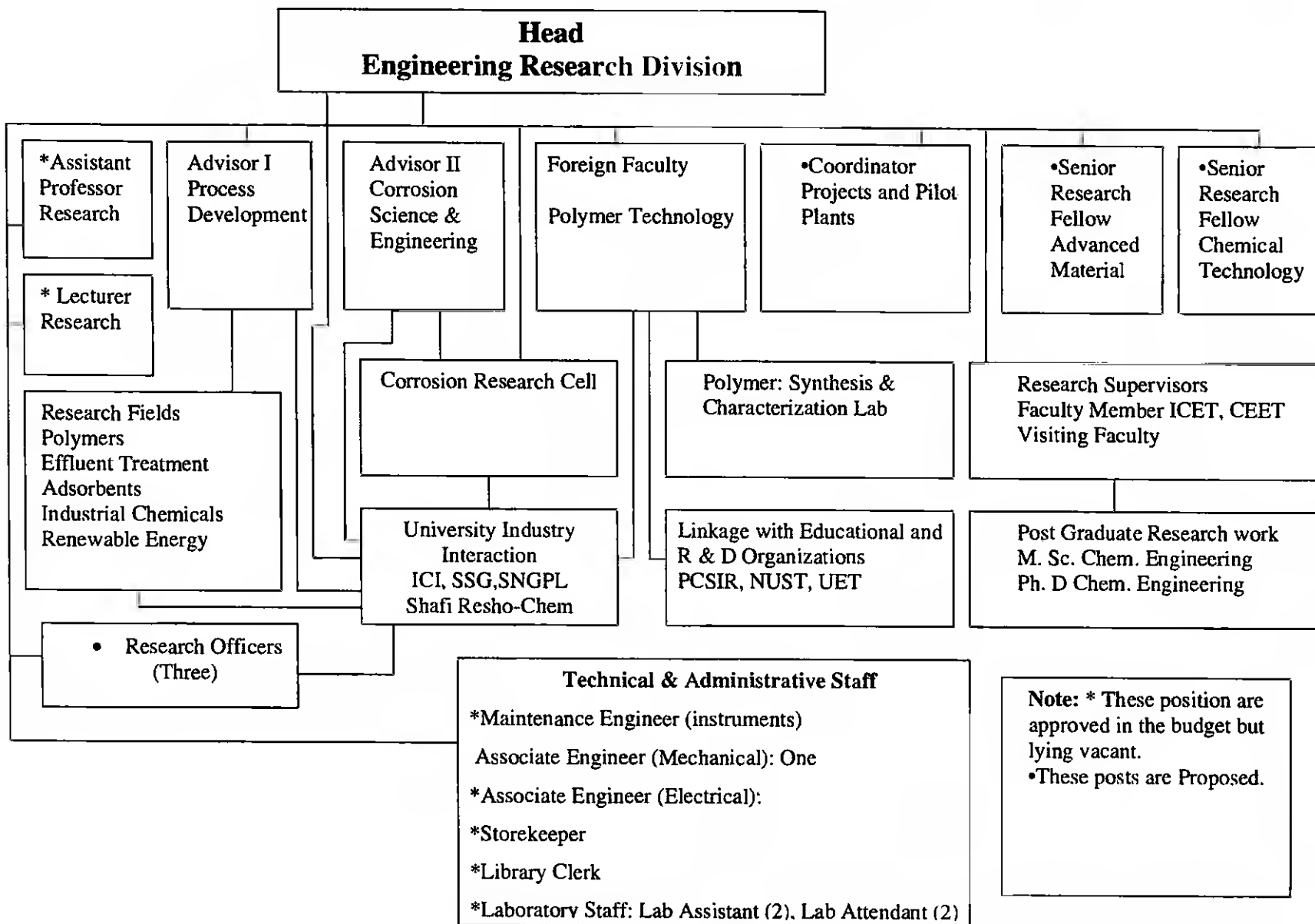


to be established which involve considerable hard work and dedication. Once established its benefits are immense, it is cost effective and will enhance university –industry interaction, facilitate scale up and technology transfer.

The countries in our region like China, India, South Korea and Taiwan have established and strengthened public sector engineering institutions and the research output has enhanced their economic growth. In China which has highest economic growth in the world, in one school of chemistry and chemical engineering (DUT) have 56 professors, 95 associate professors and 330 PhD students (critical mass for research).

- **Reverse Brain Drain:** With current pace of development work in the country in science and technology, considerable time is required to attain acceptable output in research. A crash programme for reverse brain drain must be adopted with commitment and dedication. A database of expatriates experts should be developed and active linkage with these persons should be maintained. As this programme involve considerable money, the objectives should be well defined. The goals and roles of these persons must be emphasized. Attractive salaries, good governance and rule of competence in the country will definitely improve reverse brain drain.
- **Intra University & Inter University Interaction:** In the research there is going be greater trend of interdisciplinary research due to overlap of different fields. Within one university there should be mutual interaction between various departments. Moreover departments should share the experimental and analytical facilities leading to optimum use of resources.

There is also a need for active linkage between universities and research organizations. Different Universities and research organization should work on joint projects related to society and industry. The current practice in various universities is preferably to collaborate with foreign universities. Conversely there is strong argument that initially collaboration within a university for inter disciplinary research should be adopted. These linkages should then develop at national level between various universities and industry. Once the foundations at receiving end have been established then international linkage will be more beneficial.



## **Working Methodology of Engineering Research Division**

The working methodology of engineering research Division is based on consolidating the existing resources, gradually building the capacity for research, and support the industry for uplift of national economy.

To set up experimental and analytical facilities from scratch, efforts were made by utilizations of the available funds to the Institute. In this regard the support of the Vice-Chancellor and Dean Faculty Engineering & Technology and Higher Education Commission are worth mentioning. A basic level of experimental and analytical facilities has been attained with the available funds. The University authorities have funded the employments of a couple of research scholars, and R&D assignments were given to them, which they completed. To fill the gap of expert persons, retired professors/researchers have been engaged. The inputs of these persons have been commendable and based on this fact the cases of employments of a Coordinator of projects& pilot plants and senior research fellows have been recommended.

A significant number of publications have been made in national and international journals. The Engineering Research Division also contributed to number of conferences and workshops. The Engineering Research Division also have the expertise from the Foreign Faculty Programme of the HEC. It is hoped that a nucleus in the field of polymer engineering and technology will be developed as a result of a team of researchers built around him. .

The Engineering Research Division is also strengthening postgraduate education with full support to M. Sc. Chemical Engineering and forthcoming Ph. D in Chemical Engineering. This Division is also giving full support for the upgradation of laboratories at undergraduate & postgraduate level. The strengthening of laboratories will definitely enhance the skills of young engineers graduating from the University of the Punjab to meet the growing needs of the country in the field of engineering & technology.

The star feature of the Engineering Research Division has been the strengthening of University-Industry interaction. A joint project with the Institute of Chemical Engineering & Technology, Sui Southern Gas Company and Science Foundation of Pakistan has been successfully completed and this will act as a model for taking-up of more of such projects. The detail of this project has been mentioned in this report.

## Faculty

### Core Group of Engineering Research Division

1. Prof. Dr. Arshad Chughtai (Head)
2. Prof. Dr. Tahir Jamil (Foreign Faculty Professor)
3. Prof. (R) Dr. Ijaz Hussain Khan, Advisor Research (Corrosion Science & Engineering)
4. Dr. Abdul Sattar, Advisor Research (Process Development)

### Expatriate Persons involved in collaborative work

Dr. Inam Khokhar (USA)	Corrosion Engineering
Dr. Amir Hussain (Germany)	Coating & Adhesives

### Research Scholars/Ph. D. Students

The following research scholars were engaged on various research projects:

Engr. Waheed-ur-Rehman	Polymer Synthesis
Engr. Sikander Rafique	Effluent Treatments
Engr. Usman Majeed	(Ph.D. Scholar) Corrosion Engineering
Engr. Ali Raza Bodla	Biodiesel
Engr. Sarfraz Akram	Chemical Reaction Engineering
Engr. Tahir Ahmad	Adsorption

## Existing Facilities

### Analytical Lab

HPLC with UV & RI detectors	(Perkin Elmer)
GC with FID & ECD detectors	(Perkin Elmer)
UV-VIS (Lambda) Spectrometer	(Perkin Elmer)
Rheometer for rheological studies	(Rheotech)
Atomic absorption Spectrometer	(purchase in process)
GC with FID & TCD detectors	(purchase in process)

### **Corrosion Research Lab**

Potentiostat DC 105, EIS 300 for Coating (Gamry incorporated USA)

Integrity evaluation

Elcometer 456 coating thickness gauge

Elcometer 3240 dry film gauge

Elcometer 3236 wet film polygonal gauge

Elcometer 139

Amine blush check it

Elcometer 135 Bresle patches

Elcometer 138 Bresle conductivity

Elcometer 134 CSN test kit

Elcometer 108 Hydraulic Digital Adhesion Tester

### **Chemical Reaction Engineering Lab**

Bubble Column reactors (Locally designed & fabricated)

Liquid phase reactor (Retrofitted the obsolete Unit)

Catalyst characterization apparatus (purchase in process)

### **Polymer Lab. (approved by HEC Foreign Faculty Programme and being purchased)**

Differential Scanning Calorimetry

Thermal Gravimetric Analyzer

Thermal Mechanical Analyzer

Fourier Transform Infrared Spectrometer

Twin Screw Extruder

Gel Permeation Chromatograph

High Temperature Vacuum Oven

Reactor for Polymerization

## **Postgraduate Teaching & Research**

To produce highly trained engineers this division is providing full support to the following programmes:

1. M. Sc. (Engg) Chemical Engineering
2. Ph. D. (Engg) Chemical Engineering

For these programmes the faculty is actively involved in postgraduate teaching and supervision of research work. As MOU has been signed between Punjab University & Sui Northern Gas Pipeline Limited, this division will provide full support with the introduction of postgraduate courses specialization in natural gas engineering and energy engineering.

### **Future Ph. D Work**

Following areas have been selected for future Ph. D studies.

1. Indigenous coal utilization; coal cleaning & gasification
2. Polymer materials development & characterizations
3. Chemical reactors studies, catalytic hydrogenation & gas phase reactions
4. Pollution control studies

### **Progress of Ph.D. Research Work on Failure of Epoxy Coatings**

The ongoing PhD work started w.e.f. September 2004. The PhD scholar is an officer of the Pakistan Air Force in the rank of Squadron Leader. The scholarship has been awarded by Higher Education Commission in its scheme "Development of S&T Manpower through Indigenous PhD (300 Scholarships)"

The aviation fuel tanks in the Pakistan Air Force are coated with protective epoxy paints from inside to not only safeguard aviation fuel but also the mild steel tanks from corrosion and damage thereof. In a similar manner, natural gas transmission pipeline of the Sui Southern gas Company are coated from outside to protect against effects of atmosphere and soil when buried underneath. The PhD work of Engr Usman Majeed relates to failure of epoxy coatings on steel surfaces.

The equipment made available for PhD work as well as research work for the PSF/SSGC joint research venture has been made available from three sources namely

- (i) University of the Punjab
- (ii) PSF/SSGC joint venture
- (iii) Higher Education Commission

The extent to which the PhD and other research activities have progressed could never have been possible but with the finances provided by Punjab University. Following equipments have now been made available:-

S No	Nomenclature	Utility	Status
1	Automatic sand/grit blasting unit (Pak made) with 7 hp compressor (Taiwan made)	Used for surface preparation of mild steel panels	Functional
2	Surface roughness tester	Used for obtaining data on surface roughness of freshly prepared sans/grit blasted surfaces	Under procurement
3	Surface Contamination test kit CSN Elcometer-134	Used to carry out surface contamination checks for Chlorides, Sulphates and Nitrates on freshly prepared sans/grit blasted surfaces	Functional
4	Wet and dry paint film thickness gauges Elcometer 3236, Elcometer 112, Elcometer 3240 and Elcometer 456 with standard, telescopic and right angle probes.	Used to evaluate paint thickness during application and drying/curing processes	Functional
5	Elcometer 139 ABC Amine Blush Check	Used to find out water contamination between two layers of the coating	Functional
6	Elcometer 106 Hydraulic Adhesion tester with flat, concave and convex dollies	Used to quantify adhesion loss between coating and steel substrate	Functional
7	EIS equipment by M/S Gamry	Used to carry out electrochemical measurements on coated Mild Steel panels	Functional

The experimental set up has been planned and finalized in view of the recent work done worldwide. In this regard samples will also be tested with the help of equipments available at Department of Solid State Physics, PCSIR laboratories Lahore and Pinstech laboratories Islamabad.

It is hoped that enough experimental data will be generated by end of the year so that publications in international journals would be possible.

## **University – Industry Linkage**

The role of a University for the uplift of national economy can be implemented through successful University -Industry interaction. In the field of engineering the University of the Punjab and the Faculty of Engineering & Technology has signed the following MOUs.

1. PCSIR Laboratories Complex, Lahore
2. Shafi-Reso-Chem Chemical Industry, Lahore.
3. Sui Northern Gas Pipe Line Limited.

The Engineering Research Division is contributing significantly for the active implementation of these MOU's. The team of advisors & Professors regularly visited these organizations, held joint meetings and explored the possibilities of mutual interactions.

In this regard following activities are presently going on:

- Research Project “Disbondment of 3L Epoxy / PE Coating and Integrity of Gas Transmission Pipeline: A joint project with Sui Southern Gas Company, Pakistan Science Foundation. This project has been completed and report is mentioned at next page.
- Chemical Industry: Shafi-Reso-Chem. Consultancy services are being provided
- The case studies of following industries were taken and their solutions were provided:
  1. Pak Arab Refinery Limited
  2. Descon Engineering Limited
  3. ICI Polyester



## **REPORT OF THE JOINT PROJECT**

### *Partners*

*Sui Southern Gas Company*

*Pakistan Science Foundation*

*University of the Punjab*

### **Title of the Project**

**“Disbondment of 3L Epoxy/ PE Coating & Integrity of Gas Transmission Pipeline” (psf/ilg/002/03) 2004 – 2007**

### **University Team**

Prof Dr Ijaz Hussain Khan	Principal Investigator
Prof. Dr. M. Arif Butt	Co-Principal Investigator
Prof Dr Javed Ahmed	Co-Principal Investigator
Engr Usman Majeed	PhD Scholar
Engr Akbar Niaz Butt	Research Scholar

### **Introduction**

Corrosion threat to Pakistan’s 10,000 km gas/oil transmission pipeline infrastructure is an engineering and economic problem. The coating of the gas pipeline is the first step towards corrosion control. The application of Cathodic Protection is the second step to protect the pipeline. SSGC management thus decided to conduct a joint project with Punjab University, Institute of Chemical Engineering & Technology and Pakistan Science Foundation.

## **Project Objective**

The objective of the joint research project has been:-

- (i) Characterization of coating disbondment (failure analysis)
- (ii) Consequential effects on long term integrity of pipelines.

The research work was conducted in detail including:-

- (i) Field visit by experts to the site of coating disbondment (10 excavations)
- (ii) Site conditions analyses
- (iii) Tests and studies in laboratories both in Germany as well as Pakistan

### **Adhesion failure analysis (Disbondment)**

During this research project, the adhesion failure analysis (disbondment) has been based on following investigations:-

- (i) Characterization of coatings
- (ii) Surface analysis of substrate
- (iii) Topographic study
- (iv) Surface contamination
- (v) Thermal analysis of cured polymeric coating materials
- (vi) Loss of bond strength (qualitative and quantitative)

During the course of this research project, following advanced analytical techniques were employed for coating characterization:-

#### **(i) *Advanced Surface Analytical Techniques***

- (1) ESCA (Electron Spectroscopy Chemical analysis)
- (2) TOFSIMS (Time-of-Flight Secondary Ion Mass Spectroscopy)
- (3) FTIR (Fourier Transform Infrared Spectroscopy)

#### **(ii) *Thermal Analytical Methods***

- (1) DSC (Differential Scanning Calorimetry)
- (2) TGA (Thermo-Gravimetric Analysis)
- (3) DMTA (Dynamic Mechanical Thermal analysis)
- (4) DETA (Di-Electric Thermal Analysis)

#### **(iii) *Characterization of Soil Corrosivity***

- (1) Linear Polarization Resistance (LPR) Method

#### **(iv) *Electrochemical Evaluation***

- (1) EIS (Electrochemical Impedance spectroscopy)

## Results and outcome

No physical wetting with moisture was observed during peel test for all 3LPE field excavations except Coal Tar Enamel (CTE) coating over a period of three years of research.

One of the most significant results of this research is the fact that the interface between the pipeline steel outer-surface and the epoxy coating is the most crucial weak point along in addition to molecular water diffusion towards disbondment of coating. Application of a coupling agent on the steel surface, after proper cleaning, would alleviate this problem to a large extent in future projects ultimately.

The moisture is bound to diffuse via PE and hot-melt because of the relatively large free volume in PE and, to a lesser extent, in the hot-melt.

Epoxy resins on all coatings are not completely cross-linked as we can show by simulation of post-cure reaction that some reactive groups are still there in the epoxy coating. The interface of Epoxy and hot melt shows various contaminants:-

**Hot-melt-surface;** *silicone, phosphates, sulphates/sulphonates and fats.*

**Epoxy-surface;** *Silicone (lesser than on hot-melt), phosphates, fats but no sulphates/sulphonates.*

LPR method has proved its importance on the basis of its quickness and reliable electrochemical basis in the evaluation of soil corrosivity.

It has been further revealed that corrosion of steel in soil increases with increasing water content up to a critical water value. Beyond this value, the corrosion rate starts lowering down. Pitting kind of behavior was seen on the steel surface visually at lower moisture content. This confirms that cyclic wetting and drying in the field conditions can cause severe pitting in case the coating fails. Characterization of soil corrosivity by Linear Polarization Resistance method has been published on the basis of these findings. A manual on corrosion testing has also been published as an outcome of the research conducted during the joint venture based on a very comprehensive literature survey (printed separately).

### Epoxy Resin Characterization Results

Epoxy Resin (Powder) Characterization was undertaken at Comtech Germany.

- Reaction kinetics were studied with the help of DSC.
- Two glass transition temperatures were measured after the Fusion bonded Epoxy (FBE) powder was cured at 190 °C for 5 min.:  $T_g = 53^\circ\text{C}$  and  $107^\circ\text{C}$  after 1. run. After thermal decomposition of the resin, the remaining inorganic material = 25% Dielectric loss was measured in the range of RT -  $220^\circ\text{C}$  after 1st and 2nd run

## **Qualitative Analysis**

Following elements were detected in the inorganic filler of the FBE powder:

- Ca, Al, Si, K, Ba and Ti (Qualitative analysis )
- Water absorbed by the cured FBE after 24 h at RT: 0.35 %
- Chlorine content of FBE:
- Total Chlorine : 1.59 %
- Ionic chlorine : 0.043 %
- Nitrogen content : 0.07 %

## **Conclusions of Research Project**

It is concluded as an outcome of this research project that the pipeline owners or their representatives must be aware of these product differences and the way in which they impact service performance. This implies a thorough understanding of test protocols and significance of the results. They must also possess the ability to apply the knowledge skillfully in the coating selection, application specifications, procedures of testing and inspection for quality control and ultimate acceptance and regular maintenance

There was no tradition of research, education and training for certification of technologists and engineers working in the field. This situation has changed and linkage of oil and gas industry with research organizations, universities has been developed as a result of the success of this venture. There was total dependence on foreign consultants and coating suppliers, while the present project achievements have created self-reliance within the country.

A full fledged corrosion/coating testing laboratory has been established through the courtesy of the joint venture in cooperation with HEC and Punjab University. Testing facilities include surface preparation/evaluation, coating application/evaluation and electrochemical equipment.

The objective of the project has been successfully achieved through the joint responsibility of the end user, sponsors, university and Pakistani expatriates who were expert in relevant fields having vast experience in the 3 LPE coating-CP system. Moreover, joint research venture was accomplished at a cost of about one third of the international tender basis.

## **Publications**

The Engineering Research Division made significant publications in the form of journal publications, operating manual and projects reports. It is hoped that in future the percentage of international publications will increase

### **Recent Journals Publications**

1. Ijaz Hussain Khan, M. A. Butt, (2007) "T-Type Naphtha Pump Strainer Mesh Failure Analyses" J Academy of Science.
2. Ijaz Hussain Khan, M. A. Butt (2007) "Failure Analysis of a Therminol Heating Fluid System Components" International Seminar on "Integrity of Industrial Materials and Components". 17-18 May (2007) Islamabad.
3. Ijaz Hussain Khan, M. A. Butt (2007) "Theory of Adhesion And Its Practical Implications" (A Critical Review) J. Faculty of Engineering & Technology Punjab University, Lahore.
4. Javed Iqbal, M. Y. Zaki, Rafiq Ahmad, and Tahir Jamil, Submitted (2007) "Glass fiber-reinforced phenolic matrix composites" J. of Material Science.
5. Farah Kanwal, Richard A., Pethrick and Tahir Jamil (2007)"Ultrasonic Degradation Studies of Polyacrylates" Accepted in J. Chem. Soc. Pak.
6. Farah Kanwal, Attia Gul, and Tahir Jamil (2007) "Synthesis of Acid Doped Conducting Polyaniline" Accepted in J. Chem. Soc. Pak.
7. Farah Kanwal, Sajjad M. Warraich and Tahir Jamil (2007) "FT-IR Analysis of Recycled Polystyrene For food Packing" Accepted in J. Chem. Soc. Pak.
8. I. H. Khan, M. A. Butt, (2006) "Concentration Profiles of Supported Bimetallic Catalysts" J. Pak. Academy of Sciences.
9. Waheed-ur-Rehman, Muhammad Arif Butt, Arshad Chughtai, Tahir Jamil, Abdul Sattar (2006) "Effect of Various Solvents on The Viscosity-Average Molecular Weight of Poly Vinyl Acetate" Journal of Faculty of Engineering & Technology University of the Punjab, Lahore.
10. Sikander Rafiq, Muhammad Arif Butt, Arshad Chughtai (2006)"Removal of Chromium (VI) From Electroplating Wastewater By Adsorption" Journal of Faculty of Engineering & Technology, University of the Punjab, Lahore.
11. Sadiq Hussain., Arshad Chughtai and Muhammad Arif Butt ,(2006) "Hydrodynamics Study of 3- Phase Inverse Fluidized Bed" Journal of Faculty of Engineering & Technology.

12. Zafar Iqbal Zafar, Muhammad Arif Butt, Arshad Chughtai (2006) "Desulfurization of Indigenous Coal with Sorbent Injection" J. Faculty of Engineering & Technology.
13. M. S. Anjum, T. Aziz, Muhammad Arif Butt, I. H. Khan, Arshad Chughtai and Arif Jamil (2006) Rust "Appearance Control in Humid Summer Season Using Environmental Corrosivity Evaluation" Journal of Faculty of Engineering & Technology.
14. Hamed Sattar, Syed Nadir Hussain, M. Anwaar Asghar, Arshad Chughtai, Muhammad Arif Butt, (2006) "Production & Characterization of Activated Carbon From Indigenous Coal (Lakhara Coal)" Journal of Faculty of Engineering & Technology.
15. Muhammad Ahsan Iqbal, Muhammad Arif Butt and Tahir Jamil (2006) "Removal of Dyes From Textile Industry Wastewater Using Adsorption Technique" J. Environmental Science and Technology.
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18. I. H. Khan, Rafiq Ahmad, Muhammad Arif Butt, Javaid Ahmad and Farid A. Malik (2003)  
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### **Manuals for Short Courses Cum Workshops**

- 11<sup>th</sup> Annual Short Course cum Workshop on Cathodic Protection System For Underground Pipelines (Advanced Level) 2006
- Annual Short Course on Fundamentals of Corrosion and Cathodic Protection, 2006
- 12<sup>th</sup> Annual Short Course cum Workshop on Cathodic Protection System For Underground Pipelines (Advanced Level) 2007

In-service scientists and engineers from the following industry and research organizations have attended the above said courses:

Pakistan Atomic Energy Commission, Islamabad, Fauji Fertilizer Company Ltd., Mirpur Mathelo, MAS Associates (Pvt.) Ltd. Lahore, Pakistan Air Force, Technical Services Centre, Pakistan Standard & Quality Control Authority, Lahore, Sui Northern Gas Pipelines Ltd. Pakistan Institute of Nuclear Science & Technology, Islamabad, Data Steel Pipe Industries (Pvt.) Ltd. Sadiqabad, Pak Arab Refinery Ltd. Distt. Muzaffargarh, Sui Southern Gas Co. Ltd. Karachi, Sitara Chemical Industries Ltd. Faisalabad, Ittehad Chemicals Ltd. Kala Shah Kaku, Pakistan Petroleum Ltd. Karachi, Shakarganj Mills Ltd. Jhang, National Electric Centre, Lahore, Orient Petroleum International Inc. Islamabad, ESBI Contracting Ltd. Khanewal.

### **Manuals for Testing & Operating Method**

- Corrosion Testing and Monitoring Using Advanced Electrochemical Techniques A manual published by Corrosion Control Research Cell, Engineering Research Division, Faculty of Engineering & Technology, PU Lahore 2007
- Recommended Standard Operating Procedures for SSGC Future Gas Pipeline Projects Published by Corrosion Control Research Cell, Engineering Research Division, Faculty of Engineering & Tech. PU Lahore 2007
- Charactrizing Corrosivity of Soil by Using Linear Polarization Resistance (Lpr) Method Society of Corrosion Engineers Pakistan, Corrosion Research Cell ICET Engineering Research Division.

## **Research Reports Based On University/Industry And Research Organizations Linkage (2005 – 2007)**

The following research reports have been completed in association with Technical Services Centre (TSC), Pakistan Standards and Quality Control Authority (PSQCA), Ministry of Science & Technology, 125-A, Industrial Area, Kot Lakhpat, Lahore for various industries of Pakistan.

1. Report on T-Type Naphtha Pump Strainer Mesh Failure Analysis for Pak-Arab Refinery Ltd. Qasba Gujrat, Mahmood Kot, Distt. Muzafargarh (2005)
2. Report on Corrosion Failure Analysis of spent caustic drainage pipe at Pak Arab Refinery Ltd. Refinery Ltd. Qasba Gujrat, Mahmood Kot, Distt. Muzafargarh (2005)
3. Report on Metallurgical Testing and Failure Analysis of Damaged Mesh of HCDP Adsorption Tower for Presson Descon International Ltd, Lahore (2005).
4. Report on Corrosion Failure Analysis of WHRB economizer for Descon Engineering Ltd. Lahore (ICI Power Plant, Sheikhpura) (2005).
5. Chemical Cleaning/Decontamination of Fin Tubes of Al/Duplex Stainless Steel stained during shipment (Transport)
6. Report on Metallurgical Evaluation of Rusted Transformer Silicone Steel (2006).
7. Report on Metallurgical Evaluation of Tube Welded Join for finding the causes of tube leakage of the fire tube boiler for M/s Descon Engineering Ltd. Lahore (2005).
8. Report on Analytical Test of Rust Spots on Two Medical Instruments (2007).
9. Report on Failure Analysis of Hot Condensate Tank Nozzles for ICI Polyester Plant Sheikhpura (2007).



## Lectures , Workshops and Conferences

### Lectures held at the Engineering Research Division

- (i) Lecture on X-ray crystallography by Dr. Masood Pervaiz, University of Calgary, Alberta. Canada on 14-07-2006
- (ii) A Lecture series on Polymer Science and Technology delivered by foreign faculty professor Dr. Tahir Jamil on March-June, 2006.
- (iii) Lecture on Liquid Soil by Mr. Olaf Stolzenburg, President, RCC Group of Companies (Germany) on 14-12-2006

### Workshops held at the Institute of Chemical Engineering & Technology:

A Workshop on “Research and Development Needs in Textile Processing Industries” was held on 28 March, 2006 as per approved program of National Core Group in Chemistry.

The detail of this workshop is as follows:

Speaker Name	Title
Dr. Tanveer Hussain	Recent Trends in Textile Wet Processing
Dr. Faheem Uddin	Opportunities In Technical Textiles: Reflections On Textile Processing In Pakistan
Engr. Shafiq Ahmed Bhatti	Six Sigma an Introduction and Self Assessment Lean manufacturing
Mr. Leonardo Sionzon	Developments and Future of the Garment Industry in Pakistan
Mr. Irfan Ahmed Shaikh	Need of R & D: Post W.T.O. Scenario

More than forty people participated from the textile sectors.

(ii) A Workshop on "Research & Development Needs in Pulp and Paper Industries" was held on 20 September, 2006 as per approved program of National Core Group in Chemistry.

The detail of this workshop is as follows:

<b>Speaker Name</b>	<b>Title</b>
Engr. Akbar Niaz Butt	A Review on Corrosion Problems in Pulp and
Mr. Aizad H. Sayed	Linkage of production and research and development in pulp and paper industry.
Engr. Javed Iqbal	Pakistan Pulp and Paper Industry National Environmental Quality Standards and Compliance Limitations
Dr. Asad Javaid	Research & Development in Pulp & Paper Industry".
Dr. Abdul Sattar	Chemical Products from Cellulose

More than 100 people participated from Pulp and Paper Industry, Research Organizations and teaching institutions

### **Conferences Attended and Papers Contributed**

1. "Indigenous adsorption material for textile wastewater treatment" Muhammad Ahsan Iqbal, Muhammad Arif Butt, and Tahir Jamil. Presented in *First International Conference on Environmental Science and Technology, Houston, USA. August 2007.*
2. "Synthesis of Silica Aerogel" Tahir Jamil Invited speaker in "*International Bhurban Conference on Applied Science & Technology (IBCAST)*" Islamabad, 2006
3. "Compatibility Studies of Polyvinylchloride-Polystyrene blend by thermal and FT\_IR Analysis" Farah Kanwal, Tahir Jamil, and Nasima Kanwal. "*International Chemistry Conference on "Recent Challenges in Chemistry" GCUF, Faisalabad, 2006.*
4. Failure Analysis of a Therminol Heating Fluid system Components  
*International Seminar on "Integrity of Industrial Materials and Components" on 17-18 May, 2007 Islamabad.*

## **In House Research Projects**

A number of small projects as a continuous activity are being run in carder to create infrastructure and to enhance the expertise and knowledge base of the Research Scholars of the Division. These include;

### **1. Development of adsorbents and their applications**

Adsorbents are widely used in the chemical Industry to separate and remove contaminants and components in the chemical products. Their production from the indigenous raw materials is an on going research activity. In this regards, activated carbon of good quality has been produced from Lakhra Coal and studies has been published in J. Faculty of Engineering and Technology. In the application area removal of Cr(VI) from electroplating waste water by Adsorbents using spectrophotometer has been carried out and the investigations have been published. The research work is also conducted for the production of silicagel. In another project Acacia nilotica (Kikar), a hardwood available abundantly in the country, has been utilized for the production of good quality activated carbon through chemical activation process. The results of the study are being compiled for a publication.

### **2. Polymerization Studies.**

In order to familiarize with different polymerization techniques and to create lab facilities in this area, studies have been conducted for the polymerization of vinyl acetate in various conditions. A paper has been published wherein "Effect of various solvents on the viscosity average molecular weight of polyvinyl acetate" has been reported. The recent initiated work is the production and characterization of Latex (styrene butadiene binder latex) in which the swelling ratio and solubility parameters of cross-linked polymers are being investigated.

### **3. Synthesis of Biodiesel**

The consumption of energy is increasing continuously and petroleum, a major but a depleting sources of energy is being looked into far the replacement with other non-conventional sources of energy. Biodiesel is one such alternative source of fuel which is being investigated in all of the advanced countries for the partial replacement of diesel from petroleum sources. The common method of producing Biodiesel is by the trans esterification which is carried out by a catalysed chemical reaction involving vegetable oil and an alcohol, especially methyle alcohol to yield

methyl fatty esters which can be used as biodiesel. Beside being a perpetual source of energy, it creates less pollution than diesel. Large quantities of waste cooking oil is available from the bakeries and Fast Food restaurants which has been utilized in production of biodiesel (FAME) Admixture with diesel in various proportions yield products which have all the qualities of good quality diesel. The results are being compiled for publication.

#### **4. Production of Emulsifiers and Dispersants.**

Emulsifiers are used to make oil-in-water or water-in-oil emulsions of organic liquids, and dispersants are used for dispersion of fine solid particles in heavy liquid vehicles. Both types of materials are widely employed in the chemical industry for making cosmetics, polishes, lubricants, paints, insecticidal sprays, pharmaceuticals, beverages, ice creams, leather and textile auxiliaries, etc. There are many chemical classes of these compounds and one such type of emulsifiers/dispersants can be synthesised from vegetable oils. Sulphation of vegetable oils under controlled conditions and proper work up yield sulphated oils which are good emulsifiers and dispersants and are extensively used in leather, textile and paint industries. Sulphation of soya oil has been investigated with encouraging results. Further work on the sulphation of other oils is in progress.

#### **5. Chemical Reaction Engineering**

For hydrodynamic and kinetics studies bubble column reactors are used for two-phase gas-liquid reactions and three-phase catalytic reactions. Ruthenium and palladium catalyzed reactions will be studied. It has been also planned to initiate research work in the synthesis and characterization of hydrogenation catalysis.

### **Continued Education for In-service Scientists & Engineers**

Internationally continued educational programs are organized for formal and informal training and education in the field of Corrosion Engineering. Each year number of Corrosion Engineering short courses cum workshops are held at various places in the developed countries and all over the world. Announcement of these courses appear in the International Publications such as NACE International etc. Pakistani Engineers seldom afford to attend such courses, which involve lot of expenditure per person. In view of the facts the Engineering Research Division, Institute of

Chemical Engineering & Technology organize these courses cum workshops under the Faculty of Engineering & Technology, University of the Punjab, Lahore in association with Society of Corrosion Engineers Pakistan. These courses cum workshops are undertaken for pursuing the continued education programs in the field of Corrosion, Science and Engineering for in-service scientists and engineers. Dr. M. Inam Khokhar, Corrosion Specialist (USA Pakistani Expatriate) is invited every year to participate in these courses.

### **Grants Seeking and Utilization**

The Engineering Research Division has successful track record of obtaining grants and efficient utilization. The detail is as follows:

1. From the Higher Education Commission grant for the Central Instrumentation Laboratory the allocated Rs.1.5 million was utilized. Moreover with the grant provided by the University of the Punjab, an analytical laboratory was established. The analytical equipments purchased are chromatographs, spectrophotometer and a rheometer.
2. A PC-I worth of Rs.39 million for the strengthening of laboratories was submitted and in this regard, Rs.11.00 million were received. For the purchase of instruments a list was prepared and communicated to Project Director. The Equipments are in purchase process.
3. The Higher Education Commission provided a grant for establishing laboratory facilities in the expertise area of foreign faculty professor. In this regard Foreign Faculty Professor Dr. Tahir Jamil submitted a PC-I worth of Rs.38 million. This has been approved and as soon the amount is available, the purchase of equipments will be done.
4. For the well planned expansion of the Engineering Research Division, an idea of School of Process Engineering Research has been proposed. A PC-I worth of Rs. 490 million has been prepared and submitted to the Director Planning University of the Punjab, for onward transmission to HEC.

## Future Plans: *School of Process Engineering Research*

There is strong demand for the establishment of research based engineering solutions to the industry and development of indigenous technologies. In this regard the idea of *School of Process Engineering Research* is presented. This project with a capital cost Rs.490 million & annual recurring cost of Rs.40 million will provide required infrastructure to speed up Research & Development Activities. The proposed project is to provide sustainable development, reverse engineering of the developed technologies and promote self sustained industrial environment with a strong linkage of promoting our indigenous resources.

It is envisaged that the project would strengthen University-Industry interaction by engineering technological support in connection with research based solutions. The project would facilitate mitigation environmental aspects on national level through promotion of cleaner production processes, environmental engineering, sociological and socioeconomic engineering solutions by promoting; recycling of chemicals; efficient monitoring, utilization and control of production units; and enhancement in utilization of indigenous resources (agriculture wastes/by-products, the entire discipline of organic waste) The results of the research conducted at this school will be presented in the showcase for industry. It is hoped that activities at this research school will not only provide an opportunity for training of human resources but also act as seeding of new industrial developments.

**At the School of Process Engineering Research the Postgraduate teaching and research will be in the following areas:**

- Polymer Engineering & Technology
- Advanced Materials Engineering/Nano Science & Technology
- Absorbents and Catalysts
- Chemical Reaction Engineering
- Indigenous Mineral Based Chemicals
- Specialty chemicals
- Corrosion Science and Engineering
- Environmental Engineering
- Renewable Energy
  
- Natural gas and Petroleum Refining Engineering
- Separation Processes Engineering
- Heat Transfer
- Policy studies for Energy, Environment and Chemical industry

To supervise and conduct research in these areas highly qualified and trained persons are required. In this regard Higher education commission would be requested for the provision of 10-15 research supervisors, as a number of engineers and scientists have been sent abroad for PhD. After the successful completion of doctoral programme these persons can be placed at this school. Moreover strong linkage will be developed with alumni and expatriates. It is envisaged that this school will emerge as *centre of excellence in process engineering research*.



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