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Capacity Calculator in Recycling of Scrap/Waste Paper and Dough/Cellulose Production

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Abstract – In this study, scrap/waste paper, which is the main raw material of the paper industry, is provided for pulp/cellulose production from scrap/waste paper, which is the raw material of the paper industry. These wastes are sent to the pulp preparation unit and passed through pulping, cleaning and, if necessary, deinking and bleaching and/or fractionation, as a result of opening and grinding processes, depending on the type of paper cardboard to be produced. After that, the paper-cardboard is sent to the paper machine pre-preparation unit to be produced. There is a continuously operating fluting/test-liner paper machine in the facility that performs this process. In the pre-preparation unit of the paper machine, the pulp is fed to the paper machine by passing through the final preparation processes, processes in which the necessary additives and fillers are added and the dry matter is adjusted, depending on the type and weight of the paper to be produced. While calculating the capacity of the paper production plant, the amount/weight of the buffer (large, finished paper roll) produced in the unit time (minute, hour, day, etc.) at the exit of the paper machine goods winder unit is taken as a basis. Capacity calculation in the existing facility is calculated as 350 days and 24 hours. The annual production capacity has been determined as 42,350,000 tons/year of paper. There is no white paper production in the annual production at the facility. Production is made only as yellow paper. 25-30 grams of biocides and polymers are used to destroy bacteria as necessary materials in production. Salt and corrosion inhibitor calculations are made for various paper and boiler chemicals. Besides, in the existing treatment plant, $FeCl_3$ is used as 0.15 wt.% in the production of 1 ton of paper per year.

Keywords – Waste Paper, Pulp, Cellulose Production, Capacity Calculation

I. INTRODUCTION

As in the whole world, solid waste in Turkey also appears as an important problem. İt is seen that the demands increase rapidly with the increase in the population. As a result of this, it is observed that the amount of solid waste has also increased. For this reason, what needs to be done to minimize the current difficulties, and especially possible problems and solution methods in the future, should be revealed in advance and appropriate planning should be made The Solid Waste Control Regulation entered into force on March 14, 1991, and there are definitions made depending on this regulation.

Solid Waste

Solids and treatment sludge (coarse solid waste, domestic solid waste), which are intended to be disposed of by the manufacturer and need to be disposed of regularly to ensure the peace of society and especially to protect the environment, are

defined in the regulation as solid waste in this context [1].

Coarse Solid Waste

It refers to mostly bulky wastes consisting of household goods such as refrigerators, washing machines, armchairs, and which cannot be used. Solid wastes are classified as follows according to the place where they are produced.

Domestic Solid Wastes

Solid wastes that are disposed of from residences, do not fall under the concept of hazardous and harmful solid waste, and come from places such as gardens, parks, and picnic areas are called domestic solid waste. Food waste and the empty packaging of the products we use at home are domestic solid wastes. Shampoo packaging, juice cartons, and bottles, plastic water and soft drink bottles, glass jars, tin and metal cans, and oil cans are examples of packaging waste we produce in our homes. According to the data of our country, an average of 1.0 kg of domestic waste is produced per person per day. Accordingly, it is estimated that an average of 68.000 tons of domestic municipal waste is produced per day and a total of 28.4 million tons per year [2].

Medical Wastes

Used medicine and injector wastes formed in treatment centers such as hospitals, dispensaries, health centers, and clinics, and wastes generated during surgery and treatment are classified as medical waste [3].

Industrial Solid Wastes

Waste from industrial activities is called industrial waste. We can give examples of solid, liquid, and gaseous wastes generated during production in factories. The composition of these wastes differs depending on the type of industry [4].

Agricultural and Garden Wastes

Plants wastes originating from gardens and wastes used or produced in agriculture are in this category [5].

Hazardous Wastes

These refer to wastes that contain explosive, flammable, self-igniting, combustible gases, oxidizers, and organic peroxides, and cause negative effects with air and water in contact with water (90 % of hazardous waste originates from the industry). For the management of these wastes, the provisions of the Hazardous Waste Control Regulation, which entered into force in 1995, are applied [6].

Solid Waste Recycling in Turkey

Separation and recycling processes of solid wastes containing substances with high economic value quickly became a current issue in Turkey as of 2017. With the Solid Waste Control Regulation published by the Ministry of Environment and Urbanization Climate Change, recycling has become a legal obligation. Only 300 thousand tons of annual 2-2.5 million tons of recyclable waste is within the scope of this regulation [7].

Waste materials provide an economic contribution to be used in production with a green approach. Paper is a material that is used a lot in our daily life [8]. It is also one of the most important cellulosic biomass wastes. The number of reuses of paper by the paper industry, the change of its properties, and the loss of papermaking properties cause it to occupy 30-40 % of the landfills in developed countries. In addition, cellulose-rich fibers from the papermaking process are discharged into wastewater in quantities of several thousand tons per year. However, waste paper derivatives may find application in other industrial areas. Therefore, there are different methods for the chemical adjustment, use, and management of cellulosic fibers in the yield of different cellulose derivatives [9,10].

As a source of cellulose, there is a great need for trees, especially in the paper manufacturing sector. Trees also have a fundamental role in human life as a source of oxygen. Paper production facilities use chemical auxiliaries in the production process, and in addition to rapidly depleting oxygen resources by using trees in production, they also pollute the environment by releasing chemical gases and various solid wastes [11]. The use and waste of paper as a final product require a remanufacturing process using raw materials and creating waste. For this reason, paper recycling has an important role in the ecosystem balance in terms of causing a dramatic reduction in waste production and the use of natural raw materials [12].

It defines production, which includes printing-writing, cleaning, packaging papers and cartons of different types and weights, which works

continuously and includes many processes. The pulp preparation unit and the paper machine pre-preparation unit are designed depending on the paper production capacity of the paper machine and are installed with the appropriate capacity to ensure the paper production capacity and the operation of the paper machine without pausing or slowing down [13].

The paper production facility works non-stop for 24 hours for all types of paper production. Annual working time is 350 days, 8.400 hours. While calculating the capacity of the paper production facility, the amount/weight of the buffer (large, finished paper roll) produced in the unit time (minute, hour, day, etc.) at the exit of the paper machine goods winder unit is taken as a basis. The establishment capacity of the pulp preparation unit and the pre-preparation units of the paper machine is calculated as higher than the production capacity to ensure 24-hours uninterrupted paper production, and the units are designed accordingly. The moisture percentage of scrap/waste paper coming to the scrap/waste pulp/cellulose preparation unit as raw material varies between 10 wt.% and 30 wt.% depending on the type and season. The accepted moisture ratio in the world and in Turkey is 10%. If the humidity of the waste paper bales arriving at the facility is above 10 wt.%, a waste cut is made as much as the moisture content. At the exit of the paper machine in the paper production facility, the moisture percentage of the finished paper-cardboard varies between 6 wt.% and 10 wt.% depending on the type and structure of the paper.

Scrap/Waste Paper/Cellulose Production Process

The pulper machine describes a machine used in pulping, wet nonwoven, and paper industries for shredding, fluidizing, and dispersing. Pulper allows old papers to be opened. Coarse fibers and unopened papers are retained by sorter sieves following the pulper. Clean dough passing through these sieves is conveyed to grit traps. Heavy particles in the dough, sand, soil, pins, etc. are removed. Waste papers, and pulper at the facility in tanks with a special opening system called a paste, water, steam and the pulp to be produced are turned into pulp by adding auxiliary materials when necessary, depending on the quality.

There is a strainer system at the pulper outlet, in the discharge line, where the relatively large size of non-fiber materials and impurities in the waste paper bales are separated. The pulp separated from coarse foreign materials is sent to the cleaning processes where physical cleaning equipment is located. The average waste rate at the pulper stage (relative to a dry pulp) is 19 wt.% of the waste paper fed to the pulp, containing 10 wt.% moisture.

Dough Cleaning Process

Smaller size non-fiber materials, inorganic and organic impurities in the waste pulp, which are free of coarse-grained impurities from the pulper, are cleaned by passing them through a series of sieving and sorting equipment operating in a serial system. The average waste rate in the cleaning phase is about 7 wt.% compared to the scrap/waste paper fed to the pulper. For pulp types that undergo advanced cleaning processes where deinking and bleaching are applied, the average waste rate in the cleaning phase is 10 wt.% compared to the scrap/waste paper fed to the pulp. As it is known, stoichiometric calculations and mass balances are made on 100 % dry matter in all industrial enterprises' production [14].

Ink Removal and Whitening Process

Depending on the type and quality of the finished paper to be produced, and therefore the pulp, the waste pulp/cellulose is processed in the bleaching process. This process is completely optional; it takes place only in the facilities where the paper types that this type of pulp/cellulose will be used as raw material are produced. It is not found in other paper production facilities. In the deinking process, together with the ink, fiber fragments called dead fiber and fine fillers are removed from the system. The average waste rate during the deinking and bleaching process is 11 % compared to the scrap/waste paper fed to the pulper [15].

Final Wash Concentrating, Opening, Grinding, and Cleaning

Dough undergoing pulp cleaning, deinking, and bleaching processes are passed through washing, grinding, and centrifugation units. The average waste rate in the stage covering the finishing process is 2 % compared to the scrap/waste paper fed to the pulper.

Scrap/Waste Pulp/Cellulose Production Process

The production of deinked scrap/waste

pulp/cellulose is 28 % compared to the scrap/waste paper fed to the pulp (10 % moisture) compared to scrap/waste paper (42 %).

Paper Machine Preparation

It is fed to the wet part of the paper machine after passing through the final preparation processes in which the necessary additives and fillers are added and the dry matter is adjusted. The wet part of the paper machine is the whole of the processes and equipment that enable the pulp to be converted into paper form. The conversion rate of pulp to paper (on a 100 % dry basis), which is called retention in paper terminology, is approximately 95 % with 5 % wastes.

II. MATERIAL AND METHOD

Capacity Account

The annual production capacity of the paper production facility is calculated as follows:

K tons/year = (M tons/min)·(60 min/hour)·(24 hours/day)·(350 days/year)

K: Paper production facility capacity (tons/year)

M: Paper machine output, amount of paper produced per unit time in the goods wrapper (tons/min).

Necessary items

Raw material, scrap/waste paper usage corresponding to the finished product capacity of the paper production facility

The capacity is calculated as follows.

Calculation of the amount of scrap/waste paper required per 1 ton of finished paper:

Calculations for 1 ton (1000 kg) of finished paper at the paper machine exit, at the goods wrapper, are performed.

H = U/(1-N) / R/(1-F)

H = U/(1-N) / R/(1-FM) (for deinked paste)

H: Amount of scrap/waste paper with 10 % moisture content fed to pulper in scrap/waste pulp/cellulose production facility (tons)/finished paper (tons).

U: Amount of finished paper 1 ton

N: Moisture content of the finished paper (%)

R: Retention ratio (%)

F: Waste ratio of scrap/waste pulp/cellulose production plant (%)

FM: Deinked scrap/waste pulp/cellulose production plant waste ratio (%)

U = 1 ton

N = 8 % = 8/100

R = 95 % = 95/100

F = 28 % = 28/100

FM = 42 % = 42/100

H = U/(1-N) / R/(1-F)

H = 1/(1-0.08) / 0.95/(1-0.28) = 1.345 tons of scrap/waste paper / 1 ton of finished paper

H = U/(1-N) / R/(1-FM)

H = 1/(1-0.08) / 0.95/(1-0.42) = 1.67 tons of scrap/waste paper / 1 ton of finished paper.

Based on the calculations given above, the capacity calculation of the facility in question is given below. Annual production amount:

The capacity calculation is calculated as 350 days and 24 hours per year.

K (tons/year) = M (tons/min) · 60 (min/hour)·24 (hours/day)·350 (days/hour)

Required Items

Calculation of the required amount of scrap/waste paper per 1 ton of product paper:

H = U/(1-N) / R /(1-F)

H = U/(1-N) / R /(1-FM) is the calculation for the deinked paste.

H = U/(1-N) / R /(1-F)

U: The amount of finished paper is taken as 1 ton.

N: The moisture content of the finished paper is 10 %

R: Retention rate 95 %

F: The waste rate in scrap pulp is taken as 28 %.

H = U/(1-N) /R / (1-F)

H = 1/(1- 0.08) / 0.95/(1-0.28) = 1.34 tons of scrap/waste paper/ 1 ton of finished paper

H = 42.336.000·1.34= 56.730.240 tons of scrap/waste paper.

Example Calculation

H = U/(1-N) / 0.95 /(1-FM)

H = 1·(1-0.08) / 0.95/(1-0.42) = 1.67 tons of scrap/waste paper/ 1 ton of finished paper (There is no deinked paper production in the factory).

Starch = 42.336.000·0.99 = 41.912.640 tons/year of biocides and polymers are used to destroy bacteria in 1 ton of paper.

For 1 ton, 10 kg of starch is used and 10,000 grams are used. 30 grams of biocide, 30 grams of polymer

It is 1006000 kg in total.

10000/10060 = 99 %

30/10060 = 0.0030 we got 0.005.

Biocide = 42.336.000·0.005 = 211.680 tons/year

Polymer = 42.336.000·0.005 = 211.680 tons/year

14.4 tons/year used for various paper and boiler chemicals. Here, a salt corrosion inhibitor was taken. Since it said 15 tons in total, 96 % of it was salt and the rest was 4 % corrosion inhibitor.

Salt = 42.336.000·0.96 = 40.642.560 tons/year

Anti-corrosion = 42.336.000·0.04= 1.693.440 tons/year used in purification is used as 0.15 % for the production of 1 ton of paper.

In chemical treatment, $FeCl_3$ = 42.336.000·0.0015 = 63.504 tons/year.

In Figure 1, the production scheme of pulp from paper waste is given.

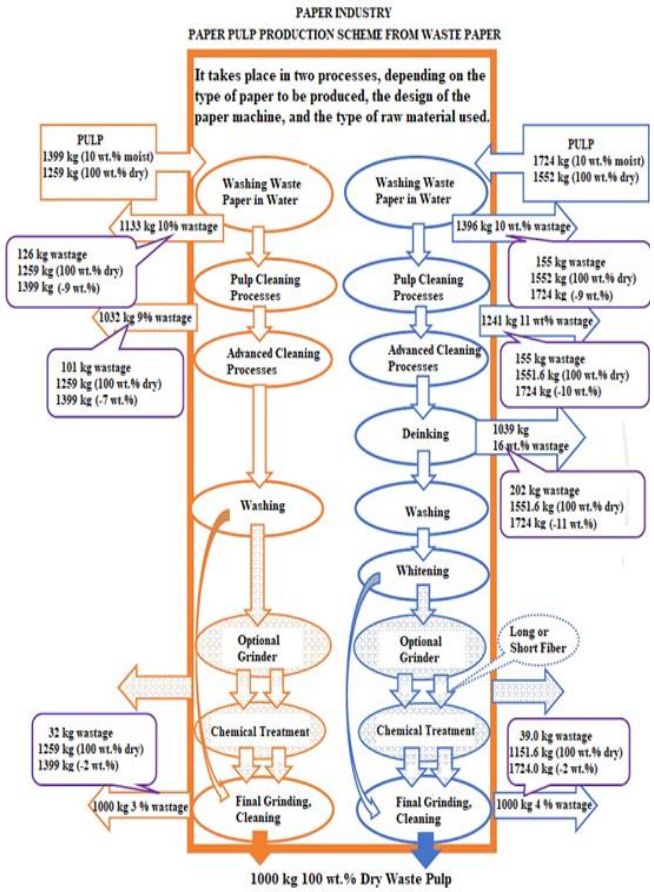

Fig. 1. Paper pulp production scheme from wastes

III. RESULTS AND DISCUSSION

Recycling waste paper is important for waste management. As a renewable resource all over the world, waste cardboard waste was recycled at the facility and used as yellow paper. Controlled and sustainable disposal and proper use of the ever-increasing waste paper volume is an important problem. In this way, the current work could play an important role in advancing technologies that could use this material in an alternative viable way. It is seen that economic gain and environmentally friendly production are made with the recycling made in the mentioned facility.

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