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THE STUDY OF ENERGY USAGE AT REFINER MACHINE IN WRITING PAPER MANUFACTURE

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ABSTRACT

Writing paper in today's digital era is still needed in daily use or special purpose, for example in elementary education. In response to this, the paper industry must make innovations and efficiency in order to prevent deprivation. One method that can be taken is to do efficiency of energy refining. Refining serves to expand and fibrillate by providing mechanical treatment to the fiber. This mechanical treatment requires much energy. The objective of this study determine the effect of energy on fiber by using daily data from the paper industry. In this research, it is used as controlled parameter namely freeness interval 400 - 420 CSF, 4.5% consistency and 600 rpm rotation at 80 gsm grammage. From the study it was found that the energy used is still low and innovation can be added to the refiner engine rotation to match the flow rate.

Keywords: Refining, Energy, Intensity, Freeness.

I. INTRODUCTION

In the digital era the usage of printing paper is decreasing, but it does not mean that can be replaced. Before the covid 19 pandemic broke out [1], 40-55% of business documents still used paper.

In terms of correspondence[2], the physical form of the letter still received a great response. Elementary school to college students still need paper even though during the pandemic, teaching and learning activities take place online. Thus, the usage of printing paper still plays a big role in the life of modern society. Although writing paper is still necessary , producers still have to make efficiency in order to increase profits or optimize all of factors that can reduce company profits. Efficiency in the pulp and paper industry can be taken from many things such as raw materials to energy. In terms of energy consumption, the pulp and paper manufacture is an industry with a large energy consumption. As the illustration, the specific consumption of electrical energy for the pulp and paper industry in India reaches 91.85 kWh/ton of paper and thermal energy of 1619 MJ/ton of paper [3]. Another one, in Indonesia, energy usage for pulp and paper processes can reach 70-80% of the total energy consumed [4].The energy can be in the form of electrical energy and from steam.

At the pulping stage, the largest portion of energy is consumed in the cooking and washing stages of the pulp. This cooking and washing process requires conditions at certain temperatures and pressures for a certain period of time [5]. With the amount of pulp up to the order of tons / day, then it takes a lot of energy. In the paper-making process, the energy used by paper machines reaches 50% to 80% of the mill energy [6]. This illustration is assumed that the paper industry is not integrated with the pulp industry.

The objective of this research find out how much energy taking in Refining process as a part of paper-making process. As illustration, used-paper refining process requires 130 Tbtu of energy [7]. This fact become the basis that energy for the refining process is included in the efficiency priority. The place for research was taken at the paper industry in Indonesia. This research analyzed usage energy on a refiner machine unit which has a single disc. The sample to be reviewed is printed writing paper with a grammature of 80 gsm. Other parameters used as control variables are freeness of 400-420 csf, engine speed of 600 rpm and consistency of 0.045.

The outline of processing wood into paper can be seen in Figure 1

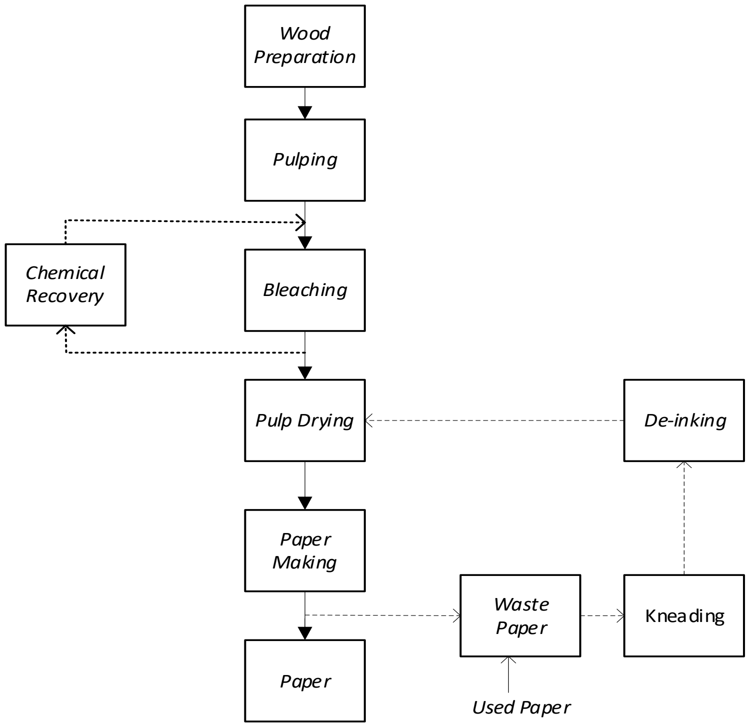

Figure 1: Brief Schematic of Process in Pulp and Paper Industry

Wood that is still in the form of a log will enter the wood preparation (WP) section. In the WP unit, the wood will be cleaned of bark and unused parts. After cleaning, it will be processed into wood chips. The next process is pulping. The main purpose of the pulping process is to remove lignin from the wood fiber. After all the criteria for cooking have been met, it will enter the bleaching process. Chemicals used in the pulping and bleaching process will be recovered so that they can be reused. Chemicals that have passed the recovery stage but cannot be used will be sent to waste treatment to be processed so that they are not harmful to the environment. After the bleaching process, the next process is drying. At this stage the pulp is ready to be sent to the paper making department or to the customer's paper industry.

The paper-making process can be divided into 3 main stages, namely, the provision of raw materials (stock preparation), the wet end stage and the dry end stage. The stock preparation stage [8] has the main function, which is to make the slurry homogeneous and of appropriate properties before entering the paper machine. Wet end is the stage of forming paper. At this stage, water removal also occurs by relying on gravity and vacuum pressure. The third stage is dry end. The dry end unit has the main function of drying paper sheets. After passing the dry end stage, the paper will be rolled up and can be sent to the customer or stored in the warehouse.

The paper industry also uses used paper and the rest of the paper that is wasted when it is rolled up. This type of paper will be combined and then passed in the kneading process to then go to the deinking unit. After the deinking process, the pulp from this used paper will be fed to the paper-making unit to be processed into paper.

The flow of the paper-making process can be seen in Figure 2 below

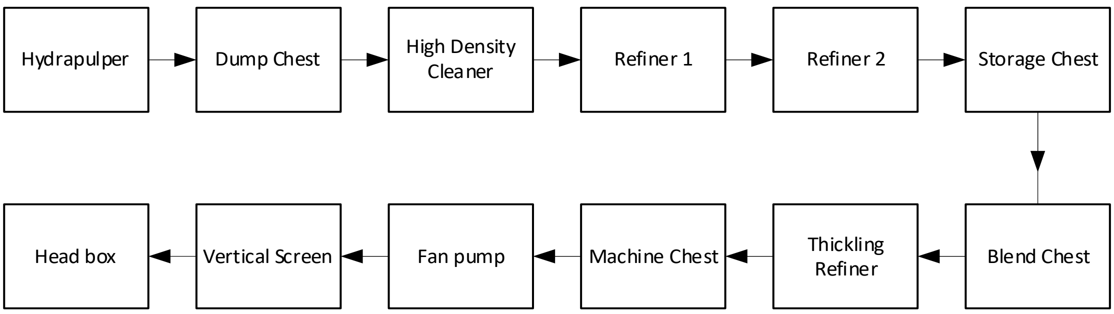

Figure 2: Schematic of the process flow in the Stock Preparation area

Hydrapulper is a machine that functions to break down the bonds between fibers contained in dry pulp. An enzyme is added to increase the fibrillation ability of the fiber as it enters the refiner machine. Pulp that has been processed in the hydrapulper machine will be accommodated in a dump chest. The agitator in dump chest is to keep the pulp homogeneous and there is no growth of anaerobic bacteria.

The next process is pulp separation from impurities such as non-pulp solids such as gravel, wire and others will be separated from the pulp. The working principle of high density cleaner is to utilize centrifugal force. The cleaned pulp will go to the refining section for the fiber fibrillation process. The fibrillated pulp will be accommodated in a storage chest to make diluted pulp with consistency of 4.5 – 4.7%. The next stage is the addition of chemicals according to the type of paper to be produced. After passing through this unit, the pulp will enter the approach flow section. In the approach flow pulp, it will receive several treatments, both adding more specific chemicals according to the type of paper and mechanical treatment. From the whole process in Figure 2, the refining process in the manufacturing flow is the process that requires the most energy [9]. Therefore, this research will make an analysis of energy use in the refining process.

The principle of the refining is to provide mechanical treatment to the fiber such as shear stress by grinding, twisting or pulling it. Fibers that have gone through the refining process are expected to have a high degree of fibrillation. The more Increased fiber fibrils the more hydrogen bonding potential between fibers. The addition of hydrogen bonds will increase the tensile strength of the paper. In addition to increasing fibrillation, mechanical processes in the refining system can also cause changes in fiber structure that can have a positive or negative impact. The positive impact is the achievement of fiber flexibility through internal and external fibrillation. The negative impact, among others, the fiber is stretched and compressed.

In the refining process, the intensity and amount of energy used is the main control in producing the desired fiber bond. The intensity used is expressed in specific edge load (SEL, Ws/m) or specific surface load (SSL, Ws/m2), while the amount of energy used is the net energy expressed in SRE (kWh/ton). SEL is the amount of effective energy used per unit total length of the rotor and stator bars that pass in one engine revolution [10].

The parameters used in refining are specific energy, refining intensity and intensity factor. Net specific energy is the amount of net energy absorbed per unit weight of pulp. Refining intensity is a measure of the intensity of energy used. The intensity factor is the ratio of the net energy to the pulp flow preparation (stock throughput).

II. METHODOLOGY

This study observes the performance of the refiner machine so that for the analysis used event recordings on the machine. The records used are refiner machine operational data for two months. To verify the recorded data, interviews were also conducted with operators and all parties involved in the refiner unit. After the daily data/records are obtained, the amount of energy refiner will be recalculated.

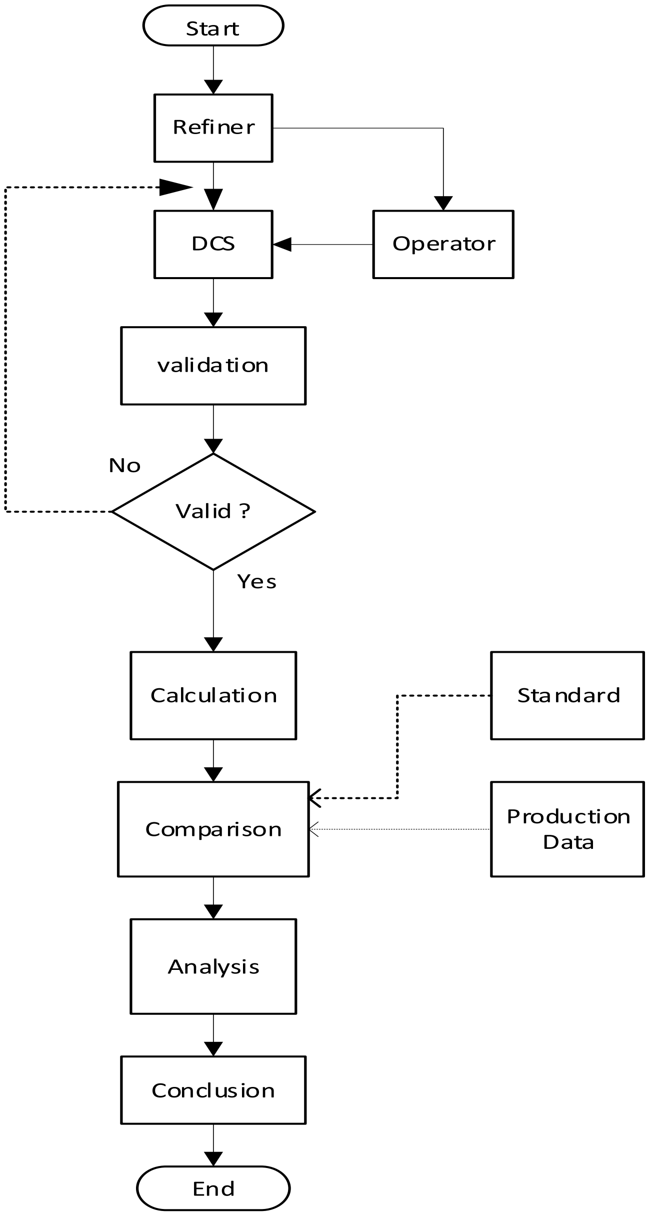

Figure 3: Research Methodology

This study combines data sources, namely daily recordings in paper mills and literature studies. The daily mill data is raw data taken from DCS including flow, engine speed and pulp consistency. Literature studies are carried out by taking data from papers, paper pulp professional associations or reference books. In addition to these two things, a direct survey method was used to ask questions related to refiner operations to the operator. The purpose of the survey is to get an overview from the human side (operators). The results of all this will be analyzed to get an idea of the magnitude of energy efficiency.

Calculation of the value of the intensity and specific energy can use the formula below [1-4] can use the equation below:

$$I = \frac{net\ power}{bar\ edge\ length\ x\ speed\ x\ \frac{1\ min}{60}} \quad [1]$$

With

I = Intensity or total energy received

Speed = Rotating speed of the Refiner Machine

Bar edge length = The total length of the bar edge when the refiner engine speed is 1 rpm

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The specific energy (SE) or net energy used to drive the flow of raw materials is expressed in tons per hour. The equation used is as follows:

$$SE = \frac{Total\ Energi - No\ Load\ Energy}{flow\ x\ consistency} \quad [2]$$

SE	= Spesifik energy
Total energy	= Used energy
No Load Energy	= Energy without pulp flows
Flow	= Pulp flows speed
Consistency	= Pulp consistency

III. ANALYSIS

The following is data from the paper-making unit. The data obtained in the form of total energy, and flow rate. The parameter data that are kept constant are the consistency of 4.5%, the rotational speed of the motor on the refiner machine is 600 rpm and the engine energy when there is no load is 95 kW. The amount of data obtained is as many as 67 data sets.

a. Flow Rate and Total Energy Data

The following is the flow rate data obtained from the refiner unit.

Table 1: Data Flow Rate and Total Energy

	Flow [ton/min]	Energi Total [kW]
Number of data	67	67
Mean	1.3254	215.21
Deviation Standard	0.1690	39.33
Maximum	1.6600	339.00
Minimum	0.9500	160.00
Error	0.0206	4.81

For more details regarding the data obtained from the Refining unit and can be read easily, the data will be show as the following image.

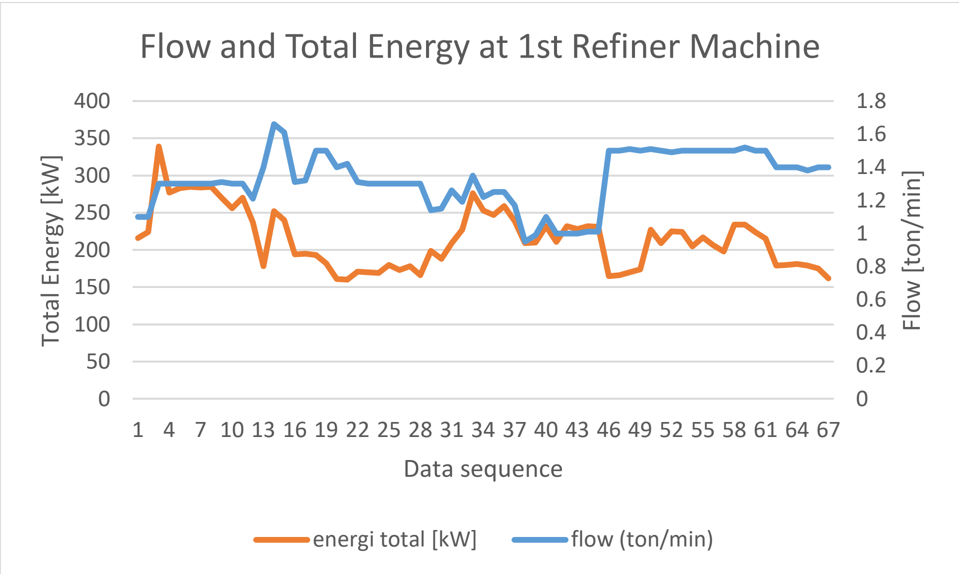

Figure 4: Data Flow Rate (flow) and Total Energy at 1st Refiner Machine

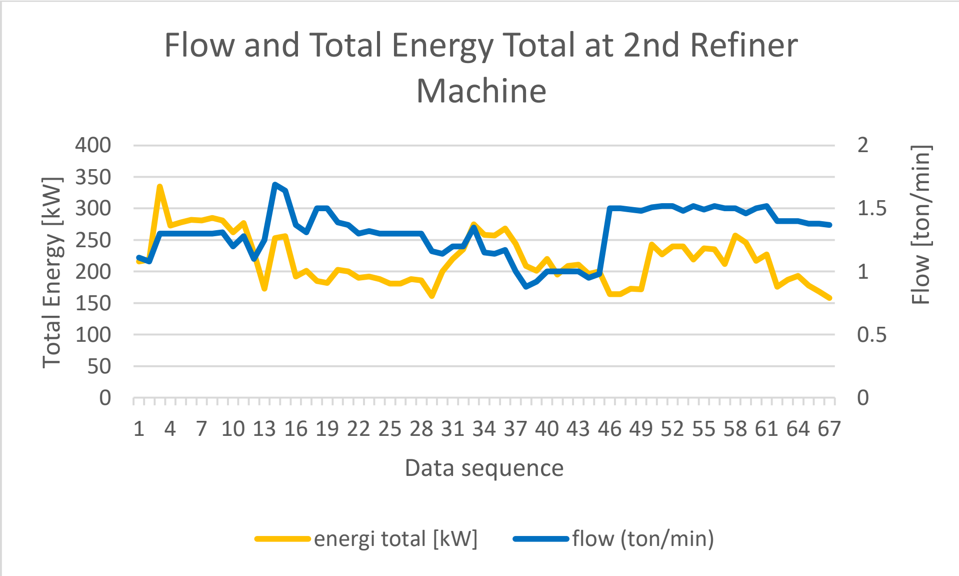

Figure 5: Data Flow Rate (flow) and Total Energy at 2nd Refiner Machine

Figures 4 and 5 show that the graph at the top (blue color) shows the flow rate in tons per minute. The graph at the bottom shows the total energy in kilowatts (kW). The left vertical axis shows the total energy amount and the right is the flow rate. The horizontal axis is the order in which the data is obtained.

To see the relationship between total energy and flow rate, a correlation test was carried out on refiner machines 1 and 2 giving the results of -0.286 and -0.067, respectively. This value means the level of correlation is very low. This can be seen, for example, in data sequence no 13. In data no. 13 the total energy is lower than data no. 1. The flow rate at no. 13 is higher than in no. 1. Taking into account the energy and flow rates in other data sequences as well there is a low level of correlation.

Thus, for the analysis of the performance of the refiner machine, the calculation of the intensity of each machine is used.

a. Intensity

As previously mentioned, the refining process aims to make the fiber expand optimally. The parameters that hold the main control to produce the desired fiber bonding are the intensity and energy used [10].

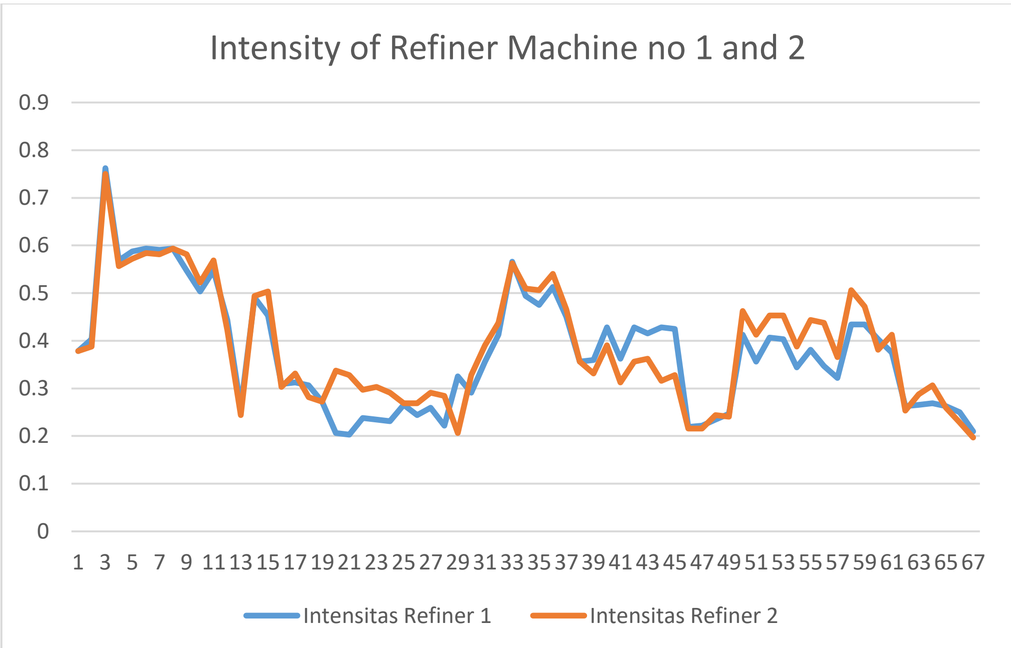

Figure 6: Refiner Machine Intensity

Figure 6 states that the intensity or amount of energy received by the fiber from the end of the rotor to the end of the stator in the refining process is recorded in the 3rd data showing the energy received by the fiber is 0.75 J/m. And the lowest was recorded in the 67th data, which is in the range of 0.2 J/m. where if the intensity of the fiber is too high, the higher the chance of fiber cutting or the creation of fines in the fiber. And if it's too low, the chances of fibrillation are getting smaller. In the refining intensity calculation data, it can be seen that the average intensity value is in the range of 0.3 – 0.5, which means that the pulp receiving refining treatment is of the Hardwood Dissolving (HWD) kraft type [11] or it can also be of the recycle pulp type. In the paper-making industry, the raw material does not always use pulp from plants/trees but also from recycled paper. Given that the refining data is taken for the production of printed writing paper, then this intensity value is appropriate because it is for printed writing paper. The pulp used is from HWD kraft with mixed recycle paper.

In the picture there is also a high intensity value or an outlier, namely in data no 3. Data no. 3 is the initial data of 67 data used. The possibility that occurs is that in the initial data, unexpected events occur, such as, for example, a sheet break that causes a surge in total energy in the refining unit.

1. Specific Energy

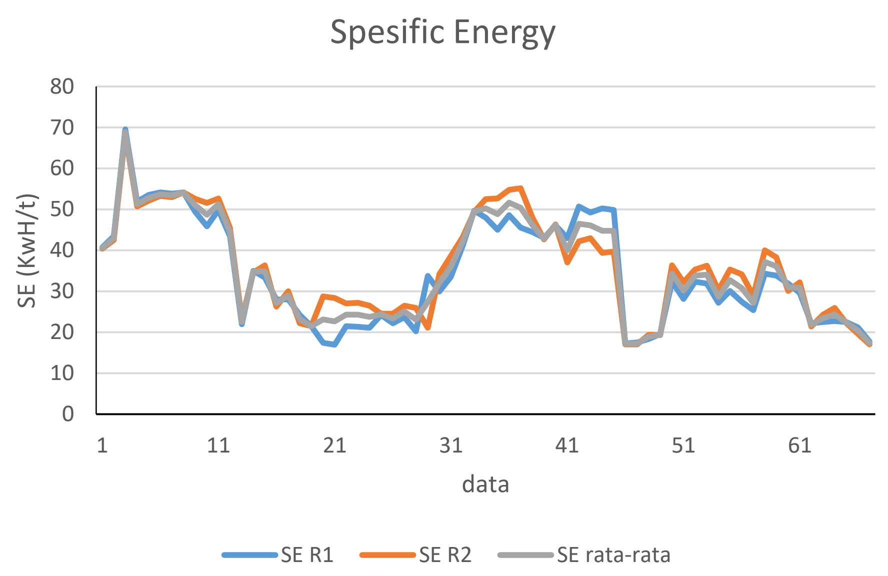

Figure 7: Energy-specific graph

Figure 7 shows that the 3rd data uses too much energy in the refining process, which is an average of 68.945 KwH. And the 46th data shows that energy use is able to decrease to an average of 17.16 KwH with a freeness value that is still within the specifications for grammature 80 gsm.

Based on observations from the graph, it can be concluded that in the 3rd data the energy use and intensity received have not been efficient. In this 3rd data, there is a high probability of fines ratio. As is well known, the use of large and inappropriate energy will cause the fiber to receive excessive mechanical treatment. The 46th data shows the most efficient results because with low energy it is in accordance with the freeness specification for 80 gsm paper.

IV. DISCUSSION

Daily data shows inconsistent movement of values in energy use and intensity. This inconsistency can be caused by several factors, both technical and non-technical. These factors include humans, methods, materials and the refiner's own machine. From these 4 main factors, other sub-factors can be traced. In this study, what will be highlighted are factors related to the technical aspects of the refiner machine.

1. Refiner Machine

The refiner machine used is a single disc type. As already described, the refining process produces fibers that have received mechanical treatment. The data obtained show that the bar edge length and engine speed are set at 32 KM/rev and 600 rpm. This results in any large pulp flow rate will get the same BEL and engine speed. The determination of the BEL number and the rotation rate is not flexible so that when there is a change in the consistency value, it will affect the amount of energy needed or energy is wasted.

What can be done so that the energy used can match the flow rate to be processed by the refiner machine is to add some control devices. The first device to consider installing is a variable speed drive (VSD) on the motor. The use of VSD will be able to adjust the engine speed according to the given load. The second device is the peng can be connected to the control valve installed at the inlet of the refiner machine. The control valve can be a solenoid valve (SV). This SV can be connected to a VSD. The combination of these two devices can adjust the performance of the refiner machine to be in optimal condition. In the end, the SV and VSD will be able to be monitored by the main control unit/control room unit.

2. Raw material

The refining process in the paper industry uses the HWD type or short fiber for the manufacture of printed writing paper. From the literature, the intensity values for HWD kraft and recycle paper have the same range of numbers, namely 0.3 – 0.8. In terms of operational cost savings, it is easier to use recycle paper than completely with HWD kraft, but for this reason the quality of recycle paper needs to be considered.

V. CONCLUSION

From the results of observations and data processing in the previous chapter, it can be concluded that:

1. The intensity values on refiner machines 1 and 2 have an average of 0.3, which means that the milled pulp is HWD kraft and/or mixed with recycle paper.

2. There is an inconsistency in the use of energy with the pulp flow rate, this is because the engine speed is set at a fixed number of 600 rpm so that even though the flow rate is small, the engine will still rotate. This results in wasted energy

3. It needs to be supported by very comprehensive data because there are data that are outliers, namely data no. 3 and 46. In data no. 3 and 46, there is a significant spike or decrease. With comprehensive data, analysis related to energy in the refining unit can be more detailed so as to produce the right decisions in energy saving in the pulp and paper industry.

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