0. EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Maleic anhydride (MA) is a 5-membered ring compound. It is a free flowing white solid and exists in the form of, needles, crystals, flakes or pellets. The Indian Standard (IS 5749-1977), for quality control of MA, has been in existance since 1977 and more or less, is on the same lines as the ASTM standard. However, IS 5749 specifies, additionally, maximun content of maleic acid (0.5 wt %), ash content (0.005 wt %) and Fe content (30 ppm).

The product is being, extensively, used for manufacture of pesticides, food additives, unsaturated polyester resin, alkyd resins, preservative for oils and fats, paper, permanent press resins used in textiles, etc. It, also, finds application in the production of, plasticizers and stabilizers, vulcanising and modifying agents, for, rubber, synthetic polymers, etc.

0.2 PROCESS

0.2.1 Maleic anhydride is produced,commercially, by catalytic oxidation of a hydrocarbon (benzene or butane),at 350° C-420°C and 7–10 kg/cm^2 g, using air/oxygen as the oxidising agent. Some modern processes use a synthesis pressure of 0.5 - 1.5 kg/cm^2. The catalyst is, generally, V_2O_5 or V_2O_5 – MnO_2, coated on a base of, Al_2O_3 or Al_2O_3–SiO_2.

The exothermic heat of reaction is removed, by circulating molten salt, or by generating steam, in the shell side of the reactor.

0.2.2 In the process using benezene as feedstock, vapourised benezene is mixed with hot air and passed through a tubular reactor. The effluent maleic anhydride gas is, partially, condensed. The gas is, further, scrubbed with water. Pure maleic anhydride is produced, through, a series of thin film evaporators, dehydrator and a distillation column. Process flow diagram, along with equipment specification and the utility summary, has been given, for a 20,000 MTA plant, based on this process.

0.2.3 Maleic anhydride, from butane, is produced, with an average yield of 50 mole %, using a series of similar units, namely, vapouriser, reactor, scrubber, thin film evaporators, and distillation columns. A process flow diagram has been given for a 20,000 MTA plant. The reactor has 6,300 C.S. tubes, of 30 mm dia, compared to 13,000 for the benezene process.

0.2.4 Although, not much of economic importance these days, oxidation of butene/isobutyléne, to MA, was looked at, with interest, in 70's. A few plants were also in operation. A process flow diagram, along with list of equipment and utility summary, has been given in the report.

0.2.5 An evaluation of, benezene and butane, oxidation routes, for a 10,000 TPA unit, has been made. The economics of aqueous, versus, solvent absorption, of MA vapours, has been worked out.

0.3. STRUCTURE OF INDIAN INDUSTRY

0.3.1 There are two manufacturing units, in India, producing maleic anhydride, from benezene, with a total installed capacity of 6600 TPA.

M/s Adarsh Chemicals & Fertilizers Ltd., at Udhna, Gujarat, have an installed capacity of 3,600 MTA and their production rate has been 2,000–3,000 MTA, during 1987–88.

M/s Allied Aromatics Ltd., at Kalyani, West Bengal, has an installed capacity of 3,000 MTA and a licensed capacity of 6,000 MTA. However, their production rate has been, only, about 700 MTA, since 1985, when the plant was commissioned. It is expected that their production capacity will increase, after the recent, catalyst change over.

0.3.2 Maleic anhydride is, also, formed as a by-product, from phthalic anhydride process. From the, present, six phthalic anhydride plants, with an installed capacity of 55,000 TPA, about 2,000 TPA of MA is recoverable.

0.3.3 In addition to the above, a number of units have been issued letters of intent/industrial licence, for MA, for a capacity of 34,000 TPA.

0.3.4 The present consumption of maleic anhydride is, about, 4,200 tonnes per annum and it is growing at the rate of 11.5% per annum. It is observed that, a substantial quantity, of MA, has been imported, since 1980. However, it is expected that the trend will change, in future, with commissioning of units, already, in the pipeline. A good export market is developing.

0.3.5 The user industries of MA, like malathion producers, are, mainly, in the organised sector. However, there is also some consumption in the small scale sector, such as, for polyester resins.

0.3.6 Both of the, present, manufacturing units are based on imported technology. The actual, raw material and utility, consumption figures are higher than the guaranteed figures of process licensors. R & D support from process licensors is lacking.

0.4. TECHNOLOGY STATUS - INTERNATIONAL

0.4.1 The present, global production, of MA, is, about, 500,000 TPA and the demand growth rate is, around, 5% per annum.

0.4.2 New catalysts with higher, selectivity, life and stability, have been developed. There is, also, a shift in feed stock, from benzene to butane, because of, economics and pollution control laws. Till recently, fixed bed tubular reactor used to be the general choice for plants. However, recently, fluidised bed reactor and moving bed transport reactor systems, have been developed and they are, more suited, for MA production. Further improvement in recovery system, has been possible, with organic solvent, instead of water, as was being used earlier.

0.4.3 The names of technology supplier, for MA , are listed, along with salient features of the technology, in table 4.3.

0.5. TECHNOLOGY ABSORPTION EFFORTS BY INDIAN INDUSTRIES

0.5.1 NCL, Pune and CFRI, Dhanbad, carried out experimental research to develop, MA catalyst and the process know-how, at a bench scale level. However, pilot plant studies for, over-all, technology development programme, were not carried out. Operating companies have put in, only, marginal efforts, for indigenisation of the technology, received by them, from foreign suppliers.

0.5.2 Benzene and normal butane are, the main feed stocks, for maleic anhydride industry. In India, both the present plants, are based on benzene. Presently, benzene is in short supply. In order to bridge this gap, benzene is being imported. On the other hand, natural gas is available, in India, in large quantities and normal butane is a constituent of the natural gas. If, butane can be used for production, foreign exchange, spent on benzene imports, can be saved, while, at the same time, reducing the cost of production, of MA.

0.5.3 Engineering capabilities, for hydrocarbon oxidation processes, exist in the country. However, indigenous supply of, some critical equipments, like, reactor, salt pump, compressors, etc., is lacking. These items were imported, along with imported technology, by the maleic anhydride units.

0.6. TECHNOLOGY GAP

0.6.1 The international technology has moved towards butane as feed stock, fluidised bed reactor, and anhydrous recovery system.

0.6.2 Plants which are, still, running on benzene, in advanced countries, have better benzene recovery and less power consumption, due to operation in explosive zone, with higher benzene concentration in the feed.

0.6.3 In seventies, 83% of MA production, in US, was by oxidation of benzene, 15% by n-butane and 2% as by-product of phthalic anhydride. Presently, most of the US manufacturers use, n-butane, as the feed stock. The same trend is observed in, Europe and Japan.

0.6.4 The reason, for the feed stock switch over, is the easy availability of C_4 feed stock, strict benzene emission control standards, progressive increase in price of benzene and low price of C_4 feed stock.

0.6.5 India, with vast gas reserves, is in a position to provide C_4 feed stock to MA manufacturers, thereby, saving benzene for other uses.

0.6.6 In future, the technology for MA production, is likely to be based on butane, fluid bed reactor and anhydrous recovery system.

0.6.7 The thrust area, for the future indigenous development, should be, finding more application of MA and catalyst development for MA synthesis.

0.7. CONCLUSIONS AND RECOMMENDATIONS

0.7.1 CONCLUSIONS

(i) The MA technology, through benzene route, which Indian entrepreneurs opted for, in 70's, was appropriate, till early 80's. Because of the health hazards associated with unreacted benzene vapour, rising cost of benzene and its demand in detergent alkylate, caprolactum, etc., attention, in developed countries, was focussed on alternate feed stock. Butane emerged the winner, because of, low cost and easy availability, besides, being less hazardous to health.

(ii) India has vast reserves of natural gas, the utilisation of which is poor, because of lack of infrastructural development, so far C_3/C_4 fraction has been earmarked for domastic fuel only, which is a less profitable use, vis-a-vis, raw material for MA.

(iii) The demand of MA has been sluggish due to high cost of raw material and various taxes on different end products.

(iv) Installations of benzene recovery system, in the existing manufacturing units, are lacking.

(v) Development of further applications of MA, or, value added product growth, specially, with respect to usage of polyester resin based products, appears insignificant, in India, going by the usage, of MA, in developed countries.

(vi) Some research, on benzene oxidation, and, also, for development of catalyst, on a limited scale, was undertaken by two National Institutes, without much fruitful result.

(vii) Enough capabilities exist, within the country, with respect to fabrication of critical equipments, e.g., reactor, submersible pumps, distillation column internals, etc., for MA Plants.

(viii) There is no evidence to show that, on-line optimisation, was done, for the existing plants.

(ix) None of units is having any benzene recovery system.

(x) MA units in India are working, outside the explosive range, with low benzene/O_2 (air) ratio, with, consequent, higher utilities cost, bigger reacter size for a, compartively, less through-put.

(xi) No attempt has been made to manufacture MA catalyst, though V_2O_5 based catalyst has been developed and successfully used for other chemical processes. Hence, import of catalyst would be necessary, for some years to come, with foreign exchange outflow of, nearly, Rs. 250-650 lakhs, a year, when all projects, in the pipeline, are implemented.

0.7.2. RECOMMENDATIONS

(i) The C_4 feed stock should be made available, to MA producers, which will release benzene, for essential requirements. Future plants should be based on butane. The choice of, reactor and recovery system, will depend on the scale of operation. However, the selection of fluidised bed reactor will be prefered, as it will provide, added flexibility, to reactor system, by switching over, from one feed stock to another, as a result of easy removal of the catalyst from the reaction zone.

(ii) C_4 feed stock should be made available, to maleic anhydride producers, which will release benzene for essential requirements.

(iii) Benzene recovery system should be incorporated, by existing manufacturers, from, pollution, health and economics points of view.

(iv) Existing units should, also, examine the possibility of operating plants, with higher benzene concentration (in the explosive range), for energy saving. This will require utmost attention to safety aspects of the plants.

(v) On-line optimization of the existing processes, by improved instrumentation or distributed integrated digital control system, should be incorporated in MA plants.

(vi) Efforts should be made towards, better application and producing value added products, of MA, having scope for domestic, as well as, export market, such as, polyester and alkyd resins. For this, suitable incentives, reduction in various levies, etc., may be necessary.

(vii) Capabilities exist in the country, for manufacture of critical equipment, like, reactors, salt pumps, etc. A dialogue should be initiated, between fabricators, like, L & T, APV, Anup Engineering, etc., and maleic anhydride units, existing and proposed, to step up indigenisation of the capital equipment of maleic anhydride plants.

(viii) There is a need for intensification for R & D, related to various oxidation reactions for hydrocarbons, in national laboratories. This R & D should include development of new technologies, like, fluidised bed reactor system, development of catalysts, etc. Leading petrochemical producers in the country and leading consultancy organisation in the field, as well as, equipment fabricators, should be actively associated with such R & D efforts, which should aim, both at, absorption of imported technologies in the field, as well as, generation of new improved technologies.

(ix) For improved operation of the MA units and production of quality products, all the MA units should share their experience, through a system, like, quality circle meetings.