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08183

Distr.
LIMITED

ID/WG.273/4
22 June 1978

ENGLISH

United Nations Industrial Development Organization

Seminar for High-Level Governmental and Corporate Officials "Bauxite - Alumina - Aluminium: Analysis of Demand for Decisions on Industrial Development"

Budapest, Hungary, 3 - 12 May 1978

ALUMINIUM SEMIS AND FINISHED PRODUCTS :

- RECENT TRENDS IN END-USE PATTERNS
- THE PATTERN OF DEVELOPING MARKETS
- ASPECTS OF SUBSTITUTION BY ALUMINIUM*.

by

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id.78-3862

1.0. INTRODUCTION

(1) Following up this morning's lecture which described the development of the aluminium market as a whole, it is now my task to outline to you the various developments in different application areas.

If aluminium consumption is examined separately according to application areas, it appears for instance that in the USA

-	transport	accounts for 20 %
-	machine building, fine mechanics and the optical industry	" 7 %
-	electrical engineering	" 14 %
-	construction	" 24 %
-	packaging	" 18 %
-	others	" 17 %.

This distribution is relatively stable in the short run. Seen over a decade, however, it becomes apparent that strong shifts have taken place. The share of packaging for instance was only 9 % in 1965 and has doubled within 10 years.

(2) The situation is almost the same in Europe. If the shares of the various user groups in Germany are examined, we see that

- transport	accounts for 24 %	(approximately)
- machine building, fine mechanics and the optical industry	" 6 %	"
- electrical engineering	" 10 %	"
- construction industry	" 20 %	"
- packaging industry	" 11 %	"
others	" 29 %	"

The strongest growth has been registered by the construction industry and by the packaging sector.

It can however be ascertained that in the USA as well as in Europe, approximately 60 - 70 % of aluminium consumption are accounted for by the sectors transport, construction, packaging and electrical engineering. These major user groups will be analyzed in greater detail in the following.

2.0. DEVELOPMENT OF ALUMINIUM CONSUMPTION IN THE TRANSPORT BUSINESS

2.1. General Development

(1) Major products within the transport sector which are partly or totally made of aluminium are :

- passenger cars
- trucks for various uses
- buses
- caravans
- military vehicles
- aircraft
- ships
- rail vehicles

(2) A comparison of various countries - as far as this is possible on account of available statistical material - shows that :

- In the USA and Japan, specific aluminium consumption for passenger cars has already risen in the past - from an average of 28 kg per car in 1965 to 38 kg in 1974 ;

- Among European countries, there is also a marked difference - the list is headed by the Italian automobile industry with just 28 kg per passenger car in 1974, while Great Britain was last with only approximately 16 kg ;

- Also among car makes and among serially produced models (that is without special vehicles) divergencies up to 300 % may be found.

(3) Detailed statistical data on the aluminium consumption of other transport conveyances are not available, but it may be concluded from a number of indices that more aluminium than in former years is being used for :

- trucks
- buses
- caravans
- railway vehicles

Consumption of semi-finished material for these products in the FRG has increased more or less constantly. Those West European countries which do not produce passenger cars generally register a larger growth of aluminium consumption in the transport area.

2.2. Specific developments within the transport sector

Passenger cars

(1) In the production of passenger cars, aluminium can be used for the following parts :

1. Engine and auxiliary aggregates
2. Chassis
3. Body
4. Electric equipment
5. Wheels.

Engines

(2) Three automobile companies, Peugeot - Renault - Volvo -, have developed an all-aluminium engine in a joint venture, with apparently satisfactory results.

On account of the existing gray cast iron capacity in this sector, only a slow change-over to aluminium is generally expected. High investment costs and the risk connected with such a reorganization are seen by the automobile industry as the main obstacles against a speedy change-over. High pressure on all car manufacturers to make lighter engines is, however, to be expected.

(3) Under the motto 'appropriate use of aluminium' the development of aluminium radiators, on the other hand, is regarded with great optimism. For aluminium, no price increases like in the case of copper are to be feared and an aluminium radiator is 50 % lighter in weight than one made of copper. Good prospects as future aluminium-made parts are also seen for other aggregates like heat exchangers and oil coolers. Certain other parts, however, which are not so much exposed to wear and tear - like for instance water pumps - will in the future not be made of aluminium but of plastic material.

Chassis

(4) The chassis offers the best pre-conditions for the use of aluminium since anti-corrosion standards, the relative low weight as well as the lower investment risk as compared with the engine block show more distinct advantages over the use of gray cast iron. In progressive car models, the gear case,the Cardan gear cover, steering-gear box, clutch housing, and controls are made of die cast aluminium, while in ordinary cars this is true at least of the lid covers of these items and other relatively small parts, such as brake shoe tongs. According to our information, the application area of aluminium which is second in importance - after the radiator - will be the chassis.

Body

(5) The sector of the car body must be regarded as very problematic for the use of aluminium although it is very interesting with respect to weight. It is generally known that General Motors in its "Vega" has also manufactured parts of the body of aluminium. The following disadvantages of kneading alloys which can be used for parts of car bodies are cited :

- deformability
- low solidity

The aluminium industry seems aware of these shortcomings, and serious efforts are being made (Péchiney alloy Al-Cu-Mg-Si under the trade name of CP 485 ; 2 new Alcoa kneading alloys for the use in car body construction) to improve material conditions in this sector. After Citroen, also General Motors and Ford now want to equip their expensive models (Cadillac, Lincoln) with aluminium roofs and bonnets for engines and boots.

Electric equipment

(6) Comparable to the aluminium radiator, the electric equipment of cars is an application area which can be derived immediately from the characteristics of aluminium, that it its relatively low price and conductibility. For this reason it is being regarded as a growth area within the automobile sector.

Wheels

(7) Car models which are equipped with aluminium tyre rims have increased considerably, for reasons of fashion rather than justifiable economical criteria. A further growth of demand is expected, though only in the short run.

Opinions concerning aluminium-made bumpers, on the other hand, differ. Although some models are already equipped with such bumpers - in Europe upon request - better prospects are here generally seen for plastic, since it has the capacity of being re-formed.

Another sector, in which nowadays mainly alumium is used - trim strips on doors, windows, and car bodies - is also expected to be lost to plastic as a substitute.

Commercial vehicles

(8) Almost in the same manner as the use of aluminium for passenger cars differs from one model or make or country to the other, the use of aluminium for trucks varies in different countries.

Foremost in this development are the USA, where after all as many as 20,000 trucks of a total of 2.8 million produced in 1974 were equipped with aluminium chassis, and already approximately 60,000 - 70,000 of a total of 140,000 driver's cabs for trucks of over 15 tons GVW are also made of aluminium. In the USA, aluminium is moreover used as material for forged truck tyre rims and largely also for bunks and special superstructures.

According to information received, the efforts of the industry and the government within this sector towards energy saving through weight reduction are also stepped up.

Increasing use of aluminium - especially as chassis material - therefore seems largely to depend on the development of aluminium prices.

Furthermore, quite a number of die cast metal parts are used in passenger cars as well as trucks, as for instance for oil trays, gear cases, flywheel housings, protecting caps of rear axles, gear shift caps and gear shift lever bearings, to name only the most important items.

The introduction of drop-forged tyre rims has so far failed on account of the costs which are more than double the amount to be paid for steel rims.

Other road vehicles

(9) Not only for passenger cars and commercial venicles a partial further development of the use of aluminium is seen for the future, but mainly also for motor bicycles and bicycles. Especially the present steel tube frames are mentioned, which can in the future be made of aluminium as well as - especially for motorbikes - a replacement of conventional rims by rims made of aluminium.

Rail vehicles

(10) Although between 1968 and 1975, rail vehicles accounted for less than 10 % of total aluminium consumption within the transport sector in the FRG, this sector is all the same seen by the aluminium producers as a typical growth sector.

On account of its low weight, aluminium is very well suited for superstructures and chassis of short-distance railway coaches and express

coaches. The weight of a subway or suburban coach is reduced by 30 - 40 % through the use of aluminium.

The use of aluminium for the construction of express train coaches has the advantage of reducing the load on the roadbed - which is caused by high speed - somewhat as compared with the use of steel sheets.

In Switzerland and the USA, all-aluminium freight cars are in use apart from the all-aluminium passenger coaches, which are registering a breakthrough in most industrialized countries.

Shipbuilding

(11) The shipbuilding market can be subdivided into :

1. Private boats of mostly small or medium sizes
2. Commercial boats for several purposes.

For smaller or medium-sized private boats, the use of aluminium is restricted to the superstructures. The hulls are mostly made of glass-fibre re-inforced plastic.

Besides this, there is now also a growing supply of boat engines using gasolene, and especially diesel oil, which are made of die-cast aluminium.

(12) A particularly interesting new application area for aluminium has emerged through the growing number of liquefied natural gas tankers (LNGs). The majority of these newly built tankers are equipped with Moss-Rosenberg ball tank systems and use an average of 60 - 100 tons/1000 sq.m. of aluminium sheets. For a tanker of a capacity of

125,000 m^3 of natural gas - which is a rather normal capacity - already 10,000 tons of aluminium sheets are required.

Aircraft construction

(13) In the aircraft industry, aluminium is nowadays the most used material and accounts for 85 %. Aluminium producers do not believe that this share can be increased. On the contrary, it is feared that some of the current application areas of aluminium will possibly have to be ceded to plastic materials, for instance interior fittings. Yet another possible development - which however does not seem probable in the near future - would be the substitution of aluminium sheets used as outer coating by Titan, provided tnat in the commercial sector, too, aircraft with more than twice the speed of sound would be introduced.

A possible chance to sell more aluminium to this sector - at least in Europe - in spite of this development might arise if the current efforts of West European aircraft producers (Airbus A 3000, multi-purpose fighters, etc.) to attain a higher share on the world market should be crowned by success. Since the alloys in question are the products of highly developed technologies, they sell at very profitable prices.

2.3. Summary

(1) To summarize, the following statements can be made regarding the use of aluminium in the transport sector :

(2) General reflections on the transport sector

- With an average - unweighted - annual growth of consumption of 8.2 %, the transport industry (next to electrical engineering) is heading the list of all the major consumption sectors. The largest percentage of the growth of consumption will be accounted for by die-cast aluminium (chassis, engine parts in passenger cars and trucks, axle-tree bed bolsters of rail vehicles, motor-bicycle frames), but apart from this, the demand for profiles (truck and railway coach superstructures), rolled products (driver's cabs of trucks, sheets for LNG tankers and (for the time being only with the more expensive models) parts of bodies of passenger cars and forged products (rims for road vehicles and motor bikes) is going to grow.

- The volume of the consumption of conducting materials will only rise slightly, but their share will register the strongest increase.

3.0. ALUMINIUM CONSUMPTION IN THE CONSTRUCTION INDUSTRY

3.1. General survey

(1) The second largest application area of aluminium over the last 15 years was the construction industry.

(2) Within the construction sector, the following aluminium products are used :

- doors
- windows
- facing elements
- roof covering
- exterior panelling
- fittings
- sunshades
- heating and ventilation equipment.

According to the statistics which have been compiled by the European Wrought Aluminium Association and which provide a more detailed breakdown of the consumption of semi-finished products in 1974 and 1975 in Germany, France, Great Britain, the following statements can be made on the structure of consumption of semi-finished aluminium products in the construction industry :

- The largest share by far is accounted for by the market segment of doors, windows, and facing elements

- The second place is taken by the market segment of roof and wall coverings, panels and facing elements including the necessary accessories.

(3) Of the other segments of the construction industry which have contributed to a strong growth, mainly prefabricated houses for commercial and housing purposes are worth mentioning.

The segment of interior fittings includes very heterogenous products, such as heating elements, balconies, garage doors, locks, etc. The above average expansion of this sector was due - according to our opinion - to the use of aluminium heating elements.

3.2. Specific development in partial segments

(1) The construction sector must be regarded as the most heterogenous and complex sales market of aluminium, especially if the different situations in the various countries are taken into consideration.

In the following, it will therefore be attempted to illustrate the different prospects of the application of aluminium products, as far as general statements can be made.

(2) Aluminium products are mostly used in the following sectors of the construction market :

- above surface-construction
- fittings
- public institutions and facilities
- pre-fabricated houses

(3) Generally speaking, the best chances of the application of aluminium are seen in institutional construction, i.e. the erection of office and administration or representative buildings, but also of schools and kindergardens, because the light construction system leads to considerable cost saving.

The possibilities of applying aluminium in institutional above-surface construction are manifold. The most important ones are windows, separating walls, pre-fixed ceilings and pre-fixed façades.

Pre-fixed façades are formed from aluminium sheets and profiles in eloxated, stove-enamelled or plastic-coated surfaces. These can be produced in self-manufacture, provided it is done by a large metal-construction plant with respective experience, and the architect wants greater freedom of design, or else they can be supplied in the mechanical assembly technique by the producer of semi-finished products. Also smaller metal construction firms can usually install such system-made façades without any difficulties.

Yet another possibility of designing façades is the use of panels and cast plates ; cast plates and shape-cast plates are increasingly used for particularly exposed surfaces where they are popular on account of their variety of surface structures and artistic appearance.

(4) The joint application of aluminium and synthetic material for cold façades may serve to stabilize or change the appearance of the surface. Besides, aluminium panels are also used together with various areated plastics (polyurethane, polystyrol, phenol hard foams) as fully insulating façade elements.

The future development in the treatment of surfaces of aluminium façade walls is judged very differently. Although anodizing (fewer but larger plants), varnishing, and plastic coating will be further developed alike, many construction experts state their preference for stove-enamelling and plastic coating, since the eloxation layer might suffer during plaster work.

On the other hand, further improvements are also requested for surface varnishing and plastic laminates with regard to :

- environmental criteria, i.e. substitution of currently used lead-soluble varnishes through water-soluble ones
- durability of the laminates.

Among the desired improvements there is finally also :

- less sensitiveness to corrosion of the cuts.

(5) In competing with synthetic materials - the main competitor within the non-housing construction sector - aluminium has the advantages of :

- better rustproof qualities
- less colour-fading (in spite of the progress made in the meantime with synthetics)
- lower modulus of extension
- better functionality.

The disadvantages of aluminium which should be mentioned in this context are :

- inferior insulation
- higher price (though insignificant)

Which characteristics will tip the balance with regard to future prospects of application also depends (among other criteria)on the country in question. In Germany, France, and Italy, for instance, definitely better prospects are seen for aluminium in the non-housing (= institutional) sector, while in Holland and mainly in Great Britain competition from the side of synthetic materials seems to be much keener.

Aluminium products can however not only be substituted by pure synthetic materials but also through aluminium/synthetic compounds, for instance an aluminium kernel which is coated with plastic. For these compound materials, considerable chances of development seem to exist, while this applies less to aluminium/wood compounds.

Another substitutive trend which should be observed by aluminium producers is the laminated light steel from the United States which is used for outer façade walls. The light-steel construction system also seems to be one of the main obstacles against a large-scale breakthrough of aluminium as a supporting construction element.

4.0. ALUMINIUM CONSUMPTION IN THE PACKAGING SECTOR

4.1. General trends

(1) The use of aluminium for packaging purposes is one of the major application areas in nearly all industrialized countries. Its share fluctuates between 5.2 % in Japan and 22.8 % in the Netherlands.

Apart from the more or less domestic significance of this market, which of course also depends on the importance and consumption of the other sectors, per-capita consumption also is an important index which could supply some information on the still existing development potential.

An analysis of the per capita consumption of aluminium for packaging purposes results in the following ranking order of the countries in question :

USA	4.85 kg
Netherlands	1.77 kg
FRG	1.47 kg
Italy	1.05 kg
France	0.97 kg
Great Britain	0.96 kg
Japan	0.76 kg
Belgium/Luxembourg	0.67 kg
Spain	0.54 kg
Brazil	0.13 kg

As may be seen from this list, there is such a large difference between consumption in the USA and the remaining countries that it cannot be explained by higher per-capita income alone.

(2) If we try to break down the total field of packaging more finely (see Table) the outstanding importance of the use of foils is very obvious. In most European countries, their share reaches approximately 80 %.

Specific development

(1) Nearly all aluminium packaging materials reciprocate the use of other materials. Relations range from a sensible complementation to keenest competition.

As compared with plastics, aluminium is important in all those areas where high standards are required with regard to light and gas-tightness, as well as neutrality of taste. In cases where standards are lower, price considerations mostly predominate for the selection of a material. In other instances, some packaging elements are made of aluminium, as for instance lids or sealings of white tins, glass bottles or plastic containers. In addition, increasingly more aluminium-synthetics compound materials exist in which the individual qualities compensate each other in a sensible fashion.

(2) The major competitor among rigid packages still is tin-plate, since it concerns the tonnage-intensive market of beverages and foodstuffs.

(3) The development of the aluminium can is receiving varying judgements from the side of experts. Especially European manufacturers (Péchiney, Alusuisse, VDM) take a rather pessimistic view on account of the conservative attitude of the consumers and the price. According to our opinion, the aluminium can for soft drinks and beer will have a breakthrough in Europe too, progressively from the north to the south, with an annual growth rate of approximately 10 %, if it is possible to keep the price development of the aluminium can within a comparable range to that of tin plate.

In the foodstuffs sector it will be much harder for the aluminium can to succeed than with beverages, since the anodized layer on aluminium cans is much less acid-resistant than the tin contained in tin plate cans. On the other hand, aluminium will also in this sector have to fight competition from other newly developed products, such as tinless steel plate cans and plastic cans - depending on the filler.

(4) Yet another type of product of considerable market presence in the packaging sector are extrusion-molded packaging materials, that is to say tubes and extrusion-molded aerosol-cans : their share of total aluminium consumption for packaging purposes in France is around 13 % and in Germany 9 % (no figures are available on Great Britain). The market for extrusion-molded aluminium products has not expanded any further during the last 6 years and we do not think that there is much chance of further development, because

- the tubes (for toothpaste, foodstuffs, pharmaceuticals, chemical/technical fillers) will - for price reasons - have to face ever growing competition from the side of lined aluminium products (in the USA, toothpaste is already sold in glanimate tubes, a plastics/aluminium/paper compound) ;

- aerosol cans are being attacked for price and environmental reasons (feared destruction of the ozone layer in the atmosphere through the fluor-hydrocarbon propellant gas) and will probably have to face growing competition from the side of the plastic can.

(5) Of major importance among all packaging materials with regard to share and volume are flexible packaging materials, that is to say foils. Their growth in the past has not been overwhelmingly large with around 2 %, but their manufacturers had also not to suffer greatly from the recession which can probably be explained by the fact that foodstuffs do not react as sensitively to economic cycles.

(6) From a technological point of view, some additional impulses have moreover to be expected in the future for tinfoils for domestic use, because the development in the sector of containers for beverages, foodstuffs and pharmaceuticals continues in the direction of compound materials, of which aluminium foil is a necessary ingredient on account of its :

- neutrality
- density
- low permeability of
  - . atmospheric oxygen
  - . humidity
  - . smelling substances
  - . micro organisms

(7) The production of tin foils for industrial use, on the other hand, seems to us to be much more profitable. The application areas reach from the construction sector, transport, and machine building to electrical engineering, while the greatest part - for thermic insulating purposes - is probably accounted for by the construction industry.

A more recent development within this area is the enamelling of aluminium foils, which leads to an improvement of the resistance to corrosion, resistance against climatic influences, temperature stress (in the range of - 40 to + 500°C) and colour fastness. The following application areas are possible :

- compression plates, foam boards
- façade elements
- escalator and lift linings
- railway coach and container linings
- school blackboards
- crash barriers (traffic)
- sign boards

(8) As competitive materials for aluminium foil and thin tape for packaging purposes, mainly plastics - in the first place aluminium vapor - deposited plastic foils and co-extruded plastic foils - qualify. For the future use of aluminium foils and tapes the desired or requested durability of the packaged goods will also be important.

(9) Apart from the packaging products containing aluminium which have been discussed so far, also glass and bottle sealings have registered a very positive development in Germany during the last 8 years, with an average annual growth rate of 12 %. It must be taken into account however that the preconditions for this expansion were particularly favourable because the mineral waters industry in the years 1969/70 changed over completely from spring caps to aluminium screw tops.

(10) To summarize, we believe - based on the information and figures we have at our disposal - that

- aluminium consumption in the packaging sector up to 1990 in the West European industrialized countries will expand at the rate of approximately 5 %,

- Spain, the USA, Japan, and Brazil can still attain a growth rate of approximately 8 - 10 %,

- the growth of West European aluminium consumption in this sector will largely depend on whether the aluminium can will succeed against the competition from conventional containers as well as against metal containers. On account of high investments for filling stations, the development coming from Great Britain and Scandinavia is likely to be only slow but positive, provided the generally expected official regulations regarding environmental protection can be fulfilled, and the price of aluminium will keep within a range comparable to that of steel plate,

- although the market for foils and thin tape will continue to expand considerably, aluminium foil will increasingly be used as compound material or will have to cede market shares to newly developed plastic foils,

- the market for aerosol packaging and tubes is hardly going to expand any more.

5.0. ALUMINIUM CONSUMPTION IN ELECTRICAL ENGINEERING

5.1. General trend

(1) The analysis of the past shows that the electrical engineering sector with a share ranging between 6.6 % in Italy and 17.7 % in Spain, generally is the fourth in importance after transport, construction, and packaging regarding the use of aluminium.

(2) The increase of total aluminium consumption in this sector however was only weak in the highly industrialized countries (USA, FRG, Netherlands, Great Britain) between 1960 and 1974, all the more if it is compared with the development of the electrical industry branch as such. On the other hand, it should also be stressed that especially in the past 3 years, aluminium consumption in the electrical engineering sector in the USA has grown considerably by around 10 % annually.

5.2. Specific developments

(1) It may be assumed that aluminium after having replaced copper for quite some time already for open-air transmission lines - will quite generally deplace copper in the cable sector as well in the near future. Estimates on the current share range from 60 - 100 %, depending on the tension concerned (1 kV to 50 kV).

(2) On the other hand, it must also be expected that aluminium as coating material will to a great extent - possibly even completely - be replaced by plastics : in the same manner, extensive substitution of paper as insulating and coating material by synthetic material is to be expected for the communication cable sector.

Apart from high-voltage cables, increasing substitution of copper communication cables through aluminium is also to be expected. Following upon the decision of Bell telephone in the USA to make investments to replace existing telephone circuits with alumium for cost reasons (1/3 of cost savings), this realization is also gaining ground among European telephone companies (for instance new investments by the British Post Office).

(3) It can furthermore also be expected that aluminium will increasingly be used for internal wiring, for the time being mainly in the form of bus bars. By the copperplating system according to ASEA, Västeras (Sweden) practically the same conductivity is achieved as that of copper (taking the skin effect into account). Some partly still existing problems connected with the clamping of aluminium circuits are today no longer regarded as severe drawbacks.

(4) A third application area which also promises a strong growth of aluminium conducting materials is seen in the use of aluminium in automobile electronics. The clamping problems which will still have to be overcome in this respect seem to be more severe, but very intensive research efforts are going on in this sector on account of already existing and probably even growing costwise advantages (In the case of a substitution of copper, more insulation would moreover become necessary due to the larger diameters of the circuits.)

6.0. OTHER INTERESTING DEVELOPMENTS WITHIN THE ALUMINIUM SECTORS

6.1. The prospects seen for the application of aluminium in the machine building industry can, according to our opinion, be outlined as follows :

- The current use of aluminium die casting will in many instances be questioned by injection molded synthetic materials, since much progress has already been made in this sector and will yet be made. In detail the advantages of synthetic injection molding are as follows :

  . relation aluminium-synthetics = 2.4 : 1
  . lower price of synthetics
  . faster dying (during casting process)
  . during eloxation of the injection cast, streaks (schlieren) are generated (which are hoped to be eliminated by means of new alloys)
  . larger development potential of the material (new types of material)
  . greater possibilities of variety with synthetics.

- Aluminium die casting is used where large series are produced and greater stress resistance is required, for instance for

  . air conditioning
  . casings and case connections as well as armatures of electromotors
  . molds for plastic products
  . mounting supports and cases for machine tools

  to a decreasing extent on the other hand, for

  . office equipment
  . household equipment

- Another user sector which has already grown considerably in the past and will continue to generate large demands for aluminium are aluminium engraving plates for the printing industry.

- Thick aluminium plates for the machine-tool industry

- Profiles as parts of household and kitchen machines.

6.2. Manufacture of apparatus

(1) The manufacture of apparatus depends particularly strongly on innovation. This applies particularly to the refrigeration sector as well as to the chemical industry.

For industrial refrigeration units, aluminium sheets of large widths and thicknesses are required for inner linings ; for this reason, a relatively large demand is connected with the erection of each single plant.

Apart from this, aluminium is also used for the cooling fins of the plants themselves. The system of using cooling fins of inserted steel has been introduced to the market for the first time by the Vereinigte Deutsche Metallwerke and has been widely acclaimed.

(2) In the chemical industry, mostly containers for liquids and pipelines of aluminium are used. As mentioned, in the foregoing, substitution by stainless steel is to be feared in this sector too, since the price ratio has dropped from 1 : 2 to 1 : 1.5.

In a broader sense, the seawater desalination plants also belong to the chemical industry. In view of worldwide growth of demand, considerably increasing demand for aluminium rolled sheets and profiles can be expected.

A third application area with a great growth potential are containers for liquefied gas (mainly used on tankers), since increasing exploitation of this source of energy is to be expected in addition to natural gas.

(3) Similar to the chemical industry, the brewery industry also needs large storage and fermenting vessels. Some enterprises which used to specialize on the manufacture of welded aluminium containers have come into straits through rising aluminium prices ; it would be worthwhile considering if it would not be a good idea to close long-term contracts with them even though a fixed price would have to be guaranteed over a lengthy period. This applies particularly against the background of growing utilization of capacities of container manufacturers on account of large orders from the Middle East and Africa.

7.0 The development of future aluminium consumption in industrialized and developing countries

(1) The past has shown that aluminium consumption in the industrialized countries of the West has been subject to strong fluctuations. Generally, the changes in the consumption of aluminium followed relatively consequently in the wake of overall economic development. It is not new to say that aluminium is a so-called cyclical product showing strong reactions to the business cycle. This has been particularly evident during the years of the recession (1973 - 1975).

In the 1960's, the rule of thumb could be applied that aluminium consumption rises twice as fast as GNP. This is true only to a limited extent at the present economic growth rate, although it may be said that aluminium consumption still rises at the ratio of 1.5 as compared with GNP.

(2) After the strong decline of aluminium consumption in the years 1974 and 1975, the situation on the aluminium market is now quite rosy. In the USA, the aluminium market is recording a boom which is mainly due to the strong demand within the sector of rolled products. Since around 70 % of total demand is accounted for by rolled products, aluminium producers in the United States are experiencing rising sales at prices which have recovered far enough to permit sensible profits. The demand boom mostly originates in the motor vehicle and construction industries.

The automobile industry - on account of the regulations concerning petrol consumption (due to the relatively poor energy balance of the USA)-is seeking to reduce the weight of transport vehicles, which means automatically the use of aluminium, as already practised.

Another reason for the demand boom in the United States is the fact that on account of rising prices in the semi-finished products sector, the aluminium-working industry is now to a large extent in the course of refilling depleted stocks.

(3) The situation in Europe is about the same as in the USA. The order books are full, a fact which is also due to the demand boom from the side of the rolling mills. Pressed aluminium products, for instance, do not show the same rate of demand acceleration. In Europe, too, it is assumed that above all the motor vehicle industry is responsible for the present boom.

A disadvantage for the European aluminium industry is the decline of the dollar. On account of international competition, aluminium and aluminium semis are traded at dollar prices. For producers in the Federal Republic of Germany this means for instance that their products continuously fetch lower prices. Since 1976, the price decline has been approximately 15 - 20 %.

General future development

(4) In 1978,

aluminium consumption was 12,421,000 metric tons

as compared with

aluminium production capacities of 13,500,000 metric tons.

It is expected that production capacities will grow at an annual rate of approximately 2 - 3 %. This can be assumed with relative certainty because plans regarding newly projected aluminium plants are known worldwide and it takes 4 years on average until maturity is achieved. In other words : by 1983, capacities in the Western world will have reached 16,000,000 metric tons.

With regard to the growth of aluminium consumption, it can be assumed that it will grow more markedly in the future than the production capacities. It must also be said, however, that in the future relatively strong fluctuations have to be expected in the growth of consumption. This means that at an average growth rate of approximately 5 - 6 % for the next decade, i.e. up to 1990, cycles of a strong acceleration of consumption will repeatedly alternate with cycles of a marked reduction in consumption. All the same, the aluminium industry is facing a situation which can yet assume a relatively constant growth of demand as compared with other branches of industry. This situation will rather be marked by competition, i.e. by creating new capacities, and thus by further pressure of the prices and a deteriorating profit situation.

Since demand very strongly depends on economic movements,and cyclical fluctuations no longer occur every 5 - 6 years as previously but at 1 - 2 year intervals, the first setback in the demand for aluminium has to be expected already in 1979. The future situation will accordingly be marked by increasing instability, caused by so-called 'flutter cycles'. The aluminium industry is therefore likely to feel increasingly insecure.

Development in the various branches

(5) It is certainly of interest to note besides the general prospects of development in the aluminium industry - which we demonstrate below by citing some examples - how aluminium consumption is going to develop in the different countries and application areas.

The Federal Republic of Germany can certainly be regarded as a country of central importance for Europe. It is expected that up to 1990, the FRG will register an average growth of GNP of 3.2 %. According to our calculations, the growth rate of aluminium consumption will be around 4.5 %. The individual application areas show the following growth rates :

	1960/74	1974/90
Transportation	4.2	5.3
Machine construction	4.2	5.7
Electrical engineering	1.4	5.3
Construction	13.6	3.7
Packaging	7.2	5.1
Total	6.0	4.5

(6) For the remaining Western industrialized countries, the following development data are to be expected up to 1990 :

Growth rate	France	Great Britain	Italy	USA	Japan
GNP	3.6	2.4	3.3	3.4	6.6
Total aluminium	5.7	4.0	7.7	5.8	11.6
of which :					
- Transportation	6.6	2.5	9.0	8.9	10.7
- Machine building	3.8	3.8	5.2	5.2	8.5
- Electrical engineering	5.1	4.9	9.5	5.5	12.4
- Construction	6.0	4.3	7.1	6.4	11.1
- Packaging	4.5	3.5	5.5	7.5	9.3

The USA and Japan will also in the future have to be counted among the growth-intensive countries. Their high growth rates within the sectors of transportation, electrical engineering, and construction are interesting to note.

(7) It is however not right to concentrate entirely on the industrialized countries when examining the future development of demand. Especially the countries of the Third World, which are just at the outset of their development process, will in the future play a greater role on the world market as consumers - and partly also as suppliers - of aluminium.

(8) Unfortunately no figures are as yet available on aluminium consumption in developing countries. I must therefore restrict myself in this paper to three countries, each of which belongs to a different type. They are Brazil, Iran, and Turkey.

Aluminium consumption in 1974

in Brazil	was approximately	216,800	metric tons	(rise of 16.6 % over 1960)
in Iran	"	20,000	"	(rise of 23.5 % over 1960)
in Turkey	"	15,000	"	(rise of 27.6 % over 1960)

If aluminium consumption is related to the purchasing power or the population of a country, it would for instance be as follows in actual figures (kg/cap):

FRG	up to	16.4 kg	with an	annual	growth	of	6.1 % (1960 - 1974)
USA	"	28.6 kg	"	"	"	"	7.2 %
Spain	"	7.2 kg	"	"	"	"	15.8 %
Brazil	"	2.0 kg	"	"	"	"	12.4 %
Turkey	"	0.39 kg	"	"	"	"	20.8 %

These figures demonstrate that with rising GNP, aluminium consumption can also be expected to grow.

(9) Brazilian GDP will grow by approximately 7.7 % p.a. up to 1990.

Aluminium consumption in absolute terms will be for

- Transportation	(mill.)	270.242	as compared with			currently	1.169.4	bill.	in USA
- Machine building	"	50.1	"	"	"	"	441.9	"	"
- Electrical engineering	"	490.8	"	"	"	"	780.2	"	"
- Construction	"	318.3	"	"	"	"	1.363.1	"	"
- Packaging	"	67.3	"	"	"	"	1.027.4	"	"

In other words, the growth of consumption in Brazil will be around 13 % annually in the various sectors.

(10) In Iran, the development will even be more turbulent. Iran is a developing country which can finance its development largely from its oil revenues.

In the past, GNP increased by annually 8.6 % on average, while up to 1990, a rate of approximately 10 - 11 % is anticipated. Total aluminium consumption is around 20,000 tons. Up to 1990 it will grow to approximately 280,000 tons, corresponding to a growth rate of 17.9 %.

(11) It is not necessary to present a similar calculation for each individual developing country. Conditions in other developing countries are similar and can best be characterized by a low volume of consumption and high growth rates. Increasing consumption of aluminium does after all presuppose progressing industrialization and accumulation of wealth. This can be proved without any doubt by an examination of the application areas such as transportation, housing construction, packaging. We can therefore state that the highly industrialized countries will continue to be the major aluminium consuming countries. Consumption in the developing countries will grow too when these are reaching levels of development which are comparable to those of the industrialized countries.

(12) South America, the Middle East, and some African states are today regarded as countries of particular interest. It must however also be mentioned that especially in these countries, e.g. in :

- Venezuela
- Brazil
- Indonesia
- Egypt
- Kuwait
- Dubai
- Ghana

new mills and aluminium-working plants have been erected with the aim of meeting domestic demand and exporting surplusses to neighbouring regions.

(13) Competition on the world markets is therefore going to grow further. All the same it can be said that

the aluminium market

- in the industrialized countries of the west will grow but will be subject to relatively frequent fluctuations, while
- in the developing countries a relatively marked increase of demand will occur. These markets will however be very much exposed to international competition.

On the whole, the aluminium industry can however look into the future with some optimism.

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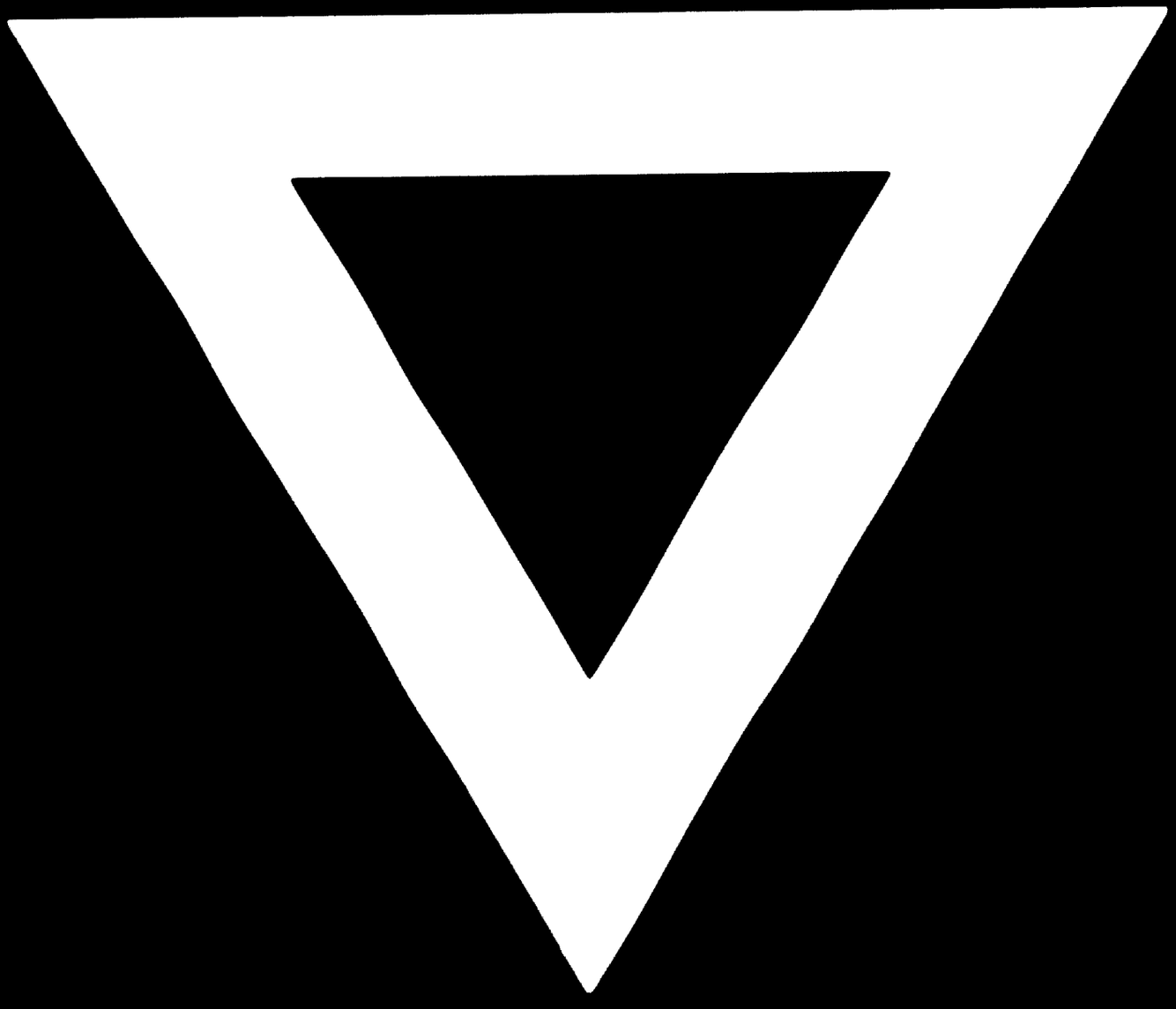

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