EXECUTIVE SUMMARY

1.0 INTRODUCTION

1.1 Phenol is the monohydroxy benzene C_6H_5OH having a characteristic odour and when very dilute, a sweetish taste.

1.2 Coal tar was the only source of phenol almost until World War I. Then came various synthetic routes. The modern phenol industry is based on the pioneering work in Germany by Dr. Heinrich Hook and SonLang in 1944 on the oxidation of cumene to cumene hydroperoxide which under the influence of an acidic catalyst would decompose into phenol and acetone.

1.3 Phenol is toxic and corrosive. In case of accidential contact, the area exposed should be rapidly and throughly washed with a mild alkaline solution.

1.4 The most significant products from phenol are phenolic resins, Bisphenol A, Caprolactam and salicylic acid.

1.5 The industrially important methods of manufacture of phenol are the following :

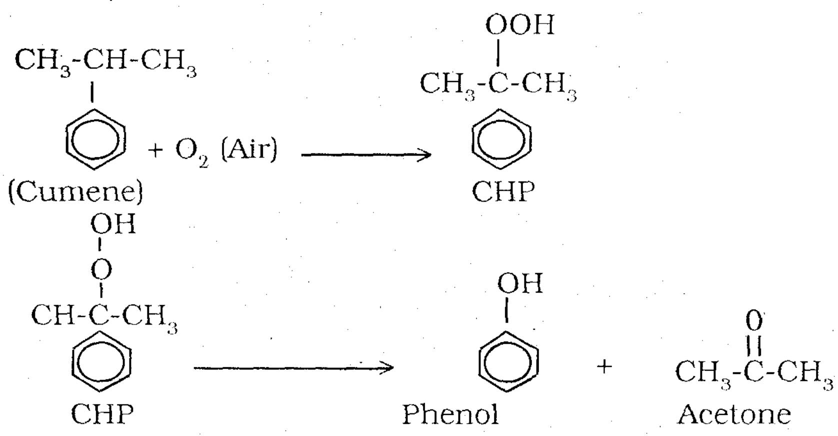
(i) Cumene Oxidation process.
(ii) Toluene Benzoic Acid process.
(iii) Sulphonation process.
(iv) Chlorobenzene process.
(v) Rasching Hooker process.

Today cumene oxidation process is the only commercially significant route for the production of phenol. This process also gives a very important co-product acetone.

1.6 The cumene oxidation process consists of the following stages :

(i) Cumene Synthesis.
(ii) Cumene oxidation.
(iii) Concentration of cumene hydroperoxide.
(iv) Cleavage of hydroperoxide into phenol and acetone.
(v) Recovery of phenol and acetone.

The chemical reaction sequence is as follows :



1.7 The raw materials and utility consumption by different process routes are as under :

S. No.	Specification	Units	Processes				
			Cumene Oxida-tion	Toluene Benzoic Acid	Sulpho-nation	Chroro Benzene	Ras-chig
Feed Stocks							
1.	Toluene	T/T		1.45	-	-	
2.	Benzene	T/T	0.67	-	0.95	1.01	0.925
3.	Chlorine	T/T	-	-	-	1.04	-
4.	Propylene	T/T	0.38	-	-	-	-
Utilities							
	(Consumption per tonne of phenol)						
	Steam	Tonne	3.5	9.0	2.7	9.0	16.5
	Cooling water	m^3	35	65	80	250	50
	Process water	m^3	0.02	-	6.5	1.0	-
	Electricity	KWH	350	650	100	3900	350
	Fuel Oil	10^6KJ	4.5	3.5	15	5.5	14
	Inert gas (High Pressure)	SCF	80	40	-	-	-
	Natural Gas	BTU	--	--	2100	10000	40 00

1.8 The most widely accepted technology for producing phenol is cumene oxidation process because of better economics due to by-product acetone.

1.9 If one wants to avoid acetone, the choice will be toluene oxidation process. The reaction sequence of toluene process is as under :

$$C_6H_5CH_3 + 1.5O_2 \longrightarrow C_6H_5COOH + H_2O$$

$$C_6H_5COOH + 0.5\ O_2 \longrightarrow C_6H_5OH + CO_2$$

2.0 STRUCTURE AND STATUS OF INDIAN INDUSTRY

2.1 The production of synthetic phenol started in India in 1968 with the commissioning of unit of Herdillia Chemicals Ltd at Thane, Maharashtra with an installed capacity of 10,000 tonne per annum. A unit to produce 6,000 tonne per annum of phenol based on chlorobenzene route was established in Durgapur but it had to shut down because of maintenance and corrosion problem. A 40,000 TPA phenol unit of Hindustan Organic Chemical Ltd was commissioned in 1987 at Cochin.

2.2 With Durgapur unit closed the present installed capacity of two units HOC and Herdillia amounts to 60,000 tonne per annum. In addition there is another unit of Neyveli Lignite Corporation which recovers phenol from its coal tar distribution unit with an installed capacity of 1,470 TPA.

2.3 The present production of phenol is nearly 52,000 tonne giving about 85% capacity utilisation. A small quantity of phenol to the tune of 3,000 tonne per annum is being exported.

2.4 The projected demand of phenol in 1994-95 will be 65,000 tonne and 105,000 tonne by 1999-2000 AD. With Herdillia Chemicals and GIIC persuing new phenol capacity, the availability of phenol is assured.

2.5 Both Herdillia Chemicals Ltd and Hindusthan Organic Chemicals Ltd are doing well with more than 85% capacity utilisation. The current growth rate is 7.5 % per annum giving enough encouragement for new capacity generation.

2.6 The raw materials for phenol are benzene and propylene by cumene oxidation route, followed predominantly throughout the world. There is likely to be shortage of both benzene and propylene in local market.

2.7 In India both the phenol units have adopted cumene oxidation process. A detailed process write up is given.

2.8 The technology for phenol is not available indigenously. Herdillia Chemicals Ltd imported technology from B.P. Chemicals UK and Hercules Company, USA. While HOC opted technology of UOP Chemicals (Inc) USA. The technology for recovery of phenol from coal tar was arranged by Neyveli Lignite Corporation from Lurgi, Germany.

2.9 There are a number of technology for manufacture of phenol. However the most dominant technology is cumene oxidation process because of availability of acetone as a by-product along with phenol. The demand scenario of acetone in India makes cumene oxidation route the ideal choice for the present.

2.10 The products of two manufacturing units meet international specifications.

2.11 The list of equipment with specification for a 40,000 TPA phenol unit is given in para 2.10.

2.12 The phenol being toxic, the tolerance limit of effluent discharged to inland water is 1 ppm. In phenol plants the primary treatment is effected by solvent extraction followed by secondary effluent treatment which involves neutralisation, sedimentation, equalisation, active sludge biological treatment, mixed media filtration and activated carbon absorption.

2.13 The ex-works price of phenol in India is Rs. 36,500-38,300 per MT while European price is $ 460-470 per MT.

2.14 A 40,000 tonne per annum is the minimum viable capacity of a phenol plant requiring an investment of Rs. 200 crores.

3.0 INTERNATIONAL SCENARIO

3.1 The present world consumption of phenol is 4.5 million tonne with an installed capacity of 6.0 million tonne. The major change in use of phenol is likely to be in Bisphenol A by 2000 AD when 24% is expected to be consumed from the present figure of 19%.

3.2 The major technology suppliers for different processes are the following :

Cumene oxidation process - B.P. Hercules, UK; Allied - U.O.P. (USA) SIR (EUTECO) (USA) & Rhone-Poulence (USA)

Toluene Process	-	Dow Chemicals, USA, Stamicarbons, B.V. Netherland
Rasching Process	-	Hooker Chemicals, USA
Natural Phenol	-	Lurgi GmbH, Germany.

3.3 The salient features of modern technology is low pressure oxidation of cumene resulting in lower air compression cost, high yield and low operating temperature with greater oxidiser volume for a given capital cost.

3.4 The second most important factor is low residue cleavage. In normal practice the by-product oxidation product DMPC (Dimethyl Phenyl Carbinol) generates a lot of tar while new process directs DMPC in formation of AMS (Alpha Methyl Styrene) which is a costly product. In this process the tar cracking section is not necessary.

3.5 The new technology can give better and purer phenol suitable for polycarbonate grade bisphenol.

3.6 With L.P. oxidation, a significant amount of cumene remains in spent air after cooling with refrigerated water. This is normally passed through a single stage adsorber which brings down the cumene concentration down to 536 mg/m^3. Number of techniques are now available to reduce this concentration to meet the stringent laws being framed in all developed countries.

3.7 Similarly technologies have been developed to reduce the phenol content of waste water from 100 ppm to 20 ppb level by various techniques.

3.8 The current research is aimed at single stage hydroxylation of benzene under various process conditions. This is in anticipation of fall in demand of acetone in future.

4.0 R&D EFFORTS, TECHNOLOGY AND GAP

4.1 The research in existing manufacturing units is directed towards recovery of useful chemicals from waste stream and effecting value addition to the existing products.

4.2 Simulation of various section for plant optimisation is in progress with Hindusthan Organic Chemicalss Ltd. Indian Institute of Petroleum is engaged in development of antioxidants based on phenol.

4.3 IS 538 (1968) gives national specification for phenol while BS 523 (1964) gives British specification and ISO-1987, the international specification of phenol.

4.4 Facilities for manufacture of process equipment is available in the country. A few critical equipment and instruments are however still being imported.

4.5 Consultants with wide design and engineering experience are available in the country who can implement such projects if basic process engineering package is made available to them.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 There are only two units in operation for the manufacture of synthetic phenol in India with a total installed capacity of 60,000 TPA. Both the units are based on cumene oxidation process. The technology is imported.

5.2 Acetone is produced as a by-product in cumene oxidation process and meets nearly 60% of total acetone demand in the country.

5.3 The growth rate of phenol is 7.5% yearly as the demand of phenolic resin, pharmaceutical, alkyl phenol and epoxies is increasing. Also there is a great demand for acetone.

5.4 The projected demand for phenol in 1999-2000 is 1,05,000 tonne while for acetone the demand will be 90,000 tonne.

5.5 A 40,000 TPA capacity phenol plant on cumene oxidation process is a viable proposition and would cost nearly Rs 200 crores.

5.6 In view of nearly equal demand of phenol and acetone in the country the cumene oxidation route may be encouraged as it gives two useful products simultaneously. This is more economical than producing two items separately.

5.7 However the demand scenario for acetone may change with new routes available for MMA. If acetone demand falls in future toluene route may then be considered.

5.8 Considering so many coal carbonisation units operating in the country, only Neyveli Lignite Corporation is recovering phenol. The problem faced by other units may be looked into and debottlenecking done to recover the valuable by-product.

5.9 Considering the price of Indian chemical raw materials, it may be desirable to concentrate more on speciality chemicals based on phenol as being pursued by IIP, Dehra Dun.

5.10 Looking at the potential demand of polycarbonate in the country for automobile light lenses, electronics etc. as in developed countries, efforts may be made to bridge technological gap to manufacture ultrapure phenol required for such purposes.