CHAPTER 5

GENERAL DISCUSSION

The paint manufacturing industry is one of the many industrial sectors that generates considerable quantities of both hazardous and non-hazardous wastes as incidental by-products. The wastes are often discharged on-site at various stages of the production processes and are subsequently collected for disposal off-site. Particulate matter emissions and foul odour occasionally escape to the immediate environment of the work-site and also to the ambient air outside the plant. Reducing waste is therefore a high priority for the paint manufacturing industry because it not only helps to minimise operating costs but also ensures that the health and well-being of the workers are protected.

The present short-term study shows that paint pigment dust do in fact contain traces of 8 toxic elements(arsenic, cadmium, chromium, cobalt, copper, nickel, lead and zinc) of which the following 4 elements present in excessive concentrations were selected: namely, arsenic, copper, lead and zinc. It is therefore of utmost importance that these dust should not escape to the working environment in the plant and its vicinity since this may cause serious health problems to the workers when inhaled (Khoo,1988). The inhalability and toxicity of these dust however depends on the size of the dust particles. The toxicity of particle increases with decreasing particle size (Godish,1991; Natusch and Wallace,1974). This study shows that the particle size ranges from 0.941 μm for solvent-based paint dust to 8.185 μm for water-based paint dust (volume weighted mean diameter: Table 5 and Table 7). The solvent-based paint dust is thus significantly finer than the water-based paint dust by about nine times. The solvent-based paint dust was found to contain much higher concentrations of these toxic elements as compared to the water-based paint dust. Although inconclusive, this has an implication on the size-related absorption capacity of the particle. Nevertheless, these findings confirm the inverse relationship between the toxicity of dust particle and the particle size. Particles in this size range are also able to enter the lungs and deposit therein (Walton,1974). The workers are therefore rightly provided with safety masks for this purpose. This is certainly a good measure undertaken by the management.

Additionally, appropriate dust-collecting devices have also been installed. It is commendable that the management installed two dust-collecting devices, one for collecting dust generated from the water-based paint manufacturing factory and the other one for collecting dust generated from the solvent-based paint manufacturing factory. This "sorting up" measure facilitates possible recycling so that these dust could be used for other useful purposes instead of being dumped in a landfill. These dust-collecting devices are of the pulse-air-jet bagfilter type which is very efficient in collecting dust of this size. This pulse-air-jet bagfilter is an advanced type of the conventional bagfilter where the latest technology in fine particles collection has been incorporated. However, in order to further improve the present dust emission management, it may be desirable to also consider an installation of an electrostatic precipitator(ESP's) downstream of the bag filter to scrub the finer dust from the solvent-based paint manufacturing factory. This measure would enhance the compliance of regulatory requirements. The budgetary constraints should, however, also need to be considered.

Collecting dust generated from industrial activities is however a conventional and outdated approach in environmental management. This is because the collected dust leads to another environmental problem, namely, that of solid waste disposal. Solid waste disposal essentially entails a landfill or an incinerator. The landfill requires a tract of land which could perhaps be better utilised for a more productive purpose such as for agriculture. In the landfill, these paint dust can pose environmental hazards such as ambient air pollution or groundwater contamination when seepage of leachate accidentally occurs. The incinerator is costly and also may cause air pollution from its emissions. Therefore, there must be an effort to change this conventional way of environmental management. A sure way of overcoming this predicament is to prevent pollution at the source.

Indeed, environmental programmes that focus on the end-of-pipe or the top-of-the stack, on cleaning up after the damage is done, are no longer adequate. What is needed are new policies, technologies and processes that prevent or minimize pollution - that stop it from being created in the first place. The thrust is on the "cradle-to-grave" approach or the life-cycle assessment with special reference to dust emission (Fava,1994; Pereira,1996).

With the above objective in mind, the following recommendations are proposed in respect of the paint manufacturing plant. The regulatory requirements for dust emissions (industrial and ambient) in the Malaysian context are first explored as assessment guidelines for compliance with regulations. The various processes in the manufacturing of paint are then described and finally, the likely sources of wastes and their generations with special reference to paint dust emission are identified. This is essential before any dust pollution prevention options could be proposed and tested for economic and technical feasibility.

5.1 COMPLIANCE WITH ENVIRONMENTAL QUALITY (CLEAN AIR) REGULATIONS,1978

Statistics on the loadings of the dust pollutant emissions to the workplace and its vicinity of the paint manufacturing plant under study is unavailable. This information is most wanting for the management of the premises of manufacturing chemical products including paint, varnishes and lacquers (WHO,1982). However, the emission standards of dust (total suspended particulates) recommended in the Malaysian standards should be complied with. As a guide, the emission of dust per stack should not exceed the emission standard set at $0.4 g/Nm^3$ specified for industries as reported in the Environmental Quality (Clean Air) Regulations, 1978. For the ambient dust emission, the currently applicable guideline values recommended by the Department of Environment, Malaysia are (1) an 24-hour maximum of 260 $\mu g/m^3$ that should not be exceeded at any one time and (2) a concentration of 90 $\mu g/m^3$ for annual average (ESI-DOE, 1987; SMHB-DOE, 1989). To assess compliance or non-compliance, air quality monitoring programme with particular reference to dust emission is recommended to be carried out to determine the existing levels and the trends of the atmospheric fine and coarse particulate matter at the study site.

5.2 PROCESS DESCRIPTION

The total annual output of this paint manufacturing plant at Shah Alam is about 40,000 tonnes. The national annual output of paint is about 70,000 tonnes with contribution from the Johor plant and Kota Kinabalu plant. The Shah Alam plant is therefore a major production plant insofar as this company is concerned.

Of the total annual production in the Shah Alam plant, one-third is solvent-based paint and two-thirds is water-based paint.

5.2.1 Solvent-Based Paint

The process flow diagram of the solvent-based paint manufacturing process is shown in Figure 7. The production of solvent-based paint begins with the mixing of resins, dry pigments and pigment extenders along with solvents and plasticizers in a high-speed mechanical mixer. Plate 6 shows a planetary mixer.

After the mixing operation, the batch is transferred to a mill for additional grinding and mixing with beads to disperse the pigments in small quantity of solvent-resin mixture. The type of mill employed depends on the types of pigments being handled. The types of mills employed are roll mills, sand mills, pin mills, hammer mills and sieve mills. Plate 7 and Plate 8 show two typical mills. The paint base or concentrate is then

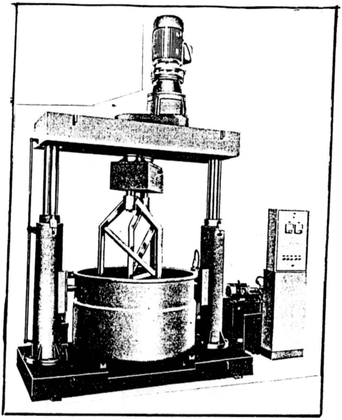

Plate 6 Planetary Mixer

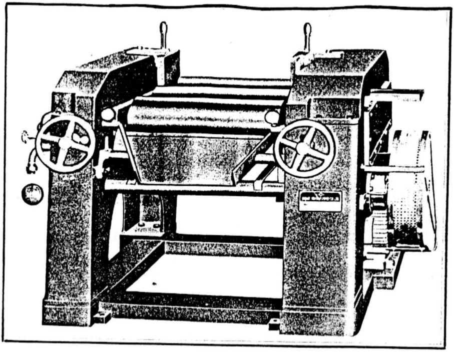

Plate 7 Three Roll Mill

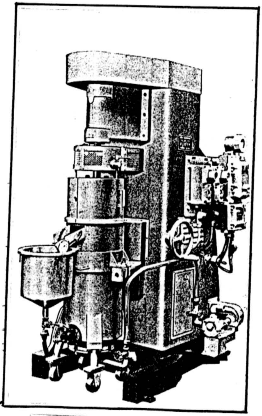

Plate 8 Sand Grinder

transferred to an agitated tank where tints, thinners and additional resins are added and mixed.

After reaching the proper consistency(viscosity and/or concentration), the batch is filtered via a cartridge filter to remove any nondispersed pigment and the paint is transferred to a loading hopper. From the hopper, the paint is poured into cans, labelled and moved to the warehouse.

The major raw materials used are oil-based solvents (aromatic white spirit) and pigments (like iron oxide, carbon black and others). The solvents are purchased in bulk /drums.

5.2.2 Water-Based Paint

The process flow diagram of the water-based paint manufacturing process is shown in Figure 8. The production of water-based paint begins with the mixing of water, ammonia and a dispersant in a high-speed mechanical mixer. Dry pigment and pigment extenders are also added and mixed into the mixture. After mixing, the batch is milled and transferred to an agitated tank where resins, plasticizers, preservatives, anti-foaming agents, polyvinyl acetate emulsion, water and thinner are added.

When the properties of the batch meet the specifications (in terms of viscosity, colour and gloss), the mixing is stopped and the mixing tank contents are pumped through cartridge filters to the filling hopper.

The raw materials used are water, water-based resins, extenders (e.g. calcium carbonate) clay and pigments (e.g. titanium dioxide).

5.3 WASTE DESCRIPTION

The major raw materials used to manufacture paints are resins, solvents, drying oils, pigments and extenders. The types of resins used include alkyd, acrylic, vinyl, and soyabean oils. The pigments include titanium dioxide and other inorganic pigments(e.g iron oxide, zinc oxide, zinc dust, aluminium paste, lead compounds and chrome compounds) and organic pigments. The powdered pigments are delivered in paper bags and slurried pigments in drums. Slurried pigments are used predominantly for water-based paint formulations. Calcium carbonate is the most common extender used along with talc and clay.

Among the wastes generated by the plant are leftover pigments in packages and pigment dust from air pollution control equipment and dust resulting from the unloading of raw materials to high-speed mixer or mixing tank.

Filter bags and cartridges are used as the dust control equipment for both solvent-based and water-based paint manufacturing processes. Spent bagfilters are washed and disposed of as non-hazardous wastes. Hazardous waste materials (chromium and lead packaging) need to be disposed off in a controlled fashion in drums and need to be sent to a secured landfill (e.g. licensed hazardous chemicals treatment plant like Kualiti Alam Ltd. Co. in Seremban/Nilai, Negeri Sembilan).

5.4 DUST POLLUTION PREVENTION OPTIONS

There is an element of truth in the maxim that waste prevention leads to profit maximization. When waste can be prevented, it implies that less raw materials are being used. This means less costs are incurred and therefore profit can be maximized.. As such, it is imperative that industries should consider and evaluate various technically and economically feasible options whereby unnecessary wastes can be reduced or eliminated completely. It is proposed in this section to recommend three pollution prevention options for the paint manufacturing plant with regard to pigment dust emission.

5.4.1 Process Modifications

Pigment waste from bags and packages may be reduced by using water-soluble bags. In water-based paint manufacturing, bags containing toxic pigments can be dissolved or mixed with the paint. However, the feasibility of this option needs to be further studied to see whether the quality of the manufactured paint would be drastically affected.

Paste pigments which are wetted or mixed with resins may be used in place of dry powder pigments that cause particulate matter or dust emissions.

5.4.2 Resource Recovery and Recycling

Pigment dust collected from the dust-collection equipment can be recycled to the production process and reused. This could be possible when pigment dust from solvent-based paint manufacturing process do not mix with those from the water-based paint manufacturing process. Two separate dust-collection equipment are therefore needed for this purpose.

5.4.3 Good Housekeeping and Operating Practices

By installing a separate dedicated baghouse for each production step (pre-mixing, dispersion, transfer and mixing), the collected pigment dust or resin dust can be recycled to the process step and re-used. However, the cost of an additional baghouse installation should be considered against the benefit of recycling the dusts.