EXECUTIVE SUMMARY

0.1 INTRODUCTION

Ethylene Oxide

Ethylene oxide is a highly reactive chemical due to the ease of opening of its highly strained three-membered ring, the bond being weaker than ether and the molecule less stable. It is a colourless gas at room temperature, turns liquid below 12°C, soluble in organic solvents and miscible with water in all proportions. It is highly flammble, with a flammable limit in air of 3 to 100 per cent, toxic, irritating to skin and eyes with tolerance limit of 10ppm in air. Indian Standard for ethylene oxide is IS-5573-1984 and the code of safety is IS-6269-1971 as adopted by Bureau of Indian Standards. It is used in the production of ethylene glycol, surfactants, acrylonitrile, ethanolamines, petroleum demulsifiers, fumigants, rocket propellants, industrial sterilants, polymer modifiers, and pesticides.

Ethylene Glycol

With more than one site for hydrogen bonding glycols have high boiling point. Monoethylene Glycol (MEG), Diethylene Glycol (DEG) and Triethylene Glycol (TEG) are clear, colourless syrupy liquids with sweet taste. They are hygroscopic and relatively non volatile, soluble in water, alcohol and acetone. They are combustible with autoignition temperature ranging between 228°C to 412°C. Glycols are toxic by ingestion and inhalation with lethal dose reported to be 100cc. and tolerance limit of about 50ppm in air. The Indian Standard for MEG is IS 5295-1985 and for DEG is IS:7918-1975, as adopted by Bureau of Indian Standards. There is no Indian Standard for TEG. MEG is used in the manufacture of polyester fibre and films, asphalt-emulsion paints, heat transfer agents, low pressure laminates, brake fluids, low freezing dynamites, solvents, cosmetics, alkyd resins, textiles, ball-point pens, foam stabilizers, as an ingredient in processing tobacco, in deicing fluid for air port runways, as a substitute for glycerine in explosive manufacture etc. DEG and TEG are used in the manufacture of unsaturated polyester resins, textile softeners, plasticisers etc. Ethylene Glycol is also sometimes referred to as monoethylene glycol or MEG.

0.2 PROCESS OF MANUFACTURE

0.2.1 Ethylene Oxide

EO is produced from polyethylene grade ethylene. The latter is produced from feed stocks like natural gas fractions, naphtha and alcohol. The modern ethylene oxide manufacturing process is based on a patent of T.E. Lefort using silver based catalyst and oxygen or air as oxidant at 15-30 Kg/cm^2g pressure and 200° to 300°C temperature.

The process of manufacture of ethylene oxide consists of four steps.

(a) Vapour phase reactions of ethylene and oxygen/air in the presence of silver catalyst at elevated temperature and pressure.

(b) Ethylene oxide recovery by absorption in water.

(c) Ethylene oxide purification by stripping.

(d) Carbon dioxide removal by absorption in hot potassium carbonate solution followed by desorption and recovery of carbon dioxide.

Pure polythene grade ethylene (99.9% Vol.) and oxygen (99.8% Vol.) are mixed using a special mixing device and taken in the reactor at elevated temperature and pressure. The reactor tubes are filled with Ag based catalyst having selectivity close to 80%. The conversion per pass is low (9-13 mol.) A large quantity of gas is recycled back after separating the same from ethylene oxide produced and after stripping carbon dioxide. This EO undergoes further purification. Relatively impure EO along with water used for EO stripping is taken to an ethylene glycol reactor. For cooling the EO reactor, boiling water, kerosene or Mobiltherm is used as a coolant. Steam generated in the EO process is used in ethylene glycol plant and also for driving various drives. For the above reasons, ethylene oxide and ethylene glycol plants are integrated.

0.2.2 Ethylene Glycol

Commercially ethylene glycol or monoethylene glycol (MEG) is produced by non catalytic hydration of ethylene oxide and water (process-condensate) at elevated temperature and pressure. The reaction is exothermic and is carried out in pipe-line or baffled column reactor. During MEG manufacture, small quantities of Diethylene Glycol and Triethylene Glycol are produced, besides some polyglycols as by-products. The process of manufacture of the main product ethylene glycol (MEG) consists of three steps.

(a) Ethylene oxide reaction with water to form ethylene glycol.

(b) Ethylene glycol dewatering.

(c) Ethylene glycol purification to separate monoethylene glycol, diethylene glycol, triethylene glycol and other heavier glycols.

Ethylene oxide and pure water are taken into a reactor. The reactor is either a pipe line or a baffled column. Ethylene oxide hydration reaction is non-catalytic and effected at higher temperature and pressure. The conversion is reported to be above 95%. Ethylene glycol so produced is dewatered in multiple effect evaporators using steam (from EO plant) as the heating medium. Ethylene glycol so produced is purified in purification columns to separate mono, di and triethylene glycols, meeting the product specifications.

0.2.3 Air and Oxygen Process-Comparison

For an identical capacity, oxygen based EO plant is reported to be less capital intensive. Most of the modern plants for EO are based on oxygen as oxidant.

0.2.4 Process Evaluation and Cost of Production of MEG

With the available information, a comparison of petrochemical based process and alcohol based process for the production of EO/EG has been made. The notional cost of production per kg. is Rs. 14.22 by the former and Rs. 25.27 by the latter process.

0.3 STRUCTURE OF INDIAN INDUSTRY

All the units producing ethylene oxide and ethylene glycol are in the organised sector. National Organic Chemical Industries (NOCIL), Thane-Belapur Road, Thane, Maharashtra; Indian Petrochemicals Corporation Ltd., (IPCL), Vadodara, Gujarat and India Glycols Ltd. (IGL), Kashipur, U.P. are the current producers of ethylene oxide and ethylene glycol. The production of ethylene oxide and ethylene glycol in the year 1989-90 was 18,340 TPA and 24,845 TPA respectively. In addition, 6 units are holding letters of intent or industrial licenses for the manufacture of EO/EG. Reliance Petrochemicals, S.M. Dyechem Ltd. Maharashtra and IPCL. Nagothane are in advanced stages of construction/commissioning of their manufacturing units. Domestic demand for MEG being high, the current years import (30,000 MT imported in 1989-90) will far exceed previous years figures as the current demand is projected to be 104,000 TPA. The demand projection for 1994-95 and 1999-2000 AD are 199,800 and 268,000 TPA respectively as per projections given in the perspective plan. Ethylene from napatha is the feed stock for both IPCL and NOCIL units while IGL uses molasses to ethanol followed by ethylene. All the technologies in use are imported. NOCIL uses Shell (Netherland) technology while IPCL and IGL uses Scientific Design (USA) technology. The current demand of ethylene oxide is of the order of 21,000 TPA. If ICAMA projection is taken into consideration, then the demand stands at 30,800 TPA. The demand is expected to grow at the rate of 10-12% per year. The thrust areas for EO, as per ICAMA, are pharmaceuticals, cosmetics, insecticides, oilfield chemicals, polyols, glycol ethers etc. As per All India Alcohol Based Industries Development Association, as reported in the Perspective Plan Chemical Industry, 2000 AD; small capacity EO/EG plants based on alcohol are economically viable with input cost of ethanol at Rs. 3/- a litre.

0.4 INTERNATIONAL SCENARIO

The world ethylene oxide and ethylene glycol capacity is about 14,000,000 TPA and 8,660,000 TPA respectively. There are ethylene oxide plants having capacity 12,00,000 TPA and Ethylene glycol capacity 1500,000 TPA (Union Carbide Corporation) as well as 16,500 TPA and 22,500 TPA respectively (India). The details of existing plant capacities are given in the Table 31. The world demand of ethylene oxide is growing at the rate of about 5% per year. The world demand for ethylene glycol during 1988 was 5,600,000 MT and the estimated demand in 1995 is 7,200,000 MT. In the world context, the high growth area for monoethylene glycol is polyester bottle resin. No such specific high growth area has been projected for ethylene oxide. Process technology for making EO/EG can be licensed from Shell International, Netherlands; Scientific Design (SD), USA; Union Carbide Corporation, (UCC), USA; Japan Catalytic (JC), Japan; Autochem, France; Huels, Germany and Snam Progetti, Italy. DOW Chemical, USA, and Monticatini, Italy, also have their own processes. Shell and Snam-Progetti processes use Oxygen, while SD, JC and UCC use both oxygen and air as oxidants, Huels, DOW and probably Monticatini processes use air, but DOW is shifting to oxygen. UCC has stopped licensing. Shell and Tube type reactors are still in use. Modern plants use boiling water as coolant instead of other mediums. Out of six licensors for EO/EG technology, currently, only three or four are actively involved in licensing like Shell, SD, UCC and Autochem. Snam Progetti, Italy; Japan Catalytic Co., Japan; Huels, Germany and DOW Chemicals, USA; each of them have licensed one or two plants each at few selected locations only. Majority of the plants use oxygen as oxidant in EO reactor. Silver based catalyst is the only catalyst used in EO reactor. Over the years both selectivity and life of catalyst have been improved. More than 70% of the plants in erstwhile USSR, and Western Europe uses naphtha as feed stock for ethylene production. In the Gulf area, all the existing capacities for ethylene use natural gas fractions and so also in 65% of the plants in USA.

0.5 TECHNOLOGY ABSORPTION EFFORTS BY INDIAN INDUSTRIES AND GAPS

The technology for ethylene oxide/ethylene glycol and the catalyst for ethylene oxide, are imported. IPCL and NOCIL both have well equipped R & D centres. IPCL had undertaken various research activities for improvement of catalyst, preparation of catalyst in laboratory scale, understanding sintering phenomenon of catalyst etc. National Chemical Laboratory (NCL), Pune and Engineers India Ltd., (EIL), New Delhi, are working jointly to develop indigenous EO catalyst and process engineering capability. NOCIL's R & D centre is also actively associated with National and Regional Laboratories to test available technologies, develop technology improvements, attend customer services etc. For the production of Ethylene, NOCIL and IPCL use naphtha in their respective petrochemical complexes and use the same for EO and EG units. IPCL, Nagothane plant will be using natural gas fractions for ethylene generation while IGL is using ethanol from molasses. This is claimed to be the first plant to its kind in the world.

Engineering capability exists for the production of capital goods like reactors, distillation columns, some of the compressors, a large variety of pumps, heat exchangers and other items. Import of capital goods cannot be ruled out completely e.g. recycle gas compressor, oxygen mixing device, large air separation unit, good number of critical instruments, high pressure/high temperature valves, safety valves etc. as they are not available indigenously. Besides, high quality foam type insulation which is in use abroad is also not available in India. Upgradation of the existing units appears to be an arduous task without scrapping old units and improving productivity in totality. Installing multiple units to enhance capacity will not lead to economic benefit. The manufacturing units have confirmed that they are supported by the licensor on a continuous basis specially where the licensor has participated in equity e.g. Shell in NOCIL, and otherwise on a case by case basis. The manufacturing units further confirmed that they are also being supplied with the latest catalysts to suit individual plant operating conditions. The existing manufacturers claimed to have improved process, output and specific consumption besides conservation of energy.

All the existing units are using oxygen as oxidants but not water as reactor coolants. The coolant for IPCL's reactor is mobiltherm while NOCIL uses kerosene and IGL boiling water. Both IPCL and NOCIL have indigenously fabricated EO reactor. It is reported that PDIL's catalyst development centre has developed a catalyst for dehydration of ethanol to ethylene. Although the industry is quite old, yet joint efforts by the industry and research institutions to develop catalysts and process engineering capabilities are wanting.

0.6 RECOMMENDATIONS

— Natural Gas fractions (C_3 & C_4) be given preference to naphtha for the production of ethylene followed by ethylene oxide then to ethylene glycol; to combat flaring of natural gas leading to less import of petroleum products.

— Ethanol (from molasses) based ethylene oxide and ethylene glycol producing units should be encouraged (being a renewable source of feed stock) because of country's position with respect to production of sugar and molasses.

— Market survey of EO/EG based products having export potential be undertaken for exporting value added products.

— Production of ethanolamines, glycol ethers, polyethylene glycols, ethoxilates, EO condensate products and the likes which can be produced in medium scale industry be encouraged with active support of EO/EG producers.

— The thrust in the present efforts by NCL, Pune, and EIL, to develop catalysts, process and process design capabilities should continue. The active support of the producers in these efforts is also called for.

— Indian engineering industry's capability should be enhanced even at the cost of importing technology (if available) for the production of critical equipments like recycle gas compressor, high pressure and high temperature valves, safety valves and control instruments/equipments.

— Industry, research institutes, capital goods manufacturers and organisations like EIL, PDIL and similar organisations should form a consortium to look into various aspects of EO/EG technology for the development of catalysts, and process design.