Chapter 7

SUMMARY AND CONCLUSIONS
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The main findings of the present investigation on the manufacture and application of Industrial Bitumen, are summarised below.

A pilot plant to carry out studies on the air-blowing process of bitumen was designed and fabricated. It had the provision for drawing samples at any desired time for kinetic studies.

Petroleum refinery caustic wash waste has been shown to be an efficient additive for the manufacture of Industrial bitumen for the first time. It is economical, since it reduces the air-blowing time. The air-blowing time is directly related to the cost of production. It improves the softening point-penetration relationship and makes possible the manufacture of good quality industrial bitumen. By air-blowing without any additive, it was found to be impossible to manufacture the various grades of industrial bitumen according to specifications. The conventional additives used for the manufacture of industrial bitumen viz. ferric chloride, phosphorous pentoxide are costly and hence the high cost of production of industrial bitumen. In petroleum refineries caustic washing process is used for the removal of hydrogen sulphide from the liquified petroleum gas and naphtha fractions and the waste so formed is disposed to the inland waters. It is highly hazardous to the aquatic organisms. Petroleum
refinery caustic wash is a waste material and its utilisation will lead to better pollution control. A comparative study with ferric chloride shows that it is equally effective.

Another significant finding of the study is that waste PVC is capable of functioning as an effective additive in bitumen polymerization process. Hydrochloric acid formed by the degradation of PVC is found to catalyse the reaction. The polyolefins formed are found to improve the softening point - penetration relationship of the air-blown products. A comparative study of the air-blown products with ferric chloride shows that the quality of the air-blown products with waste PVC are much superior. The softening point - penetration relationship of the air-blown products with waste PVC are much better i.e., they possess high penetration for a given softening point. This will impart increased flexibility in the products made out of them. The catalytic effect of waste PVC is attributed to the formation of chlorine radicals during the process.

The effect of iron powder as a promoter for waste PVC catalyst is investigated. Iron alone is found to have no effect in the polymerization of bitumen. But it was observed that the effect of waste PVC on bitumen polymerization is highly improved in presence of iron powder. The promoting effect of iron is attributed to the formation of ferric chloride. The utilization of iron as a
promoter will reduce the consumption of the catalyst.

The synergistic effect of manganese dioxide and waste PVC is investigated. Manganese dioxide alone is found to be only a feeble catalyst for bitumen polymerization. But when bitumen is air-blown in presence of both manganese dioxide and waste PVC, the rate of the reaction is found to be more than the sum of their individual rates. The synergistic effect of manganese dioxide and waste PVC is attributed to the effect of manganese dioxide to liberate chlorine radicals at a faster rate.

The study also reveals that the quality of industrial bitumen i.e. the softening point - penetration relationship made with different additives depends on the content and molecular weight of the asphaltene fraction. The higher the asphaltene content and the lower the molecular weight of the asphaltenes, the better the softening point - penetration relationship.

Our observation shows that the industrial bitumen manufactured from Haldia propane deasphalted bitumen is inferior in quality to that manufactured from vacuum distillation bitumen of Cochin Refineries. This is attributed to the presence of lower saturate content. However, it is found to be possible to improve the softening point-penetration relationship and to manufacture the products as per the specifications by lowering the process temperature.
For the planning of operations as well as for the design of plants for bitumen air-blowing in presence of the novel additives it is essential to know the kinetics of the reactions involved in the process. Bitumen air-blowing polymerization reaction is found to be first order with respect to the hydrocarbon reactants in bitumen. The possible mechanism of the reactions involved is suggested. This type of kinetic analysis gives a middle-of-the-road basis for plant design and control of operations.

Bituminous paints have been developed using the different industrial bitumen made with the novel additives. Two grades of bituminous paints (1) water, acid, alkali and chlorine resistant and (2) Heat resistant were made. The performance of the above bituminous paints were compared with those made with a conventional additive ferric chloride. The studies reveal that the industrial bitumen made with the novel additives can be applied for the manufacture of bituminous paints and they are capable of replacing the industrial bitumen made with the conventional additives. The study also reveals that cashew nut shell liquid-formaldehyde resin can be incorporated into bituminous paints in order to improve heat resistance. CNSL is cheap being the by-product of cashew nut industry and its utilization will improve the properties of bituminous paints and make them cheaper.

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