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Agenda item IV/2

ELECTRICAL ENERGY AS RAW MATERIAL[1/]

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Electrical Energy and Man :

The great role of electrical energy in the service of mankind is perhaps more popularly recognised in its direct uses in the service of man whether at " Home " at " work " in office, factory, farm, hospital ... , or in " Transport " and Communications " etc... In fact " electrical energy " is now the main driving force in our daily activities so much that it has become a " controlling " commodity in modern life. As such it is a commodity for which there is always a " rising demand " Furthermore, with modern developments and progress of mankind this " rising demand " actually increases at much higher rates than those for other important commodities. Figures showing Electrical Energy Generation per Capita and Electrical Energy Consumption per Capita are acknowledged" Indicators " of the development and prosperity of any Country.

In consequence of this great and ever rising demand for Electrical Energy, the electrical industry taking full cognisance of the fact and with a clear and astute outlook to the future responded with " crash " development programmes in the following main fields :

1 - The Generation of Electrical Energy in greater bulk at higher efficiency and lower costs of production - Hence the new giant units whether Thermal - Hydroelectric or - most important of all - Nuclear

2 - The Transmission and distribution of Electrical Energy with minimum losses at minimum costs.

3 - The development of new applications and appliances in the service of mankind for Greater efficiency and higher prosperity-

4 - a) The development of the design of all electrical appliances with the basic objective of reducing price

b) The mass marketing of these new appliances at easy terms

Electrical Energy as Raw Material :

Another very important aspect which is not receiving due attention is the role of Electrical Energy as a basic "Raw Material" in modern industrial development in the relatively new fields of Electro-Chemical and Electrothermal Industries - e.g. :

a) The production of Electrolytic Hydrogen.

b) The production of Chlorine

c) The production of Elemental Phosphorus

d) The production of ferroalloys

e) The production of Aluminium

It is interesting to note that although the basic principles for industrial production were long known yet the developments in the Electrochemical and Electrothermal industries were always punctuated by the developments of Electrical Industry in the four main fields outlined above in the exact order quoted -

In illustration we shall consider briefly in this paper two cases of particular interest to the participants and in direct relation to the General subject of the Symposium , namely :

1: The production of Electrolytic Hydrogen - A way to the production of Ammonia which is the cheapest form of Nitrogen available today

2. The production of Elemental Phosphorus by the Electrothermal Process - "p" being one of main plant nutrients -

The production of Hydrogen by Electrolysis of water :

As previously mentioned the basic principles for the electrolysis of water into Hydrogen and Oxygen were well known for a long time. It was also well known at the same time that Hydrogen so produced by electrolysis has the highest purity - It does not therefore require any special additional processes for cleanning or scrubbing - This of course is a great advantage -

Whilst Electrolysers were developped by numerous manufacturers yet they were used in the majority for the production of Hydrogen for industries other than the Nitrogenous Fertiliser Industry.

Large Electrolysis Plants for the production of Hydrogen for the Nitrogenous Fertiliser Industry such as the Norsk Hydro Installations, in Norway, The Bakhra Nangal in India and KIMA, Aswan, UAR were developped as projects and installed in connection with the development of major Hydro-electric energy resources and as such formed a major consumer, with the necessary flexibility required for the Hydro - electric energy produced with its seasonal and firm components -

The advantages of obtaining a quality clean gas (H_2) on one step is fully recognised. Yet the water electrolysis process for the production of Hydrogen for the Nitrogenous Fertiliser Industry comes often under criticsm on account of economic comparison with other processes using Natural gas of Naphtta etc...
A careful and detailed economic study must be carried out for proper evaluations taking into consideration :-

a) The assured supply and availability of the Raw Materials whether Electrical Energy /Gas/Naphtta etc...
b) The cost of the raw material (Electrical Energy /Gas/Naphtta etc...
c) The Design and location of the plant
d) The efficiency of operation of the plant.
e) The end product.

Decision could only be taken on the basis of careful study of every case and we must warn against the conception of a "slogan" answer -

Indeed, we may say that a properly designed electrolytic Hydrogen plant at the right location, judiciously integrated with the Electrical Network, efficiently operated and maintained under proficient organisation and management would certainly stand well in Competition against any plant of equal size based on other processes -

An important factor of course is the cost of the raw material (whether Electrical Energy/Gas/Naphtta...) The cost of Electrical Energy will be dealt with in later pages.

Furthermore, the economics of the Electrolysis would be greatly enhanced if the by product Oxygen is judiciously utilised -

<u>Elemental Phosphorus</u> :

Elemental Phosphorus is not found in nature - Apatites or phosphorites contain up to 17 % (normally about 13.5 % = 31 % P_2O_5) - Big deposits of apatites are found on the Kola peninsular, USSR - Pure apatites are volcanic rock -Phosphorites originate from the weathering of apatites or from deposits of animal remains; they are mined primarily in Tennessee, Florida and Idaho in USA in the Arab world , and in the Karatau Mountains in USSR.

Production of Phosphorus by the Electrothermal process requires the use of lumpy rock phosphates, dry coke as reducing agent and silicon gravel or quartzite for binding calcium.

For the production of elemental phosphorus F. Wohler compiled the formula :

$$2Ca_3(PO_4)_2 + 10C + 6SiO_2 = P_4 + 6Ca\,Si\,O_3 + 10\,CO + 5140\ BTU$$

The power requirements for this electrothermal process lies in the region of 11,000 - 13,000 Kwh per ST phosphorus as furnace power -

It is well known that there are two processes used on an industrial scale for the production of phosphoric acid, namely ;

a) acid which is produced from the wet digestion process of phosphate rock with sulphuric acid.
b) acid produced from electrothermal elemental phosphorus.

The unclarified ' wet ' process acid, in its past position as the cheaper acid, is suitable for making fertilisers e.g. triple superphosphate and diammonium phosphates (fertiliser grade 18 - 46 - 0):on the other hand it is not suitable for shipment or use in liquid fertilisers and ammonium polyphosphate production without further treatment.

On the other hand electro-thermal acid is of high purity and is well suited for the manufacture of industrial phosphates. It can be produced in any desired concentration up to 80 % P_2O_5 and is suitable for making high analysis superphosphates (54 % P_2O_5), high grade-diammonium phosphate (21-53-0), ammonium polyphosphate (15-60-0) and high analysis liquid fertilisers. There is also a substantial and growing demand for superphosphoric acid and ammoniated superphosphoric acid solution (11-37-0) for use in liquid fertilisers. The whole - sale market price of these materials is about 20% higher per ton of P_2O_5 than in triple super phosphate or diammonium phosphates.

Historically, electrothermal acid has the disadvantage of high cost which restricted its production and limited its use to high quality high priced end - products.

With demand for sulphur increasing more rapidly than its supply, one Ton of sulphur being required per ton of P_2O_5 in wet process acid, sulphur shortages developed, its prices increased, and in consequence many plants were forced to reduce production in many parts of the world.

The Shortage of sulphur and the high cost of sulphuric acid from other sources directed attention to alternative methods and in particular the Electrothermal process.

Recent developments in design and advances in electric - furnace technology resulted in the steady increase of furnace capacity from 20 - 25 MW to 50 MW which were commissioned in 1962 - 1964 ; furnaces of higher capacity of 60 MW were developed and installed by 1966 - Electric furnaces of capacity of 70 MW each were later developed and installed by 1968 - 1970.

In consequence, Electrothermal acid production is becoming steadily cheaper on account of the following economic factors :

a) Modern advances in Electric furnace design and Technology and the development of large capacity Electric furnaces up to 70 MW in operation today

b) The increase of total plant capacity to minimum 200 - 300 MW by planning and installing three, four or more large capacity furnaces.

c) Higher effeciencies in operation and maintenance of the plant.

d) Lower electric energy cost due to the developments of large capacity electric energy generation, whether by modern thermal, Hydroelectric or Nuclear Stations.

e) Lower electric energy costs due to high load factor of the Electrothermal plant.

f) Energy recovery of approx. 25.2 million BTU per ST phosphorus by burning the phosphorus furnace gas which originates as a by products

g) The possible economic utilisation of slag heat.

h) The sale of slag and ferrophosphorus.

i) The suitability of the electrothermal furnace for processing low cost low grade phosphate rock (23 % P_2O_5) provided that the impurity is mainly Silica-Contents of AL_2O_3 up to 7 % and Fe_2O_3 about 3 % or more can be utilised without disadvantage On the otherhand, these imparties AL_2O_3 + Fe_2O_3 are limited to a total of 3 % in rock for wet process acid.

j) The high concentration of elemental phosphorus which may be readily shipped by rail in mild steel tanks or by barge and by high sea vessels. It is interesting to note that shipment of One Ton of elemental phosphorus would supply the same amount of P_2O_5 as approx. 7.5 tons of phosphate rock plus 2.2 tons of sulphur in the wet process. Also one ton of elemental phosphorus is equivalent to the phosphorus content of 5 Tons TSP or DAP from wet acid process.

Therefore substantial savings in transport costs may be obtained with higher economic advantages to the Electrothermal process. Particularly for distant markets by shipping elemental phosphorus to the market area for conversion to fertiliser.

k) The production of high quality high priced industrial products and premium high analysis fertilisers as end products.

The Cost of Electrical Energy :

The Cost of electrical energy is made up of the following main components :

a) Cost of generation
b) Cost of transmission
c) Cost of distribution

In determining the selling price of Electrical Energy to consumers the following factors must be taken into account:

a) The Type of load and its characteristics including load factor and power factor.
b) The location of the load.
c) The voltage of supply
d) The quantity of electrical energy consumed per annum. (Kwhs/Ann)

Electrothermal and Electrochemical Industries are large consumers of electric energy as"raw material", hence these industries purchase their requirements of electrical energy in bulk on the high voltage terminals (e.g. 132 K.V.) Furthermore electrochemical and electrothermal industries are usually located close by the main sources of electrical energy and are characterised by a high load factor (almost 1.0). Such industries find it economical to pay special attention to the Electrical design, and layout and interconnection of these plants and to correct their power factor to the best economic limits. In consequence of all these considerations Electrochemical and Electrothermal industries have the privilege of purchasing their requirements of eledtrical energy at much lower price rates than other consumers whether other industries (e.g. wet process acid textiles etc...), general utilities e.g. pumping stations etc... or household services.

<u>**The Future :**</u>

The great developments and recent advances in the design, installation and technology of Nuclear energy generation shall certainly lead to the availability of great bulks of electrical energy at much lower prices.

This in turn shall give great impetus to the economic development of electrochemical and electrothermal industries using electric energy as " raw material".

The creation of large Agro-Industrial Complexes based on Nuclear Energy may be visualised having the following components :

a) A large Nuclear Power station
b) A large water desalination plant for irrigation, industrial and household use.
c) Electrolytic hydrogen plant for the production of Ammonia for fertiliser.
d) Electrothermal Elemental phosphorus for Industrial Phosphates and high analysis fertiliser , animal feed supplement etc...
e) N - P - K fertiliser production.
f) Other electrochemical and electrothermal industries e.g. Chlorine, Aluminum, ferroalloys as may prove economically feasible according to the location under consideration.

Such Agro - Industrial Complexes may be visualised as ' life line ' projects presenting an economic solution to the basic problems of economic development and high rates of

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