CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the discussion of the problems and the results is concluded, and further applications are recommended.

8.1 Conclusions

- The FA and MRA approach can provide a predictive model that links manufacturing operations (material and utilities supplied) and environmental impacts (wastewater load) for industrial paper as follows.

- The FA approach has been shown to reveal the patterns of industrial papermaking operations through the inter-correlation between material input variables associated in the forms of factors for two main products manufactured at the study site, Gypsum liner board (both GF and GB) and Duplex coated board (including all of the varieties produced; DP 450, DP 400, DP 350, DP 310, and DP 270). The patterns of variation of GF and GB contain 13 and 11 variables and the same four significant common factors, respectively. Also the patterns of variation for all DPs contain 16 variables and nine significant common factors for DP 450, DP 400, DP 350, and DP 270, and ten significant common factors for DP 310.

  The validity of the FA model shows that the significant factors for GF and GB represent the group of important variables better than the factors found for DP. The interrelationships expressed in the factors among the material input variables in the factors for GF and GB do a better job of interpreting the physical meaning in the production process that relate to wastewater load than do the factors for DP.

  Based upon these interrelationships within the factors, various patterns of resource use in the manufacture of each product were identified and could be mapped into a set of events which describe the characteristics of each factor.

- The FA and MRA approach has revealed that there are three major events occurring in the process, namely, increased use of broke due to high contaminants from feed stock, excess chemicals in white water due to the poor control of addition of chemicals and poor retention of fines and filler, and overflow of white water due to the change over of paper grade including scheduling of machine operations (between the paper machine and wastepaper plant). Based on the prediction accuracy of the model (>40%), these causes lead to suggestions to management for controlling wastewater load by improving the condition of material supplied, monitoring and adjusting conditions of the chemicals supplied, and utilizing planning strategies for both machine operation and product change.

- Limitations found for predictive model relate to the following issues:-

- Model building for DP's was limited due to the small data variation of DP and less data available for some DP (DP270) than was used for GF and GB. Because of this, the FA model for DP results previously in a single variable in the factors and therefore does not provide a good representation of significant factors. Such a FA model has very limited ability to increase the predictive accuracy of wastewater load. Future work, if any, should study for additional production data for the products, and seek different approaches for data analysis, such as earlier use of MRA.

- The predictive model has been developed for multi-paper grade on the same paper machine for different varieties of industrial paper (GF, GB, DP 450, DP 400, DP 350, DP 310, and DP 270). During data collection, data was not taken during the change over from one paper grade to another in order to eliminate the error from the overlap of different product in the production process. Therefore, this predictive model is not suitable for predicting wastewater loadings during the change over. However, the data that were obtained indicates that change over condition can have a large effect on wastewater quality. Extension of the model to cover these condition is advised.

8.2 Recommendations

In the following list, some ideas are provided about further applications that could make the model more useful to the plant manager.

- In order to provide for more effective prediction of wastewater load, other data variables related to the material supplied, particularly, broke and white water need to be collected for Gypsum liner board and Duplex coated board production. Moreover, some other interesting variables such as, speed of paper machine are related to the production of different basis weight of coated paper should be added to the next generation of the model for Duplex coated board, if this data can be obtained. Furthermore, product quality variables, such as, COBB (ability to prevent water penetration), brightness, and internal bonding that relates to the wastewater quality should be collected in order to determine their relation with the wastewater load, if these data can be supplied. This could be beneficial for the manufacturers in order to adjust the quality of product and wastewater quality.

- The predictive environmental model for wastewater in terms of suspended solids and organic pollution (SS, TDS, COD, and BOD) can also be extended to other parameters, such as some resin acids and heavy metals that can be adsorbed by organic solids in the mill effluent and may therefore adversely affect the environment. They have potential long-term effects as a result of bioaccumulation and transport through the food chain. Other environmental situations of potential importances include solid waste, namely, bale wrappers and wire, sorting rejects and pulping sludge (mixture of water, cellulose fiber, filler and ink), and air emissions both gaseous and particulate emissions. Based upon the set of these different parameters and/or different situations, development of the related predictive models is recommended.

- The FA and MRA approach used in this study may be applicable to other paper industries as discussed below.

- Although there are current limitations and conditions for the predictive model due to the data available, the same modeling approach could be beneficial for development of environmental models for other paper industries. Moreover, this modeling approach can be used for comparative studies of the same type of product in different paper mills in order to obtain benchmarks for environmental management. Furthermore, this approach should be applicable for other types of industries as well, with appropriate modifications.

- For further study, it is recommended that the following issues be considered in order to manage root causes of wastewater generation more effectively.
  1) The ratios of wastepapers in each layer of product should be studied to determine the highest level of the good source/good quality grades of wastepapers that can be used for GF, GB, and DP in order to reduce the contaminants that occur in the process, while achieving the desired level of economic performance.
  2) The addition of amounts of chemicals should be studied to determine the optimum level that can maintain the good retention of fines and filler. This may require analysis of residual levels of the chemicals in re-circulating water.
  3) The number of paper grade change overs should be studied for the appropriate level.
  4) The proper design of storage for white water should be studied to provide the appropriate number and locations for white water storages.

- For future work, the predictive environmental model should be used as a decision-making aid to help the manufacturers to plan their production while considering wastewater generation. Some software may be need to be developed for the plant operators to have the best information as to what is the desired level of material input components or what the level of wastewater loadings may be. Development of such a program is desirable. It should also be able to predict wastewater loadings if it is necessary to replace a particular component in the model and to accommodate constraints resulting from availability of various inputs, such as different fiber types and different chemical types. The goal of this capability is to obtain the information required to optimize control of material input and wastewater management. If this program can be developed in a user-friendly software, it would be of great benefit for helping manufacturers in planning and improving their production as it relates to wastewater generation.