Some Applications of Aluminium in Industries and its Substitution for other Materials

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Introduction

A remarkable feature of modern developments is the progressive replacement of traditional materials by new ones, as in the case of aluminium which is gradually taking the place of steel, copper, lead and zinc and other traditional materials. Among several reasons for this change, the chief ones are availability, economic price and technical suitability.

On account of the impetus given by the second world war for aluminium production in developed countries, it was easy for the producers of aluminium to meet the demands of the post war period. In fact the demands called for a rapid expansion of the aluminium industry. The world production of aluminium was 700,000 tons in 1939 and increased to 420,000 tons in 1959. By the end of the next 10 years this quantity may increase to nearly 800,000 tons. There will be a continuous rising demand in industrialised as well as in developing countries of Asia and Africa.

The advantages of aluminium are mainly due to : (1) The availability of bauxite and other raw materials required for its manufacture, in abundant quantities in most of the countries, and (2) The lesser increase in its price and its fluctuations than many other materials Thus its assured supply and stable price have encouraged new uses for it. Furthermore aluminium is the best available material for many purposes. The properties of its alloys are so varied that they can range from the malleability of lead to the strength of mild steel. It is lighter being $\frac{1}{3}$ the weight of steel, zinc or copper and less than $\frac{1}{4}$ of the weight of lead. Electrical and heat conductivity and reflectivity are high. It is durable due to the formation of the oxide. These good qualities make aluminium a strong rival to other traditional materials and is also a natural choice and is the best from the economic point of view. Aluminium has quite a few additional applications beside the traditional ones: aluminium cladding in buildings ; conductors for electrical power lines, transformers, motors and generator and all power plant; industrial containers, domestic vessels and canning ; rotary strip and casting ; equipment used in railways, aeroplanes ; and paints.

Aluminium Cladding :

This is an important development for cladding industrial and private buildings, interior and exterior trimmings, curtain walls which are good in appearance and very durable. The chief merits are permanence, ease of handling, thermal insulation with air space lighter and easy to transport, handle and site work. Cladding may be in the form of (*a*) fully supported roof, (*b*) rigid roof, (*c*) side covers, (*d*) roofs of churches, hospitals and schools. With $1\frac{1}{2}$ per cent magnesium alloy it can be used for corrugated sheets, truncated V-sheets. Due to its purity it can be used for variety of purposes.

Electrical Installations :

Aluminium is replacing copper for all kinds of conductors and cable sheaths due to its availability and its price increase being much less than that of copper. Hence for the same resistance the area of aluminium conductor is 1.6 times that of copper and has only $\frac{1}{2}$ the weight. It can compete with copper favourably in spite of extra fabrication cost. Since the cost of bare standard aluminium wire for overhead power transmission is 50 per cent of that of copper wire, most of the high voltage lines now use aluminium cable steel reinforced.

Aluminium is now being used for bus-bars, since it is cheaper, lighter and easier to handle, even though the bus bars section has to be larger. Aluminium of 99.5 per cent purity is suited for many purposes. But aluminium alloy containing $\frac{1}{2}$ per cent magnesium and $\frac{1}{2}$ per cent silicon is preferred though its conductivity is somewhat less for conductors required for transmission lines. When the original conservatism is overcome aluminium is usually preferred. Cable manufacturers prefer aluminium for conductors as well as sheaths (instead of lead), as the price of copper is high and is variable. Aluminium sheathed cables are now generally available and in

some cases with the sheaths corrugated to facilitate flexibility. In some cases the sheath is covered with PVC covering. Aluminium sheathed cables are lighter and can stand severe vibrations. There are some variations in manufacture: (1) The core is inserted in oversize sheaths and then drawn down to the required size of sheath covering, (2) Tube is formed from strip round the cable and the seam is continuously welded to save the cost; the sheath may be used as a concentric neutral conductor. In gas filled high tension cables aluminium can be used without steel reinforcement, and used for underground power distribution. For medium sizes, soled sectional base conductors may be used (solidal of Alean).

Another important application is the use of aluminium for transformer and motor windings, especially in countries where copper resources are limited and scarce. Transformers with aluminium windings if properly designed according to the specific properties of aluminium have proved as satisfactory as copper wound ones in service reliability as well as in losses and efficiency. For example: (1) Ferranti Transformers of 71 MVA, 300 kv supplied to the Kemano project (Canada), (2) T.R.O. — East Germany transformers of 40 MVA — 110 kv, (3) C.K.D.— Prague transformers of 63 MVA — 110 kv for Czechoslovakian power system. These transformers are all equipped with off load taps of small range. But modern designs are extended to transformers with on load taps *e.g.* 25 MVA — 110 kv = 8 × 2 per cent.

Calculations and designs of large aluminium wound transformers involve the following essential and closely connected problems: (1) Simultaneous alterations of dimensions and generalised values (per cent impedance voltage, no load losses and load losses), (2) Safety under short circuit conditions. Distribution transformers with aluminium windings will have the same percentage impedance voltage as copper wound transformers of the same output, which facilitates parallel operation of both types. For large unit transformers with aluminium windings a somewhat higher percentage impedance voltage is allowed than for copper wound transformers within the limitations set by system stability. But the percentage impedance voltage of an aluminium wound transformer should not be lower than that of copper wound tranformers of same output, to facilitate parallel operation and short circuit stability. If the cross sectional areas of conductivity of copper and aluminium are 1:1.6 the load losses of aluminium wound transformers would equal those of copper wound machines. If the height of the windings is maintained the same the actual width will increase by 60 per cent. This is an adverse factor in transformers of lower voltage than those of E.H. voltages. For voltages up to 35 kv. a compromise is adopted. Thus it will be seen that the position of aluminium is far more favourable for transformers of larger output, (10 mva and above) and extra high voltage.

There are some special problems involved in the design and construction of aluminium windings, which were encountered during the second world war due to inadequate technological preparation. The initial difficulties of aluminium joints has been overcome by the buttwelding process. Flat aluminium strips are welded in low voltage circuits by shield arc welding. Welding of aluminium to copper flexibles of bushings is carried out by fusing copper to aluminium by intermediate strips. Theoretical studies, modified technological procedures and short circuit tests have proved that aluminium is a fully suitable material for windings of large transformers of large output Their design and production must take into account the specific mechnical and electrical properties of aluminium. If this condition is satisfied aluminium windings are reliable in service and also are economical. Skoda Works have produced transformers up to 40 MVA, 100 kv with aluminium windings and on load tap charging equipment.

Canning:

Though tinned cans and tin foil were used for a long time, the advent of aluminium into this field has been very beneficial. Fish canning industry has adopted aluminium in Scandinavia, condensed milk in Switzerland, beer in France, Germany and the U.S.A., and for oil in U.S.A. and U.K. Aluminium foil is used in packing of cigarettes, chocolates, and other materials. Aluminium cans have some technical advantanges over tin plate being lighter and having better appearance. Investment for a plant to make aluminium cans is less.

From the above data it may be seen that aluminium has been used successfully as a substitute for other materials.