ABSTRACT

This paper presents the prototype of pulp and paper simulator which has specific design for cleaner technology approach. The prototype is generated with Microsoft Visual Basic containing graphical user interface and menu-drive. The core calculation is mass balance of every single unit of the process and identify the key point of waste. This program performs both forward and backward in order to predict the amount of bark used to produce the desired quantity of paper. The implementation to paper mulberry is undertaken to detect the waste from washing unit which is the major environmental impact.

INTRODUCTION

Paper has become an integral part of the development of our culture, both as a communications medium and in packaging. The per-capita consumption in Asia is 59 lb./year. This index reflects the relationship between paper use and industrial development in other cultures. As the less industrialized nations become more developed, the demand for paper is expected to grow, creating a continually increasing demand for paper and excellent prospects for long-term growth of the pulp and paper industry. In both processes, they comprise of various unit operations performing series of chemical process. The efficiency of pulp and production is quite low because it has the and loss from many units e.g. washing the pulp, bleaching, making the paper, etc. The industries can not detect them. There is few of computer software designed to describe this kind of process. Therefore, the modular program that can report and analyze the mass balance, layout and perform the economical task will be the central of this study.

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This paper specifies in mulberry pulp and paper making which is the local industries. The reason is that the quality of the mulberry paper is difficult to control. Moreover, the emission from this process causes directly to the environmental impact.

**The mulberry pulp and paper making**

Mulberry is one of the Moraceae family. The scientific name is *Broussonetia papyrifera* Vent. Its fiber comes from the bark of mulberry. It is a good raw material for paper making because it is a softwood. Normally, the softwood has longer fibers than the hard wood, which contributes to greater strength in paper. Moreover, this type of fiber can make the rough or coarse paper.

Mulberry paper is one of the best qualities in Thailand because of its special characteristics such as its strength, ink receptivity and stability, etc. It can be used for many applications for example, make the bank-note, crucial document, paper for oil painting, and filter paper for liquid, air and smoke, etc. The value added of mulberry paper is increased dramatically after converted from raw mulberry depending on its characteristics.

In the past, the mulberry paper manufacturing is hand-made, so it is difficult to control the quality of the product especially its uniformity. The reason conclude from the steps of operation as follows:

1. The raw material, mulberry trees, grow naturally so we cannot obtain the desired qualification.
2. During the cooking process, the mulberry bark is digested by sah, so we cannot control the quantity of base in ash.
3. The distribution of mulberry pulp is not good enough because of using manpower. Besides, it consumes more labors.

In addition, the productivity is quite low. As a result, the quality of mulberry paper from the conventional process is not reliable in the paper industrial standard. Therefore, the process must be improved and summarized as follows:

1. Raw material selection
The diameter of mulberry should be about 3 to 5 cm. Then, using steam to peel the bark off. The fiber obtained from this method is clean, moreover, some sap and dissolved impurities can be removed immediately.

2. Digestion

The digestion of mulberry bark is Kraft process. The cleaned bark will be cooked with NaOH solution and the operating conditions are shown in Table 1.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry mulberry bark</td>
<td>300 g</td>
</tr>
<tr>
<td>Sodium hydroxide (NaOH)</td>
<td>15% by wt.</td>
</tr>
<tr>
<td>Liquid/dry bark</td>
<td>10 : 1</td>
</tr>
<tr>
<td>Temperature of digestion</td>
<td>100°C</td>
</tr>
<tr>
<td>Time required</td>
<td>5 hr.</td>
</tr>
<tr>
<td>Yield of unbleached pulp</td>
<td>54% wt.</td>
</tr>
<tr>
<td>Permanganate number</td>
<td>5.4</td>
</tr>
</tbody>
</table>

3. Washing

The cooked bark is removed into washer. Washing water is poured from the top of the tank and discharged from the pipe on the bottom. This operation is repeated 2 or 3 times.

4. Bleaching

The purpose of this unit is to improve not only the brightness of fiber but also the permanence of that brightness. Bleaching of the washed bark has been carried out by single-stage of sodium hypochlorite or calcium hypochlorite and the details are shown in Table 2.
Table 2. The operating conditions for bleaching

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium hypochlorite (NaOCl)</td>
<td>4% wt of unbleached pulp</td>
</tr>
<tr>
<td>Pulp consistency</td>
<td>6%</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>40 °C</td>
</tr>
<tr>
<td>Time required</td>
<td>3 hr.</td>
</tr>
<tr>
<td>Pulp yield</td>
<td>52% wt. of bark</td>
</tr>
</tbody>
</table>

5. Washing

The bleached bark is removed into a concrete tank for washing. This operation is performed with same method after cooking. Next, it is sent to the refining or beating unit to reduce the stiffness of fibers.

6. Refining or beating

Thai mulberry pulp is more stick and hard than that of Japan, so, the effective beater is required. Time required for beating depends on the characteristics of bleached pulp. Normally, 3 kg of pulp uses 1 hour for beating.

7. Paper making

The pulp fiber is suspended in concrete tank. The consistency of pulp fiber is 2% in approximately. This unit consists of many unit operations: sheet forming, transferring, pressing, and drying.

These unit operation train represents in view of engineering design and modeling by a suitable computer programming.

Cleaner Technology Audit

Cleaner technology; the preventive approach, is the continuous application of an integrated environmental and business strategy to procure resources, process and produce products or provide services at a higher efficiency, increased profitability and at reduced risks to the environment. In this
approach, the overall resource utilization factor improves since wastes are inherently reduced. Following are few of the cleaner technology.

Good housekeeping practices; Equipment modification; Process modification/retrofitting; Raw material substitution; Product modification; Innovative manufacturing; By-product recovery from the waste; Recycling the waste (with or without treatment) in the production process itself; Reuse of waste (with or without treatment) in some other processes.

Cleaner technology has thus emerged as an essential prerequisite for any sound Environmental Management Program for industry.

**Modeling of mulberry pulp and paper making**

Some information on the operating conditions such as the concentration of NaOH, the desired moisture of the paper, the quantity of washing water in both Washer 1 and Washer 2 need to be provided in order to simulate all the necessary conditions (weight of paper form the process, the quantity of white liquor, black liquor, washing water). The Prototype has a function to detect the waste from each unit. It can also predict the suitable consumption of washing water and report the difference between the actual operating conditions and the results from the simulation.

There are two modules in this prototype. The first module is the module for the forward calculation. It uses for simulating the process when the users want to know how much the paper produced from the process with certain amount of the Mulberry Bark. Moreover, the optimal information of the operation is also reported. The second module is the backward calculation. It is used for simulating the process when user wants to know how much the Mulberry Bark they want in order to get exact amount of the paper.

In the first window of each module; the input data window, user has to input all of available data to the text box. The simulated result is shown in the window of overall plant as shown in Figure 1.
Figure 1. Mulberry pulp and papermaking process

Figure 2. The window of washer 1
If the user want to get more information, they can access to the window in each equipment. The waste spot operating condition is also detected.

For example, the program calculates the suitable quantity of the washing water, compare with the normal amount using in the process and notice to the user that their operating condition is suitable or not. Figure 2. shows the message boxes warning that the amount of washing is too low and some case it might too high. Therefore the user can simply adjust their process condition to the suitable one as be shown in the result from the calculation.

Because this model is developed from the optimize information, it can be used to be the standard model for the mulberry pulp processing. However, it might be improved to gain the efficiency of the simulation later.

CONCLUSION

Paper has become an integral part of the development of our culture, both as a communication medium and in packaging. Therefore, papermaking industry is one of the most important industries in our country. There are many manufactures in the field of papermaking industries vary from big factories to small one. Moreover, there are many kinds of paper using in the present and the quality of the paper quite different up to their application. Mulberry Pulp and Papermaking industry in Thailand is organized in the small-scale papermaking. Although, it is a local-made industry, it comprises of various unit operations performing series of chemical processing. The efficiency of production pulp and papermaking is quite low because it has the loss from many unit i.e. washing the pulp, bleaching, and papermaking. This industrial sector normally cannot pinpoint them. Therefore in this problem, the computer is used to report and analyze the mass balance, layout and perform the waste generating unit spot. The program that is used to perform in this task is generated the visual program.

The modeling of Mulberry Pulp and Papermaking is very useful to simulate the operating condition of Mulberry Pulp and Papermaking. However, it can specifically use for this industrial. This program is developed in user friendly style. The advantage of the Visual program is that it is very easy to create the user interface window. Therefore, the users can use it easily. In the program, it consists of
the user interface windows that are very easy to use. Just only do step by step that is recommend in the program, they can achieve their objectives. The result data are shown in the picture objectives. The result data are shown in the picture file that is convenience to get the result of each unit. Moreover, users can detect the waste spot from each unit in the program also. There are the message boxes in some units to warn the user about the over or lower consumption of the washing water.

However, there is something should be improved in the program, i.e. some base case data should be adjusted to get the most accuracy in the program. For example, the yield from the digester with the percentage of NaOH was assumed in the simulated stage. The assumption is to get 54% yield of Mulberry Bark by using the liquid per wood ratio at 10:1 and the concentration of NaOH = 15% by weight. That means the amount of NaOH solution has to be increased when the concentration of NaOH is decreased to obtain that amount of NaOH to get 54% yield. For this case, the liquid per wood ratio will more than 10:1 also. On the other hand, when users use the high concentration of NaOH, the liquid per wood ratio will be decrease. Therefore, percent yield might be decrease because it is too low amount of liquid phase in the digester. The contacting area between wood and the solution is decreased so the digestion might be not complete.

Moreover, the relationship between percent yield and the concentration of NaOH need to be study. The hypothesis here is the suitable NaOH usage. If it is to high, the cellulose will be destroyed. So, the percent yield might be decreased. And it is the same in the case of the bleaching unit.

For washing unit, some recommendation from textbook shows that for the good washing, the percentage of the dissolved solid should be 11% and 5% for the bad washing. The simulation with 11% of dissolved solid in the filtrate indicates the optimal operating condition which is close to their normal operator.

In order to develop this program, the information is very important. The more information the more accurate in the program. The actual or experimental data will polish our simulator to perform the robust result.
REFERENCES

Suchato, P. and T. Kongkerd. 1997. The preliminary study for the development of pulp and paper of Simulator. Special Problem, Chemical Engineering Department, Faculty of Engineering, Kasetsart University.

