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POLYMER MATERIALS SCIENCE IN THE ENGINEERING CURRICULA

Tibor CZVIKOVSZKY

Department of Polymer Engineering and Textile Technology
Technical University of Budapest
H–1521 Budapest, Hungary
Phone:(36–1) 463 1526

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Abstract

The teaching program of the re-designed Department of Polymer Engineering and Textile Technology is outlined. The advanced science and technology of polymers is well reflected in the recent technical literature, textbooks and monographs. The new teaching programs of the department serving the new modular educational system of the future mechanical engineers is surveyed. The department offers postgraduate programs and plans for advanced R/D activity on both polymer and textile engineering.

Keywords: polymers, materials science, engineering education.

Introduction

Like the technology itself, the technical education is going through a period of profound changes in our times. Although the mathematical and mechanical foundation of engineering sciences remains as important as earlier, the advent of the modern computation methods opens new horizons and allows to dedicate somewhat more time to new engineering disciplines. For the applied technical sciences, the programs and the subjects of the engineering curricula should change more profoundly as the materials and processing technologies have shown revolutionary changes in the last decades.

Polymer Engineering as a Material Science

With the arrival of new materials in the advanced technologies, the *materials science* has gained crucial importance in the teaching program of technical universities worldwide. The engineer's task is to create more rational products and technologies with less material and energy consumption, and in better harmony with our fragile environment. This requires a deeper understanding of the structure of materials, and a total, optimized control of their processing technology and quality.

The Faculty of Mechanical Engineering of the Technical University of Budapest decided a major change in the structure of the graduate level engineering curricula in 1992. It has been proposed to broaden the profile of the former *Department of Textile Technology and Light Industries* into a **Department of Polymer Engineering and Textile Technology**. In fact, the transition of the Hungarian industry, particularly the diminishing demand for mechanical engineers in the textile industry accelerated those changes. On the other hand, there has been a steadily growing interest at the Faculty as well as among the industrial processors toward the new materials and technologies of polymers.

If we consider one of the most important activities of engineers, i. e. the *product design* in the broadest range of industrial products, from the biggest transport machines to the smallest household electronics, the work starts by searching through all the three families of engineering materials:

- *metals,*
- *polymers,*
- *ceramics,*

as well as their multiphase composite material derivates.

The industrial consumption data of metals and polymers in developed countries show clearly the trends of the two major groups of engineering materials.

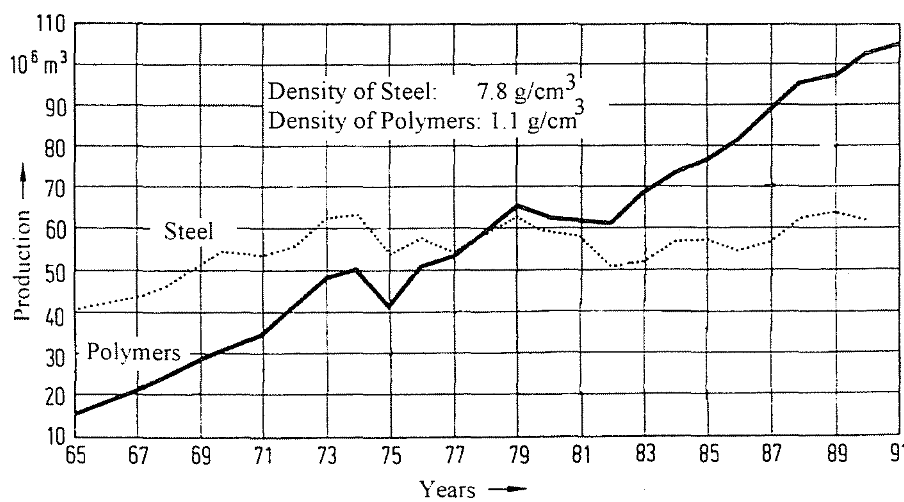

Fig. 1. Steel and polymer production of the developed world [36]

Polymers, the youngest family of structural materials, have always been the raw material of the so-called *light industries*, i.e. textile, paper, wood and leather industries and their relatives. After the years of 1930, however, a new branch of materials became significant: the *synthetic polymers*. About 60 years ago, the new age of man-made materials has begun with a production rate of some 10^3 tons/year, which has increased into a worldwide production of 10^6 tons/year by the 1960s. In the last three decades the synthetic polymer production has increased another two orders of magnitude, reaching a hundred million tons/year in the developed world of North America, Western Europe and Far East altogether. In fact, those developed countries are producing and consuming more polymers than metals since about 1980, if calculated in volume/year terms. In those 'western' countries presently the steel production is less than 400 million tons/year, while the synthetic polymer production is over 110 million tons/year, and the trends are further accentuating those figures. The Hungarian steel and polymer industries indicate similar trends.

Table 1
The production and export of steel and synthetic polymers in Hungary

(10^3 to/y)	1970	1980	1988	1989	1990	1991	1992
Raw steel production	3110	3925	3546	3303	2823	1855	1520
Rolled steel products	2488	2950	2789	2533	2165	1519	1326
Steel exports	990	1020	881	1120	1063	927	940
Polymer production	56	318	590	643	615	657	692
Polymer consumption	133	347	487	487	374	342	306
Polymer exports	10	130	245	306	341	427	494

The question is how those trends are reflected in the materials science, and how the new science and technology should be introduced into the engineering curricula, into the educational programs of the future mechanical engineers.

The **polymer science** as an engineering discipline is similar to the materials science of metals or ceramics describing

- the *structure of materials,*
- the *processing technologies* and
- the *application* technologies: the use of those materials in the *product design.*

There is no doubt that the first two subjects belong to the basic knowledge of any industrial engineer of the next century. Our department of Polymer Engineering and Textile Technology is offering a subject of *Polymer materials* in the 3. semester of Mechanical Engineering curricula, just after the *Structure of (metallic) materials* course in the 2. semester. After this, a course of *Polymer (processing) technologies* follows in the 4. semester, again, consecutively to the *(Metallic) materials technology.* By learning these polymer technologies, the mechanical engineers are interested in the plastic transformations and high speed processing technologies, including their machinery and tools, rather than in the manufacturing technology of polymers, however, those technologies should also be shortly outlined.

The maturity of the polymer science — structure and technologies — is well reflected in the technical literature of the last few years. The university textbooks show clearly the integration of polymer science and engineering into the materials science as a whole, treating metals, polymers, ceramics and their composites together [1–5]. The common base of a systematic approach of all the engineering materials shows the key: *completing* and *complementing* rather than *competing.* The different engineering materials have interesting complementary functions, making work together metals, ceramics (silicates) and polymers, typically in the fibre-reinforced composites such as in a steel-radial automobile tyre.

The German and English language literature of polymer engineering is extremely rich in the last years. Excellent handbooks of 300–600 pages are introducing the structure of polymers [6–14]. The clear concept about the build-up of polymer chains, the mechanical, viscoelastic behaviour of those chains are well described in terms of the modern mechanics.

It is important to emphasize that the cohesive strength between the members of polymer chains (monomers) would allow to produce commercial polymer products of much higher tensile strength if we better control the secondary structure of polymers by assuring better cohesion in cross-direction, e.g. by higher crystallinity. Such stronger-than-steel polyethylene fibres of extremely high (90%) crystalline portion were commercialized in the last 5-10 years. The tensile strength (3000 MPa), modulus of elasticity (90 GPa) of those polyethylene fibres are really spectacular.

There is a considerable number of excellent new textbooks of polymer processing in German language [15–20]. In the background of polymer processing technologies there is an advanced science of *melt rheology*, belonging to one of the most rapidly developing fields of fluid mechanics. The new textbooks and monographs describe this in a more and more detailed, clear way [21–23].

For advanced courses at higher level (in the semesters 7–9), an abundant flow of information is offered concerning modern polymer processing technologies, machinery and tools [24–34].

Product design is considered as one of the most attractive parts of the engineering work. As the polymer applications are extremely rapidly growing everywhere, particularly in transport machines, packaging, building constructions, computation, robotics, electronics, sport articles up to all kinds of mass-production of commodities, the constructor's work, the *part design* is described in some very well-written concise recent books, helping to select some engineering plastics of high performance together with cost-efficient, high-speed and still high-quality processing technologies [35–40]. An important feature of product design today, that the new part should be designed considering the full life-cycle, including the disassembly and re-processing after repeated recycling [36, 37].

On the top, responding to the highest requirements, *polymer composites* show really amazing performances. Those are the materials for aeronautics and space applications, and more and more for everyday engineering too, up to bicycles for children. They are the champion materials in strength/weight values among all the structural materials. Polymer composites also require a systematic approach in mechanics, as well as in processing technologies. The English and German books of the recent years are showing again how important role those composites play in the engineering curricula [41–49].

For the part of textiles as well, we tried to find and recollect the most interesting recent books of textile and fibre science, with special attention to the role of fibres in reinforced composites [50–57].

Our effort to search for updated literature, and make it available for our teaching program was greatly helped by the National Science Foundation 'OTKA' by which we were able to buy most of the here mentioned reference books (for an average cost of 100/USD each) for our redesigned department.

The recent issue of the *Periodica Polytechnica ser. Mechanical Engineering* is devoted to the activity of Department of Polymer Engineering and Textile Technology. Most of the articles show the continuing high-level activity of our team in the textile engineering. Professor M. Jederán's works present several scientific aspects of the weaving technology. Associate professor L.Vas and his coworkers dedicated their works mainly to the science of fibres, fibre bundles and yarns. His group was successful in constructing a new, computerized *image processing* system as a powerful method of yarn research as well as an instrument for postgraduate teaching.

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