The role of aluminium and aluminium alloys in engineering industries

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SYNOPSIS

The application and use of aluminium is found to be useful, a limit to its versatility has not yet been reached. Its adoption as the Twentieth Century Metal has had a stimulating effect on design and caused a chain reaction in the engineering, electrical and packaging industries in particular. It is the only non-ferrous metal for which India has abundant supplies of the basic ore. By 1970–71 it is expected that upwards of 320 000 tonnes will be consumed in India.

IN speaking on the role of aluminium in the engineering industries, where does one start? What should one include and what should one omit? Truly it can be stated with confidence that aluminium is the metal of the twentieth century. The phenomenal growth of its popularity, shown by the figures of current and projected levels of production only hint in a cold statement of facts the extent of the penetration and impact that this metal has made on modern civilization.

One cannot enter a house, shop or factory, ride in a bus, train or tram, eat, drink or smoke, apply beauty aids or take medicine, without coming within arms length of aluminium in some form or another.

The measure and recognition of the importance of aluminium to India can be illustrated by the fact that India produced the prime metal at the rate of 18 000 tonnes in 1960 rising to 96 000 tonnes approximately in 1967; the Planning Commission target for production by 1970/71 fluctuates between a tentative 330 000 tonnes and a now discussed 275 000 tonnes.

Against these figures must be placed the actual consumption which was roughly 15 000 tonnes in 1951 rising to 127 000 tonnes in 1967 and estimated to increase to 320 000 tonnes by 1970/71.

These very approximate figures are mentioned to demonstrate the impact that aluminium has had on the electrical and engineering industries. 35 to 40% of the 1970/71 figure is attributed to engineering requirement as opposed to electrical engineering and from this fact alone it can be deduced how the engineering industry has figuratively clasped this metal to its bosom and made it its own.

The role of aluminium in engineering industries is a story of vision, experimentation, determination, ingenuity and achievement.

Vision in conceiving the idea that this extremely light and ductile metal could be alloyed and strengthened to substitute for apparently stronger and heavier traditional metals.

Experimentation to select and relate the alloying substance and alloyed metal to particular characteristics required by the end use.

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Determination to persist in spite of repeated set backs and failures.

Ingenuity in devising methods and techniques for casting, heat treating and machining this metal; in extruding and rolling it and in the designing and fabrication of an extraordinarily wide range of components and finished articles.

Without any degree of exaggeration it can be said that aluminium in one form or another has achieved the position of being one of the main stays of our civilization.

Engineering applications

An example which may serve to illustrate the complexities and problems which had to be overcome arose from the decision to cast in aluminium the cylinder head of the internal combustion engine. As most of you know very well, the cylinder head of the engine on your car is a complex structure. Provision is made in it for circulation of the water which cools the engine and for the introduction of a spark to the combustion chamber to ignite the explosive mixture. To cast such an item in molten metal demands a mold and a core, complex in design, comparatively fragile in parts of its structure, yet the core must be able to withstand high temperature and hold its form while the molten metal is being introduced. After casting, the core must be capable of disintegrating, so that it can be removed after the cast metal has cooled. Thus it can be seen that ingenuity and expertise are required in making

the original patterns for fabricating the mold and the core. The designer must bear in mind that the molten metal when poured in the casting, must flow freely without forming discontinuities, fissures or air bubbles. He must also take into account the contraction in volume which inevitably will occur when the metal cools, by providing risers so that there is no shortage of metal at any time throughout the complex design of core and mold during the time cycle of pouring and cooling. The formulations of the ingredients for the cores is also a matter of detailed chemistry. The core material must be sufficiently plastic to take complex forms, capable of cohesion until it is set by heat treatment, yet with a ready fragility so that it can be disintegrated and removed without undue difficulty. The metal which is to be poured must be alloyed to give it good flow characteristics and the desired hardness and homogeneity when cooled, free from internal stresses so that the vast changes in temperature, to which it will be subjected during its working life, will not cause warping or distortion. Finally it must lend itself to machining and finishing processes.

I have taken this as an example because in broad terms the imperative stated for this type of casting applies to a greater or lesser degree to any item which has to be cast in aluminium.

You may well say that this is only an extension of the methods which have been used for many in casting steel. This of course is true, but new materials require new techniques, new materials demand new restraints. The fact that aluminium has made such an impact on our civilization is of course because of the obvious advantage it offers for many applications in its weight to mass ratio, and it took vision to see that this extremely light metal which in its first emanation was so soft that it would not hold its shape under stress could be modified by alloying so that it could withstand strains and stresses and temperature variations in excess of traditional metals.

Once this was recognised, the utility of the metal became self-evident and its use virtually created a revolution in the engineering industry.

The fact that it could be rolled, cast, extruded, formed and machined as readily if not more readily than competing metals, together with its weight to mass ratio contributed to its popularity.

Experiments showed that the aluminium oxide film which forms on the surface of aluminium inhibits corrosion and that it will also take, when treated, an anodic film which can be either bright aluminium finish or coloured in any shade of the spectrum. This has given many ingenious ideas to fabricators and we find engineering organisations making trays, beer mugs, lipstick containers and a thousand and one other items for consumer use, which are anodised to attract the eye of the consumer and give an endurable and pleasing finish to the product. Similarly this type of finish contributed to the idea of using aluminium sheet and aluminium extruded sections in architecture and here in India there are several notable examples of this particular use in modern buildings.

This ingenuity excercised by engineers, this readiness to recognize the advantages in using aluminium has had its impact through their resourcefulness on many industries which are vitally imporiant to India's progress. Not the least of these is the tea industry, where over 20 items used in the manufacture of tea are currently fabricated in aluminium. Similarly one can quote instances of the tobacco industry, which contributes so largely to the Government revenue, the railways, which unfortunately do not, the electrical, automobile, mining and the office and stationery equipment industries and many others. The communications & electronic industries also benefit from the unique characteristics of this metal. Not only do they use various components which are cast, extruded or fabricated from sheet, they also use aluminium foil for paper-interleaved condensors, electrolytic condensors and power packs. Telephones, fans, radios, lighting systems, electronic equipment, communications equipment and all types of computers, typewriters and a million other items in daily use, have some part of their construction which includes this 20th century metal.

Special characteristics of aluminium

Because of the special characteristics of aluminium and because it demands special and particular techniques in casting, forming extruding or fabrication it has greatly increased the body of knowledge which was traditionally held by the engineering industry. The fact that the problems associated with producing items in this particular metal have been overcome has given a stimulus to research, widening the horizon of engineers and enlarging the possibilities of specialised production in other metals which had heretofore apparently represented problems beyond solutions; such metals which readily come to mind are magnesium and titanium.

The fact that new approaches and new thinking had to be developed for pattern making, core making, casting, extruding, machining and finishing for aluminium may well have acted as a spearhead to penetrate the barriers which had heretofore surrounded traditional engineering in metal.

Another characteristic of aluminium which has been exploited by the engineering industry is its ductility and its free flowing characteristics. Under pressure this has been found to be of great utility in impact extruding vessels and containers of various types from a simply formed slug of metal. The impact extrusion presses built by the engineering industry have brought about a revolution in the canning industry in America and to some extent has also had some impact on the container industry in India; particularly containers for difficult products. Instances which come readily to mind are containers for agricultural chemicals and pesticides, which unless packed in leak-proof containers can by oozing or other emanations cause deterioration in comestible products if stacked together in transit or storage.

Extruded sections to almost any shape are possible today. The complexity of the profile being only limi-

ted by the expertise of the die maker. These extruded sections have gained very substantial acceptance in the building and electrical industry over and above their well recognized utility in the engineering industry.

In engineering and fabrication it is most necessary that component materials can be welded and joined together, the special techniques demanded by aluminium have revolutionized welding systems and equipment and increased the body of knowledge on the electrolytic action which arises between dissimilar metals in contact.

The fact that the properties of aluminium include, resistance to corrosion, it is colourless, non-toxic, light weight, has high thermal and electrical conductivity, presents a smooth easily cleared hygienic surface, has no sparking properties, is available in all forms, in sheet, strip, foil, plate extruded sections, tubes, rods, bars, wire, forgings, castings and slugs, makes it self-selecting for very many uses, notably in the chemical, brewing and dairy industries.

Today aluminium hurtles through the skies in our aeroplanes and sattelites and we are informed that aluminium in various forms currently sits on the surface of the moon, through the agencies of America and U.S.S.R. A submarine has been constructed, its hull entirely fabricated from alloyed aluminium which can withstand greater pressure and therefore, descend to greater depths than any submarine hitherto manufactured. Literally aluminium is everywhere. Its ore is the most prolific in the earth's crust ; its ore is the only one of the non-ferrous metals with sizeable, economically exploitable quantities in our own subcontinent.

Aluminium in India

India leads the world, and nowhere has there been such a rapid and concentrated exploitation of the use of aluminium in the electrical industry : cables, busbars, conductors, switch-gears and many other items which have traditionally used copper, replaced it by aluminium. There is no doubt that impetus was given to this by the fact that copper has to be imported at a high cost, nevertheless it is to the Electrical and Engineering Institution that credit must be given for finding the ways and means of adapting this metal for this purpose.

Not the least of the devlopments arising from revised engineering techniques is the development of aluminium as a paste for highly protective paint and as powder for pyro-technics. Here special attention had to be given in designing, techniques, and equipment so that aluminium could be flaked, granulated or powdered avoiding the risk of spontaneous combustion.

The introduction of aluminium foil in the packaging industry where its outstanding protective characteristics and its brilliant surface capable of superb decoration with its resultant high impact on the consumer and the impulse buyer has had its attendant impact on those engineering industries which fabricate packaging machines. The demand of the industries which supply the consumer is for faster running, trouble-free packaging machines, designed to the free flow technique.

Packaging materials from the reel are required to be formed, filled and sealed into unit packs and to form inner or outer wrappers. Heat sealable aluminium is used as the closure on unit containers and blister packs. Foil formed containers have gained a wide acceptance for heat-and-serve meals. Thus modern packaging machinery has been re-designed or modified to permit the use of aluminium foil and foil combination as a substitute for other traditional packaging materials.

Today in India, there is hardly an industry which does not use aluminium. This means that there is hardly an engineering establishment which does not work on aluminium. It can be stated with a fair degree of certainty that most of the young engineers who are entering on their careers today, are familiar with at least some of the characteristics which make aluminium self-selecting for very many vital end uses.

It is to be hoped that these young engineers who are our hostages of the future will take the story of the development and exploitation of aluminium and regard it as an inspiration to them in the appreciation of the fact that man's ingenuity recognizes no barriers, that man's will to do and will to overcome can solve all problems. The story of aluminium and its impact on the engineering industry and indeed on our total civilization has by no means ended. New alloys and new techniques providing new end uses for aluminium, arise almost every day making demands on the vision, ingenuity and inventiveness of the engineering industry ; posing a perpetual challenge to our technological expertise. From ancient times the story of man's progress has been a story of challenge overcome, this too is the story of aluminium and the engineering industry.