

Polymer engineering education in Pakistan: Curriculum development and prospects

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ABSTRACT

Polymer processing industry is among the major contributors to the economy of Pakistan. The industrial sector comprises mainly small to medium sized units. To support this large industrial sector, there are two departments in the country which produce engineering graduates in the area of polymer engineering and science. The evolution and development of these degree programs have been discussed. Curriculum design and development of laboratory facilities of the university degree program have been elaborated in detail. The curriculum was improvised from the existing chemical engineering degree curriculum. The evolution has been discussed in terms of defined objectives and guidelines, limitations and available resources. For the future prospects, it has been identified that academia need more efforts to develop the existing programs in terms of quality and graduate research based programs are the need of the day.

Keywords: Pakistan, Curriculum development, Polymer engineering education

Polymer Industry in Pakistan

Polymers related industries in Pakistan have more than US\$ 1.0 Billion capital investment and these have been growing with a rate of 7.5% (2009). This significant growth may be attributed to rapidly increasing consumer product demand [1-2]. Polymer sector in Pakistan comprises small to medium scale downstream polymer processing industries. A recent break up shows more than 6000 polymer processing units compared to only four resin production units in the country [3]. The latter produce Polyvinyl chloride (PVC), Polyethylene terephthalate (PET) and High impact polystyrene (HIPS). These resin producers contribute only a fraction to the total raw materials supply in the country. It is evident that development of the plastic industry has focused more on the processing than on the polymer resin manufacturing in the country. The down-stream processing industry mainly comprises injection moulding, packaging, and extrusion units. These units face common key problems such as raw materials price fluctuation linked to the global petroleum prices, severe shortage of skilled and trained manpower, product testing and quality certification issues and lack of research and development. Exports are very limited due to the problems in quality certification, strong dependence of cost of production on energy and raw materials prices and low competency and poor 'production economy'. For all these challenges, the industry seeks guidance and help from the academia.

History of Polymer Engineering Institutions in Pakistan

Currently, for the population of more than 170 million, there are seventy three public sector universities and almost sixty privately operated universities in Pakistan [4]. Among these, fifty nine universities offer engineering programs in various fields which have been recognised by the Pakistan Engineering Council (PEC) [5]. Further, only two institutions offer the undergraduate degree programs in polymer engineering whereas polymer chemistry

is being taught either as a course or as the part of organic/physical chemistry courses at graduate level in around thirty public sector universities of the country. This number has grown (e.g., from seventeen in 1995 [6]) over the years with the overwhelming growth of number of universities in last decade.

In 1988, Plastic Technology Centre (PTC) was set up in Karachi with the assistance of United Nations Industrial Development Organisation (UNIDO). It started with short courses in polymer science and technology and later introduced a one year diploma program in plastic technology in affiliation with the University of London. The program was upgraded to a degree program and first batch of B.E. (Bachelor of Engineering) Polymer Engineering graduated in 2001[3]. Later on (in 2002), PTC obtained a grant of 455 million Pak Rupees (7.6 M USD) from JICA (JAPAN International Cooperation Agency) which was used for the development of building and up-gradation of laboratory resources [3]. At the present, the centre has good laboratory facilities and human expertise especially in the area of polymer processing and fabrication [7]. Curriculum of the program offered by the centre has been evolved from the technology oriented diploma courses and it focuses on the technological aspects of polymer processing and testing technologies [8]. Little has been focused in this curriculum on the areas such as polymeric materials syntheses, polymer blending and composites, emerging polymeric materials etc. Moreover, laboratory courses in Thermodynamics, Reaction engineering, Transport processes are missing. Similarly polymer rheology is less focused as only a four credit hour course on “Flow Behaviour of Polymer Melts” has been included.

University of Engineering and Technology Lahore announced a four year degree program in polymer engineering in 2001 and later on in 2006; it was entitled as “B.Sc. Polymer and Process Engineering”. The program enjoyed an initial grant of 30 million Pak Rupees (0.5

Million USD) from the Higher Education Commission of Pakistan (HEC) which was utilized for the establishment of laboratory facilities in the area of polymer engineering and science.

Curriculum Development

Polymer engineering and science is a multidisciplinary field which encompasses chemistry, physics (mechanics) and various engineering disciplines. At the global level, graduate programs have been more focused as compared to the undergraduate programs. This trend is probably due to the fact that the specialization of polymer synthesis and characterization in the field of chemistry had been established some half century ago. As far as engineering disciplines are concerned, incorporation of polymer chemistry into the curricula of undergraduate chemical engineering program has been a matter of recent discussion [9]. Similarly, polymers are being taught as a course in the curricula of already established engineering disciplines [10]. Being emerging discipline, the degree in polymer engineering (and science) has been evolved either from plastic technology program or initiated under the umbrella of already established disciplines like Materials, Chemical or Mechanical engineering.

At the University of Engineering and Technology Lahore, the Department of Chemical Engineering was mandated to anchor the new program in polymer engineering, keeping in view the following factors.

- 1) Polymer engineering had been taught as an elective specialization course in 4th year of B.Sc. Chemical engineering since long. Polymer engineering was considered as the extending and emerging discipline of chemical engineering with many common areas.
- 2) Only chemical engineering department had the qualified and experienced faculty in polymer engineering field, though very few in numbers.

Later on, in 2006, a new department of Polymer and Process Engineering was established with full administrative autonomy and control. While developing the curriculum for this new degree program, following objectives were identified.

- The curriculum would address the polymer design, compounding and processing operations along with the design, development and operation of a chemical plant producing polymer resin through polymerization.
- Polymer processing operations would be included in the curriculum with the background of unit operations involved in the process engineering.
- Courses for polymer properties modelling and predictions and rheology would be focused.

To fulfil these objectives, two major guidelines were chalked down for the curriculum development.

- Unit operations and thermodynamics involved in process engineering would be included in the syllabus.
- Appropriate weightage would be given to mathematics, chemistry and computing courses in the curriculum.

Based on these objectives and guidelines, the degree was entitled as "Polymer and Process Engineering". The courses and their prominent interaction are shown in Figure 1. First and second years studies build the basis with the courses of introductory nature [11]. In third and final years, core level courses in polymer engineering have been introduced with the emphasis on viscoelastic behaviour of polymers and polymer rheology. These supplement to the application oriented courses in the area of polymer product and processes design. Process engineering stream stems out from the courses such as industrial stoichiometry and fluid flow and progresses by encompassing core unit operations (mass transfer, heat transfer etc.), aiming at the chemical engineering plant design. Courses such as polymer structure and

synthesis and polymer reaction engineering support the plant design to be more oriented towards polymer resin and petrochemical plants design and operation.

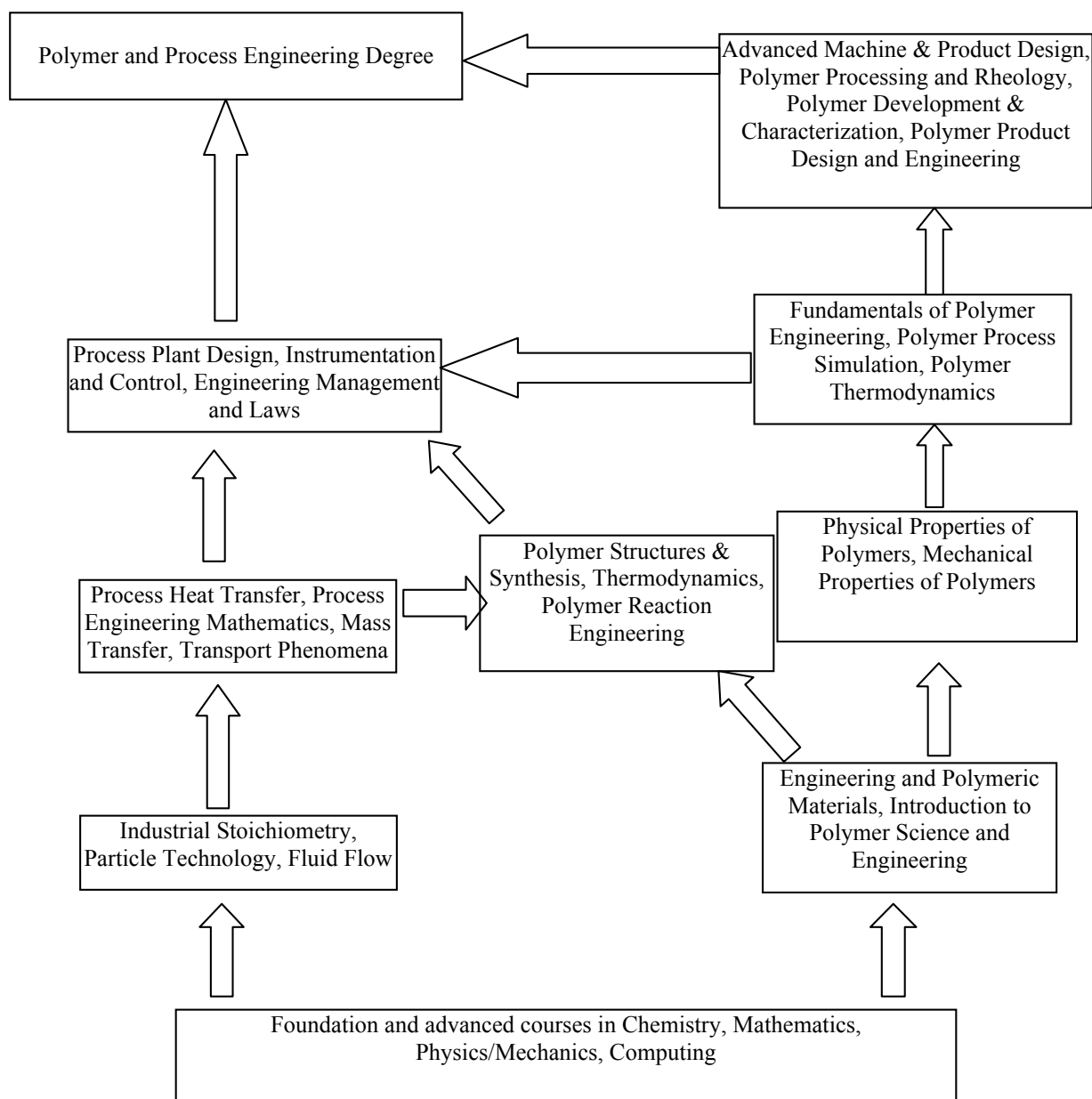


Figure 1. Syllabus of Polymer and Process Engineering

Laboratory Facilities

Laboratory facilities in the field of polymer engineering, in addition to the conventional chemistry, computing and physics laboratories, are divided into two groups as shown in

Figures 2 and 3. Process engineering laboratories comprise rigs covering the basic unit operations such as fluid flow and pumping, heat exchange equipments, distillation, absorption, drying etc. Polymer engineering laboratories are, further, sub-categorized into polymer processing and polymer testing & characterization laboratories.

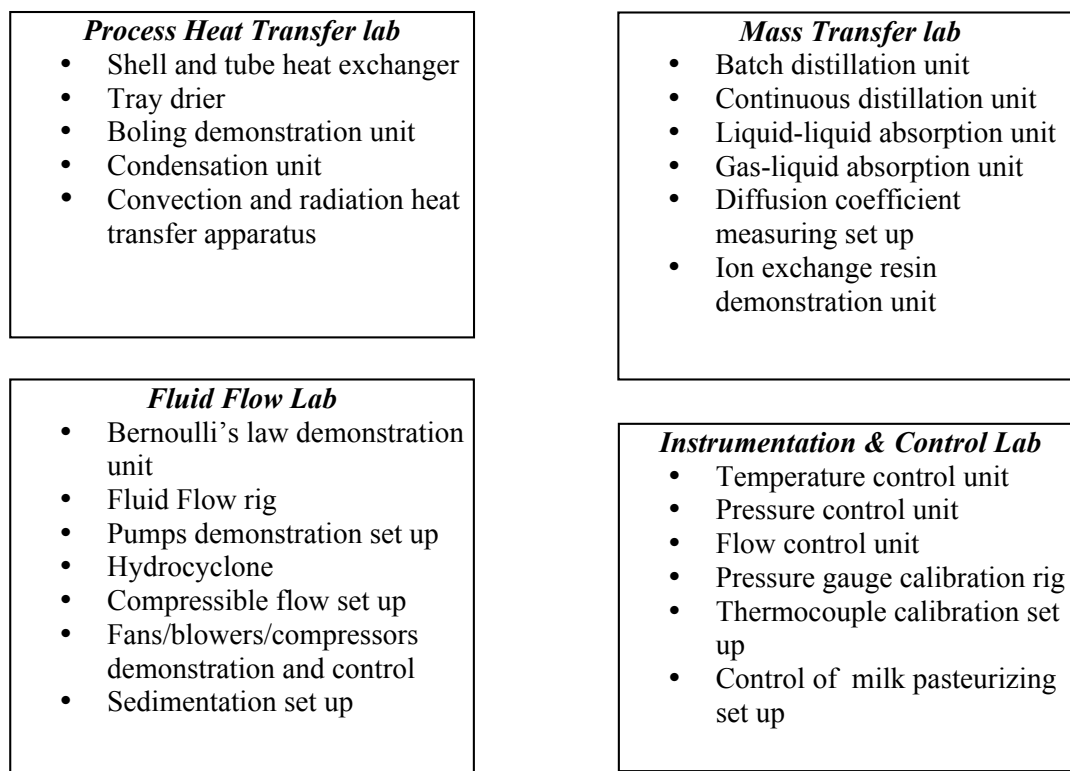


Figure 2. Process engineering laboratories

The former category comprises pilot-plant scale units in polymer processing such as pipe extruder, wire coating set up, sheet extruder, injection moulding machine, blown film extrusion set up etc. Polymer testing & characterization laboratories include modern instruments such as gel permeation chromatograph (GPC), Brabender[®] measuring mixer, differential scanning calorimeter (DSC), infra-red spectrometer (FTIR), universal testing machine (UTM) and various rheometers along with many single point testing instruments [12].

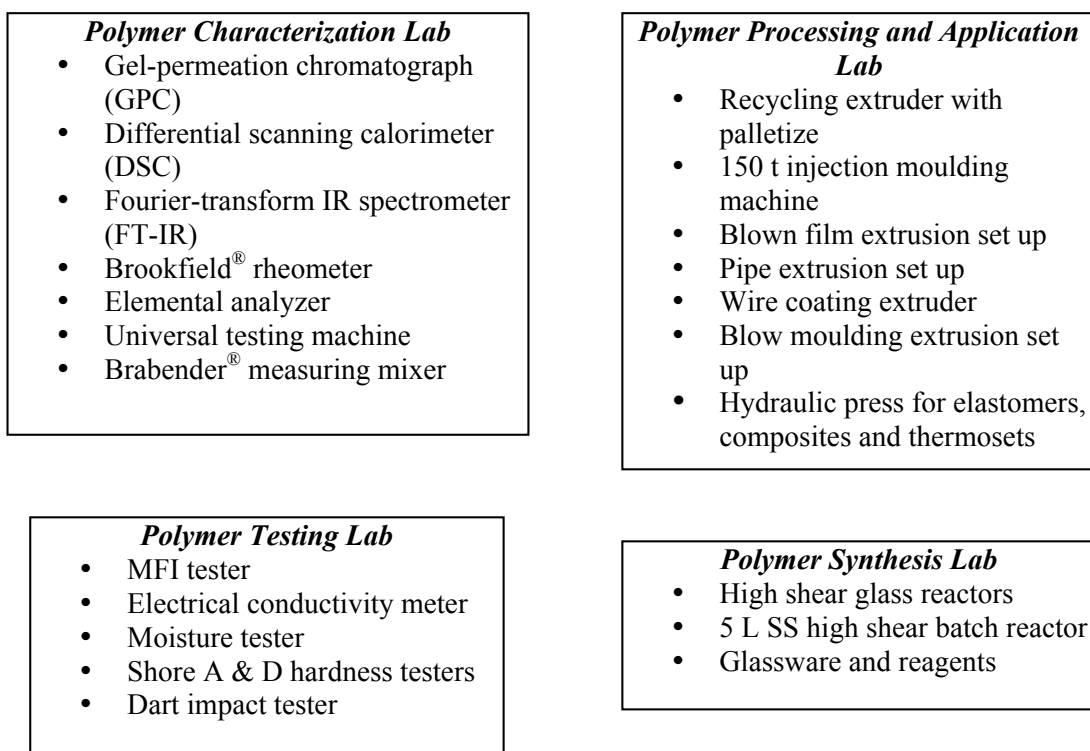


Figure 3. Polymer engineering and science laboratories

Current Limitations and Future Prospects

Recently, the department has obtained 30 million Pak Rupees for the establishment of laboratories in process engineering, composite fabrication, reaction engineering and also for the strengthening of polymer testing and characterization facilities. However, the lack of qualified faculty is the major challenge faced by the department. So far the department has relied on the faculty experienced from polymer research and development sector for its establishment and development. Recently, the University has awarded the overseas scholarship for higher studies to almost all of the faculty members of the department. Earlier, some of the faculty members have won the nation wide HEC overseas scholarships. It is expected that after four to six years, the department will have strong faculty resources qualified in polymer engineering and science from some of the best universities of the world.

The department needs to establish its postgraduate program and strong liaison with local industry. It needs to lay down a post graduation base but trained and qualified faculty is the limitation. In the present scenario, best strategy could be the inception of one year post graduate diploma (PGD) in polymer engineering and science with best utilization of the available resources. The department has recently announced MSc engineering program which is a blend of advanced courses in Process and Polymer engineering [13].

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