

## MATERIALS AND CHEMICAL ENGINEERING

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Our materials of engineering have undergone a major technological evolution within the last five or ten years. Although the rapid strides have not involved the chemical engineer as extensively as it has engineers from other disciplines, the changes which have occurred are of interest to the chemical engineer because he is responsible for a number of the processing steps which are required in materials production. Furthermore, the chemical engineer has received new materials with which he may build his equipment and base his designs.

The topics of the next six papers will be concerned with the role of the chemical engineer in materials processing, the role of the materials engineer in the chemical processing industry, the considerations which must be given to materials in chemical process design calculations, and the significant problem of corrosion and its control through materials design and selection. Each of these will lead to the pedagogical problem of how do we teach the required topics to our chemical engineering students. Two approaches may be taken, viz. through physical chemistry and through engineering. Obviously the optimum approach is probably some combination of the two; however, we shall hear opinions on the contributions of the two academic areas.

### Materials Science

The rapid evolution which has occurred in the general area of materials during recent years is a result of two situations: (1) There has been a demand for improved materials for the more complicated designs of present engineering. Previously available materials have not met these demands. (2) Science has provided the engineer with a better understanding of the nature of materials as a consequence of advances in solid state physics and crystal chemistry. These advances have permitted general underlying principles to be formulated. These principles present a better means of extrapolating our knowledge for use with the development of new and improved materials. Simply stated, the basic underlying principle in the science of materials is "properties are controlled by the internal structure." Thus (1) if we know the internal structure of a material, we can be more specific about the material's properties, or (2) if the processing or service condition which are encountered by the material alter the internal structure, then we can anticipate a change in the accompanying properties.

The significance of structure on the properties and behavior of materials has changed the teaching and engineering considerations from previous descriptive approaches to approaches that take into consideration (1) the atomic structure, (2) the arrangement of atoms into molecular and crystal structure, (3) the arrangement of phases into microstructures, and (4) variation of microstructures within macrostructures. This systemization has permitted the establishment of principles which are usable with various types of materials whether they be metallic, ceramic, or polymeric. In general, the materials specialist is concerned with solid materials; however, the principles which are developed may also be used for liquids if appropriately applied.

### Materials Processing

In general, there are two types of processing which are encountered in the manufacture of any engineering material. These include (1) chemical processing, and (2) mechanical processing. In addition, consideration could be given thermal processing; however, thermal treatments are generally used to facilitate the chemical and mechanical processing through changes in the equilibrium, kinetics, or properties of the materials.

The chemical engineer has participated extensively in the processing of polymeric materials and less so in the processing of metallic and ceramic materials. If the chemical engineer is involved in the processing of materials, he must be fully conversant with the specialist who specifies properties and applications. Conversely, if the metallurgical or ceramic engineer is to have his full effect in the manufacture of materials, he must be cognizant of the processing principles which the chemical engineer and the mechanical engineer have developed.

#### The Materials Engineer

The materials engineer may bear the label of metallurgist, ceramist, or plastics engineer. In any case he is a specialist who is concerned with (1) the development of new materials, and (2) the critical application of materials in engineering design. As such he fills the gap between processing and engineering design. The materials engineer must understand the basic nature of materials so that he may develop real materials from the chemists' and physicists' ideas. Furthermore, he must understand the service conditions which prescribe the designed requirements. To this end he must be conversant with the mechanical, electrical, structural, and chemical engineer. The procedure for training men to fill this category is a subject of active discussion in many academic circles.

#### The Future

The engineering future as measured by the present research and development indicates that several areas will receive emphasis with respect to materials processing by chemical means. Foremost among these is the emphasis upon greater purity. This emphasis ranges from the beneficiation of existing raw materials so that they have more consistent and desirable composition, to the demand for extreme purity in the manufacture of many of the newer electronic and higher temperature materials. A second area of projected activity is into the processing of new materials with compositions and structures which have not been utilized heretofore on a commercial basis. Often this means high temperature or special pressure and catalytic requirements. A third area of future expansion is that of the production of single crystals. Currently we think of single crystals as laboratory specialties. The demands for single crystals have only been scratched and almost certainly the variety and tonnage requirements will be sufficient to build several special industries.

#### Summary

There has been a rapid evolution in the area of materials science and materials development. The chemical engineer along with engineers from several other disciplines are deeply involved. Furthermore, we should expect significant changes to occur in the foreseeable future.