1.1 Introduction :

Commercial reactors are designed usually on the basis of experience and fundamental principles. Though much efforts have been expended in developing generalisation of data for the design of chemical reactors, greater emphasis has been laid on the direct experimental work. Commonly accepted method of scaling up of reactors to industrial scale is done satisfactorily by experiments in stages, like bench scale, pre-pilot and pilot plant units. Moreover, evaluation of optimum process conditions is normally carried out from a large number of designed laboratory experiments, because it produces considerable savings in money and time compared to larger units. The design data from laboratory units are generated from the results on the yield, selectivity, operating conditions, fouling of reactors, deactivation of catalysts etc. for a particular reaction.

The present reaction under study, the dehydrocondensation of benzene to biphenyl, is endothermic in nature and requires high temperature. It leads to a wide range of products, the complexity of which increases with the severity of conditions of the reaction, like higher temperature and longer residence time. Since larger conversions are prerequisites for commercialisation, occurrence of various secondary reactions cannot be eliminated under the industrial conditions usually maintained. Knowledge of various reaction steps and the magnitude of these rates is very much helpful in simulating the reaction in a commercial unit. Though the experimental data at comparatively lower temperatures may not be industrially important, these are, however, useful in understanding the reaction mechanism. In general, at lower temperatures, secondary reactions are minimised and the reaction system is usually free from interfering phenomena like coking, heterogeneity and physical effects like diffusion and heat transfer. In brief, a thorough knowledge of reaction schemes from experimental product distribution and corresponding development of rate equations enable one to make a rational design of a reactor or to optimise an existing unit. The present investigation has been undertaken with such considerations.

1.2 Chemical nature, uses and toxicity :

Biphenyl is an important commercial product. Structurally it has two benzene rings directly united without any intervening atoms. This is a white or slightly yellowish crystalline solid. It precipitates from solvents as plates or monoclinic prismatic crystals. Biphenyl is one of the most stable organic compounds. It is resistant to thermal decomposition and degradation by radiation[1-3]. Chemically it is a substituted benzene. Consequently it enters into most of the reactions characteristic of benzene though not as reactive as the latter.

Biphenyl, its derivatives and other polyphenyls, serve mainly as heat transfer fluids. The biphenyl oxide - biphenyl eutectic mixture (73.5% biphenyl oxide and 26.5%

biphenyl by wt.) marketed under the trade names, of Dowtherm A in U.S.A. or Thermex in Europe, is widely used for heat transfer by the condensation of vapours in the temperature range of 250° - 365°C. The chlorinated biphenyls marketed under the trade name 'Aroclor' (Monsanto Co.) are used as heat transfer fluids in liquid circulating systems in the above temperature range[4]. A mixture of biphenyl and terphenyls is often employed as the coolant moderator in Atomic Energy Commission prototype organic liquid cooled nuclear reactor[5], as at Piqua, Ohio. Biphenyl has been used as a paper impregnant of citrus fruit wrappers; it also acts as mild fungicide[6]. A mixture of biphenyl, ter- and tetra-chloride are both used as substitutes and constituents of transformer oil for prevention of their inflamibility. Besides, chlorinated derivatives of biphenyl serve as fillers in various polymeric materials[7].

Isopropyl biphenyl (Wemcol) is used[8] to replace poly chlorinated biphenyls as capacitor fluids. Silicone oil mixed with 0.1 - 17% alkyl biphenyl is also employed as an insulating oil having high dielectric strength[9]. Biphenyl derivatives have been found to be useful for manufacture of polyesters, hardeners and dyes[10,11]. Biphenyl and other terphenyls have also been used in thermosetting polyphenylene resins to improve thermal stability[12,13]. Chlorinated biphenyl has been employed for viscosity reduction of adhesives[14].

Biphenyl is sold and transported as a solid material in bags or fiber drums. It has a relatively low toxicity, but the dusts are irritating to eyes and nasal mucosa. Goggles and respirators have been recommended as safety devices for handling powdered biphenyl. Gerarde[15,16] gives a complete review on toxicity of biphenyl stating that because of its low vapour pressure and low toxicity it does not create industrial hygiene hazards. The greatest hazard in handling biphenyl is due to dust explosions. The dust is usually caused by vapours, originating at a hot biphenyl liquid surface and condensing in air[2,17]. Disorders of nervous system, liver and kidney functions, alteration of peripheral blood composition and induced distrophic changes in parenchymal organs have, however, been reported due to assimilation of terphenyls and was suggested a maximum permissible concentration of 5 mg terphenyls per cubic meter of air in working areas. For protection from adverse effects of benzene, a biological monitoring programme has been recommended for individuals who have a potential benzene exposure[19].

1.3 Literature Survey :

1.3.1 Historical Development :

Fittig[20] first discovered biphenyl (diphenyl) in 1862 by the action of sodium on bromobenzene. But the cheaper method was given by Berthelot[21] (1866) who isolated biphenyl and other hydrocarbons from liquid product obtained by passing benzene vapours through a red hot porcelain tube. Following Berthelot's discovery, Schultz[22] (1872) introduced several improvements and noted the influence of rate and temperature. Luddens[23] (1875) used a CO_2 stream to carry the vapours of benzene along the hot