THE METALLURGICAL ENGINEER

By ARTHUR H. DIERKER, '25

Webster's dictionary defines metallurgy as "The science and art of preparing metals for use from their ores by separating them from mechanical mixtures and chemical combinations."

However, present usage of the word would make this definition too limited and it would probably be better simply to say that metallurgy is the science and art of preparing metals for use.

In biblical history we find metallurgy placed second only to animal husbandry, for in the fourth chapter of Genesis we read that Tubal-cain was an instructor of every artificer in the working of brass and iron.

When engineering is mentioned most people think of the civil engineer. It has been said, and rightly so "that the civil engineer is continually editing and revising nature, rearranging mountains and making rivers back up and go the other way." One may wonder, nevertheless, just how much revision and rearranging of nature could be accomplished without the aid of powerful tools of iron and steel.

The metallurgist (artisan as well as engineer) may not cut such a romantic figure but he has formed a very necessary background for the characters that walk across the pages of history and legend.

King Arthur and his knights of the Round Table as they rode about righting the wrongs of the world would have presented a rather sorry spectacle without their gleaming armor and mighty swords. The unsung hero of many a battle has been the prosaic worker in metals.

Seriously, however, the insistent demand from other fields of engineering for metals with new and unusual properties has been responsible, in a large measure, for the remarkable developments in the science of metallurgy during the past comparatively few years.

The electrical industry has required metals of quite well-defined physical properties: copper and aluminum of high conductivity as well as high mechanical strength for transmission lines; resistance alloys of low conductivity; special irons of high magnetic permeability for transformer cores; permanent magnet steel of high coercive force; metallic filaments for incandescent light bulbs; and many other alloys of definite physical properties to meet special conditions.

In the mechanical engineering field the automobile has been the largest contributor to the demand for special steels and other metals. The automobile owner can have his crushed fender straightened and save the cost of a new one, only because the manufacturer has used a steel developed for that particular purpose; i. e., a steel that will stand a great deal of cold work without becoming brittle. The cast-iron cylinder blocks in the modern engine will resist wear much better than the old blocks, due to recent developments in the metallurgy of cast iron.

High speed motors demand light reciprocating parts. Their demand has been met by the development of light alloys for pistons and connecting rods. The high speed and quick acceleration of the modern automobile means less weight with increased strength of all parts. This means special steels. Quantities of alloy steel as well as high quality carbon steels are used. Most of these receive special, closely controlled heat treatment to secure the maximum strength and greatest degree of resistance to shock and fatigue.

Extreme hardness of metals is usually associated with brittleness. Parts such as gears and pinions, roller bearings, spring shakler, etc., must be extremely hard to resist wear and at the same time very tough to resist shock. These requirements have been met by the development of case hardening. By special treatment the outer layer of the metal, possibly 1/16 of an inch or less, is hardened while the interior retains its soft tough properties.

Small parts for carburetors, fuel pumps, speedometers, etc., are made by the die casting process. The production of die castings has become an industry in itself.

Probably the most exacting demands on metallurgy have been made by the aircraft industry. Due to the necessity for light weight and the nature of aeroplane operation, aeroplane parts are probably more highly stressed than any other type of machine. For that reason it is important that the maximum strength and endurance properties be developed in all the metals and alloys used in its construction.

Boiler pressures in modern power plants have been advancing rapidly in the past few years and pressure of from 600 to 1200 pounds per square inch are not uncommon. High steam pressures mean high temperatures and the metallurgist has been forced to study the behavior of metals under stress at high temperatures.

The rapidly expanding chemical industry has required the development of alloys that will withstand the action of corrosive liquids and gases.

Enough, I believe, has been said to give an idea of the importance of metallurgy in the engineering field. I should now like to discuss a few of the recent important developments in metallurgy.

Metallography as a distinct branch of metallurgy is of comparatively recent origin. It has been defined as "the study of the internal structure of metals and alloys, and its relation to their composition, and to their physical and mechanical properties." This internal examination has been accomplished, not by actually using some means of looking into the metal itself, but by cutting it up and examining the cross section through a powerful microscope. The microscope has shown that even pure metals are complex in physical structure. The apparently homogeneous mass is seen to be an aggregate of crystalline grains. Careful examination and actual tests have shown that the properties of a metal are closely related to the size and shape of the grains.

(Continued on Page 20)

THE METALLURGICAL ENGINEER

(Continued from Page 5)

Metallography has proven a powerful tool in the hands of the present day metallurgist and its intelligent use is responsible for many of the recent developments in this branch of engineering.

More recently, the X-Ray has enabled the metallurgist to determine the arrangement of the individual atoms in the crystals of metals and alloys. Further than this, due to the ability of X-Rays to penetrate substances opaque to ordinary light, it is now possible to examine the interior of a mass of metal and discover any hidden defects that may be present. This is a most important development, for often metal castings have failed in service due to some defect that could not be detected by the closest visual examination.

I do not want to give the impression from the foregoing that science is alone responsible for the rapid expansion in the field of metallurgy. Science, in this field, has been largely preceded by art, and most of the interesting developments have resulted from accidental discoveries and experimentation of a nature that could hardly be classed as scientific research. However, these new developments such as high speed steel, stainless steel, alloy that will withstand high temperatures without oxidation, various light alloys, etc., have been carried to their present state of perfection largely by the application of science.

Aluminum and the light alloys are interesting because of their recent discovery and rapid development. Where practically all of the other well-known metals in use today were known and used thousands of years ago, aluminum was first produced in the metallic state as late as 1827 and it was not until 1888 that a method was discovered for producing it in commercial quantities.

Pure aluminum is soft and has a low tensile strength and consequently has a limited commercial application. However, when cold worked or properly alloyed with other metals, its physical properties can be improved to a remarkable extent.

In 1910 Dr. Alfred Wilm in Germany discovered duraluminum. This is an alloy of aluminum with about 4% of copper, ½% of 1% Mg. and ½% of 1% Mn. After mechanical working, that is, forging and rolling, this material, when properly heat treated, develops a tensile strength comparable to mild steel. Since it weighs only approximately ⅓ as much as steel the advantages of its use for certain purposes becomes readily apparent. In fact, the construction of such dirigibles as the Graf Zeppelin and Los Angeles would be impractical unless duraluminum or some similar material were available for fabrication of the framework.

Duraluminum, as well as other alloys of aluminum, is not nearly so resistant to corrosion as the pure metal. This characteristic has led to the development of a very interesting material. Sheets of an alloy similar in properties to duraluminum are produced with a thin coat of pure aluminum on one side. Thus we have the high strength of the alloy with the corrosion resistance of pure aluminum. This material, in the form of corrugated sheets, is used in the construction of all-metal aeroplanes.

In conclusion I should like to mention one phase of metallurgy that is probably not so well known

(Continued on Page 22)

THE METALLURGICAL ENGINEER

(Continued from Page 20)

but nevertheless important. The supply of high grade ores is being gradually exhausted and it is becoming more and more important that means be devised for so treating the low-grade ores as to make their use economically possible. In this connection the recent development in the flotation process is of outstanding importance.

It was accidentally discovered that if certain chemicals or oils were added to agitated water, a froth would be formed and certain minerals (finely ground of course) would float on this froth while others would sink rapidly. Fortunately, many of the important metals are found as sulfides and it is chiefly these sulfides that will float on the froth while the gangue or worthless material ordinarily associated with these ores will sink to the bottom. Flotation has made possible the use of many ores that would otherwise be commercially worthless.

In the foregoing, I have written about the science of metallurgy, but said little, if anything, about the metallurgical engineer.

Since engineering, however, in a broad sense is simply the application of science to the solving of the everyday problems of industry, an understanding of the science is an understanding of the work of the engineer.