CH2356 Energy Engineering

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Energy Saving Measures in Fertilizer Industry

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Fertilizers

- Agricultural growth is mainly dependent on advances in farming technologies and increased use of chemical fertilizers.
- The fertilizers contain the three basic nutrients for agriculture: nitrogen (N), phosphorous (P) and potassium (K).
- Nitrogen: urea (46% N), ammonium sulfate (20.6% N), or from NPK
- Phosphorus: single super phosphate (16% P_2O_5), or from NPK
- Potassium: muriate of potash, i.e. KCl (60% K_2O), sulfate of potash (50% K_2O), or from NPK

Fertilizers (contd.)

- Nitrogen presents the most essential nutrient for plant growth holding the biggest share in the optimal mix.

- Raw materials:
  nitrogenous fertilizers - ammonia
  phosphatic fertilizers - phosphate
  potassic fertilizers – potash

- Of the total fertilizer production in India, nitrogenous fertilizers constitute more than 80 % and phosphatic fertilizers account for most of the remaining 20%.

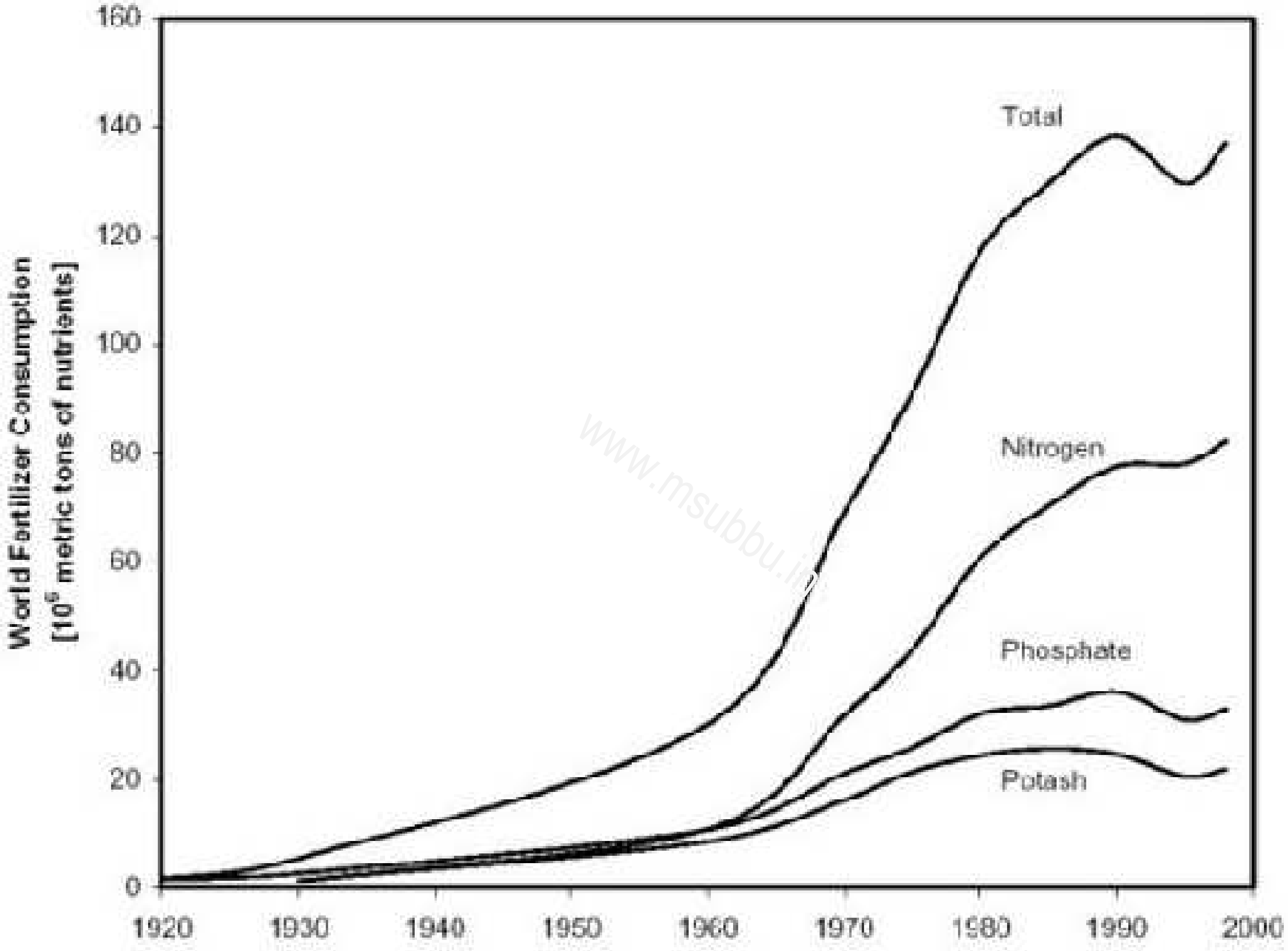
- India produces nitrogenous and phosphatic fertilizers only. Due to unavailability of raw materials, entire requirement of potassic fertilizer is met through import.

Fertilizers (contd.)

- Principle raw materials used for nitrogenous fertilizer making are ammonia and carbon dioxide.

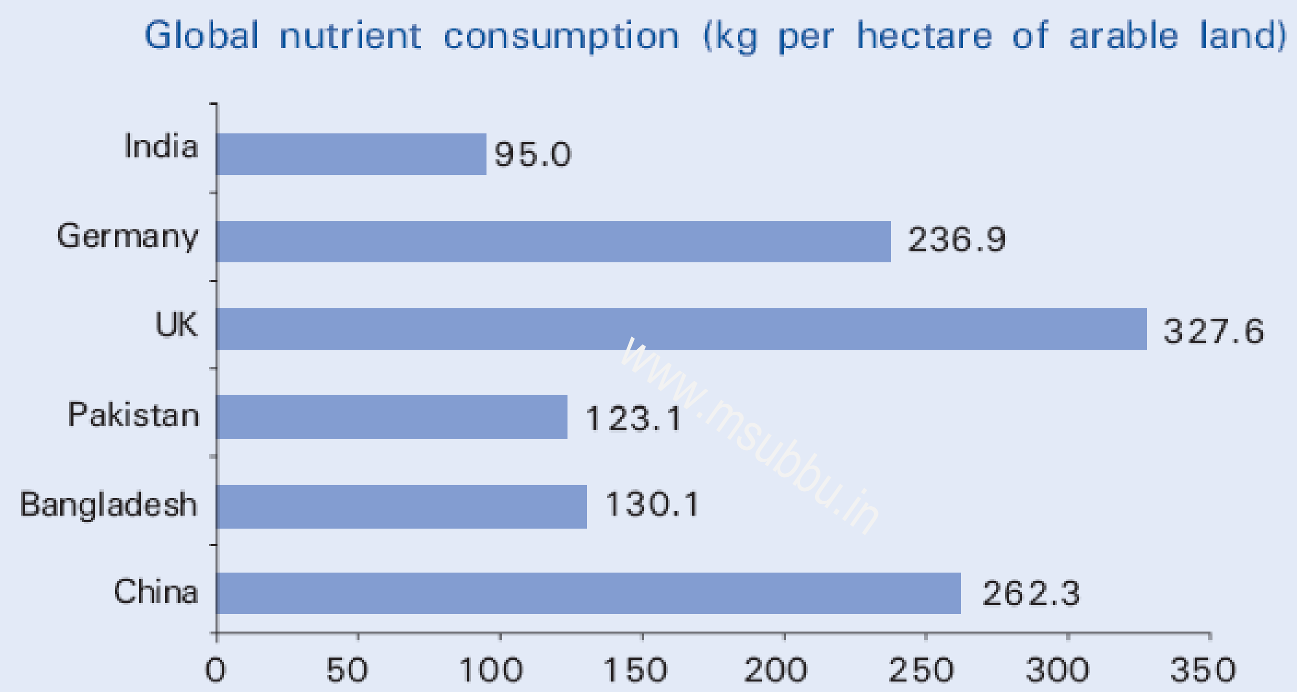
- Production of ammonia is the highest energy intensive process in fertilizer manufacturing, it accounts for almost 80% of the energy consumption in the manufacturing processes of a variety of final fertilizer products.

World fertilizer consumption by nutrient, 1920–2000



Source: data compiled from International Fertilizer Industry Association, <www.fertilizer.org/ifa/statistics/STATSIND/pkann.asp>.

Fertilizer Consumption Per Hectare



Source: FAQ, ICRA Information Service

The fertiliser consumption per hectare of arable land in India is amongst the lowest in the world. This is linked to low levels of productivity of Indian agriculture. The average yield of paddy is around 2,890 kg/ hectare as compared to the world average of 6,059 kg/ hectare.

Source: The Indian Chemical Industry, 2003, KMPG India

NH_3 production

- The most important step in producing ammonia (NH_3) is the production of hydrogen, which is followed by the reaction between hydrogen and nitrogen.

- A number of processes are available to produce hydrogen, differing primarily in type of feedstock used.

- Feed stocks: Naphtha, fuel oil, natural gas, coal. Out of these, gas is most hydrogen rich and easiest to process due to its light weight.

NH_3 production process

- Catalytic steam reforming of the sulfur-free feedstock is then used to form hydrogen plus carbon monoxide:

  $$CH_4 + H_2O \rightarrow CO + 3H_2$$

- The next step then uses catalytic shift conversion to convert the carbon monoxide to carbon dioxide and more hydrogen:

  $$CO + H_2O \rightarrow CO_2 + H_2$$

- The carbon dioxide is then removed either by absorption in aqueous ethanolamine solutions or by adsorption in pressure swing adsorbers (PSA) using proprietary solid adsorption media.

- Following bulk CO_2 removal, traces of CO and CO_2 are catalytically reacted with H_2 (methanation) to avoid poisoning the ammonia synthesis catalyst

- To produce the desired end-product ammonia, the hydrogen is then catalytically reacted with nitrogen (derived from process air) to form anhydrous liquid ammonia.

Energy Efficient Practices in NH_3 Production

- Currently, CO_2 removal is accomplished using aqueous amine solutions or physical solvents like glycol di-methyl-ethers. New, more easily regenerable sorbents, membranes, or ionic liquids could potentially save 30% of the separation energy.

- There is significant potential for improvement by:
  - Development of a highly efficient means to produce H_2 as feed to the process.
  - Development of an ammonia synthesis catalyst that would be resistant to poisoning by CO_2, thus eliminating the CO_2 removal unit and methanation operations entirely.

Specific Energy Consumption (GJ/t NH3) for the Production of Ammonia

	1990-91	1997-98	2000-01
Gas	40.2	37.1	36.5
Naphtha	49.9	45.8	39.9
Fuel Oil	63.1	55.7	58.4
Coal	163.8	201.5	NA

Natural gas plants used 40.2 GJ/t of energy for the production of ammonia in 1990-91. Naphtha plants used 24% more, and fuel-oil based plants used 57% more energy per unit of output.

Energy Efficient Measures

- The following factors have been identified as affecting energy consumption in ammonia-urea plants: capacity utilization, type of feedstock, technology employed, and vintage of the plant.

- **Capacity utilization** is important as losses and waste heat are of about the same magnitude no matter how much is actually produced in a plant at a specific point of time.

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Phosphate Fertilizers

- Phosphate fertilizers are produced by adding acid to ground or pulverized phosphate rock.

- If sulfuric acid is used, single or normal, phosphate (SSP) is produced, with a phosphorus content of 16–21% as phosphorous pentoxide (P_2O_5).

- If phosphoric acid is used to acidulate the phosphate rock, triple phosphate (TSP) is the result. TSP has a phosphorus content of 43–48% as P_2O_5.