A NOVEL APPROACH FOR DESIGN AND RETROFIT A FLEXIBLE WATER TREATMENT NETWORK IN PULP AND PAPER INDUSTRY

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Abstract:

The Egyptian Pollution Abatement Project (EPAP) aims for developing five Egyptian sectors, which are as follows, Food industry, Pulp and paper industry, Metallurgical industries, Engineering Industry and Textile Industry. The paper manufacturing process is extremely water intensive, fresh water consumption reduction has a lot of advantages either on the environment & economic benefits such as, decreasing heating fresh water energy costs, in addition to reducing the pollution load via reducing the volume of effluent & thus lowering the cost of processing municipal waste and recovering usable fabric. However, a risk of reducing the usage of fresh water, like contaminants build – up in the water recycling loop, which affects the product quality. One of Egyptian paper and pulp companies, which produces 27 MT per a year of writing & printing paper had been chosen as a case study for the industrial sector. Water demand for the mill achieved by combination of both of fresh water & regenerated process water, that's to remove all suspended solids, which are present in water streams and allows water usage in several purposes, such as, chemical dilution, vacuum pump seal water, etc. The study goals to propose a plan for reducing of fresh water while preserving product quality, meeting process needs via constructing an optimization program (GAMS) to reduce fresh water demand, verify the model with the material balance results and studying the effect of changing the quality of regenerated water with fresh water demand.

Keywords: Freshwater minimization; Modeling; GAMS; pulp and paper industry

I. INTRODUCTION

Numerical approaches methods via using compaction software with built- in solvers targets to solve nonlinear problems. An excessive processing requirement is function on system's size and process complexity. Takama et al. (1980) was the first one to develop a mathematical model, where all possible configurations were tested for a superstructure network, later on in 1988, Alva-Argaez et al. the total annual work cost had been minimized by developing a method based on graphical approaches, meanwhile according to Manan et al., 2007 geographical, controlling a safety matters still a constrain on a network optimizing. A series of linear programs had been replaced by a non-linear program in 2008 by Castro et al., where the non- linearity had been addressed in water network mathematical formulation. In 2011, Boix et al. developed using GAMS software a procedure for solving multiple contaminant water network optimizations. This research targets to minimizing water network demand in an Egyptian paper & pulp industry, which in turns will results to rise in regenerated water flow rate thus, increasing the operational costs, this will be solved and optimized by using the second objective function by GAMS.

For a better reduction on the fresh water demand on the working mill by re-allocation of aqueous resources, this is considered a big challenge, but can be solved by using a network superstructure, where all possible configurations are combined together. As illustrated in figure, a mixer (M), that collects water from different process units (U) & a splitter (S) and discharges water from other process units are modeled. Fresh water feeds to process unit and the latter discharges it to the treatment unit for improving its quality by either discharging it as an effluent or sending it to the splitter.

II. MATERIAL BALANCE

An investigation for the mill in order to develop a strategy for reduction amount of fresh water had been carried. The following rules had been taken into our consideration during performing the material balance, such as,

1. Representing all users of fresh waters.
2. Studying unit operations hat have a significant effect on water network quality.
3. Assuming steady state operation since the machine produces the same product.
4. Assume that the disturbance can occur from mechanical problem or changing the product.

Since several process streams are not well known, a degree of freedom DOF can be used, DOF presents the minimum number of streams, which is necessary to obtain a unique solution, noting that it must equal zero. Felder and Rousseau (2000) give a full representing of DOF.

Table.1. Material balance

Stream Name	**Flow T/day.**	**Composition**			
		Total Suspended Solid g/ g stream		**Chemical Oxygen Demand g / stream**	
Feedstock	107	X0	0.89	Yo	0.00297
Steam	55	X1	0	Y1	0
On Grade Stock	12755	X2	0.008	Y2	0.00147
Off Grade Stock	19	X3	0.21	Y3	0.00146
Broke’s	3301	X4	0.00823	Y4	0.00146
Diluting Agent	11002	X5	0.00103	Y5	0.00146
Huge Stock	2635	X6	0.042	Y6	0.00146
Thick water	10298	X7	0.00102	Y7	0.00146
Treated Stock	2957	X8	0.035	Y8	0.00146
Dilution	509	X9	0.00105	Y9	0.00145
Additives	207	X10	0	Y10	0.0057
Mill Feed	14960	X11	0.0009	Y11	0.00152

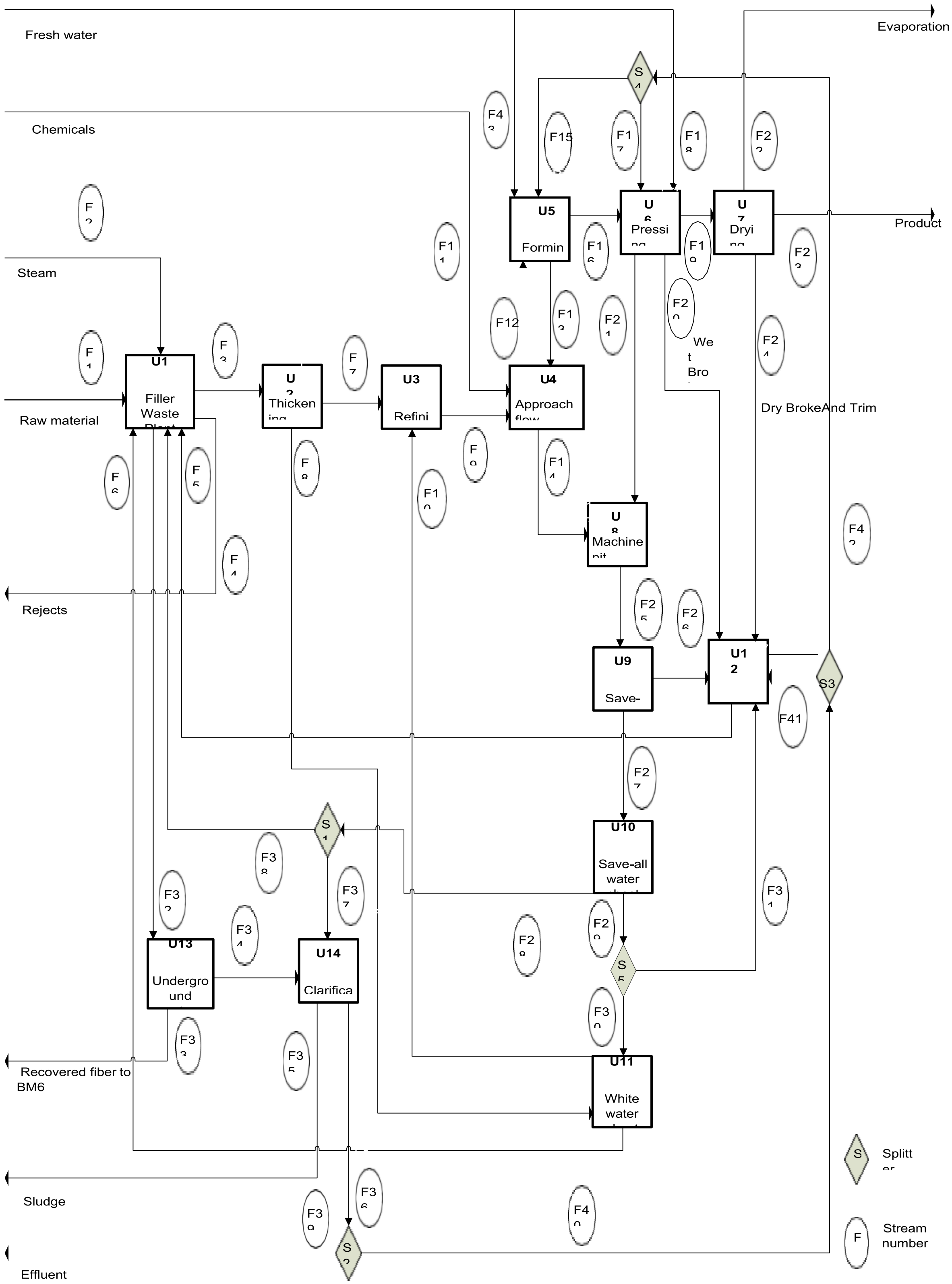

Figure.1. process flow diagram

III. MATERIAL BALANCE VERIFICATION

The input data, such as, raw material, production rate & clarifier overflow measured on a daily basis. Table.2. shows the value of the variable m which had been based on the material balance model. Sampling five streams & representing the measured compositions are presented in Table.3.

Table.2. Input values to verify the material balance

Name of the Stream	Flow rate (t/d)	Total Suspended Solid g/ g stream	Chemical Oxygen Demand g / stream
Raw material	117.1	-	-
Product	95.3	-	-
Drains &water purge	-	0.000284	0.00223

Table.3. Composition measurement

Specimen Number	Stream name	Total Suspended Solid (g/ g stream)	Chemical Oxygen Demand (g / stream)
1	Thick Water	0.0016	0.00269
2	Dilution	0.00445	0.00297
3	Returned Foamed Water	0.00149	0.00237
4	Water in Mill	0.00167	0.00239
5	Purging & draining	0.00629	0.00331

The input data, such as, raw material, production rate & clarifier overflow measured on a daily basis. Table.2 shows the value of the variable m which had been based on the material balance model. Sampling five streams & representing the measured compositions are presented in Table .3.

Table.4. Input values to verify the material balance

Name of the Stream	Flow rate (t/d)	Total Suspended Solid g/ g stream	Chemical Oxygen Demand g / stream
Raw material	117.1	-	-
Product	95.3	-	-
Drains &water purge	-	0.000284	0.00223

Table.5. Composition measurement

Specimen Number	Stream name	Total Suspended Solid g/ g stream	Chemical Oxygen Demand g / stream
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IV. OPTIMIZATION

Optimization aims to minimize fresh water demand without affecting the above aforementioned factors.

Table.6. Process streams

Stream name	Flow (t/day)	Total Suspended Solid (g/ g stream)	Chemical Oxygen Demand (g / stream)
Feedstock	107	0.887	0.035
Steam	55	0	0
Cleaned stock	-	0.0089	-
Rejects	16	0.200	-
Thick stock	-	0.042	-
Refined stock	-	0.035	-
Additives	207	-	0.060
Machine feed	-	0.0089	-
Formed fiber mat	-	0.150	-
Pressed fiber mat	-	0.530	-
Wet broke	-	0.530	-
Product	-	0.930	-

Material Balance and Constraints equations are defined in order to formulate the model. The above aforementioned estimations for both of material balance & water network exist stream could be used in optimization problem as an initial condition. By comparing the calculated stream compositions & the existing water network are used in the optimization code. In addition, COD concentrations. It was found that the results of COD & TSS calculations are much less than the material balance calculations, the relative error is 1.36 % that is because of accuracy in measuring COD, hence GAMS model was verified successfully.

V. RESUSLTS & DISCUSSIONS

Optimization verifies a reduction in fresh water demand, which is a function of TSS, Clarifier over-flow that can be used in the mill is referred as the regenerated water. Analyzing the regions on fresh water demand curve and discussing the results as per the following sections. From monitoring the Laboratory data during 2020, 200 measurements on daily regenerated water TSS concentration. Optimizing the model was made when the TSS concentration reaches 220 ppm, either a reduction in the difference in the concentration between the source & sink will lead to a minimization in a fresh water stream. One can obtain the largest reduction on fresh water upon using a source stream, which have a concentration close to sink demand of fresh water, which in turns leads to the lowest TSS concentration in the source stream be the 1st alternative on using fresh water, which was made successfully by the optimization algorithm leading to reduction in fresh water demand around 31% when the concentration of TSS in the regenerated water equals 220 ppm. The percentage of time, where water quality is accepted to be used in water sinks is defined as TSS concentration. If the quality of water is less than the concentration constraint, a blockage will occur. The down time for mills hasn't been recorded. The relationship between COD & fresh water. It was found that the imposed concentration of COD cannot exceed 2000 ppm when the water demand cannot be reduced to 520 tons /day. Therefore, in order to reduce fresh water on mill, its required to install TSS removal units to achieve operating conditions is required.

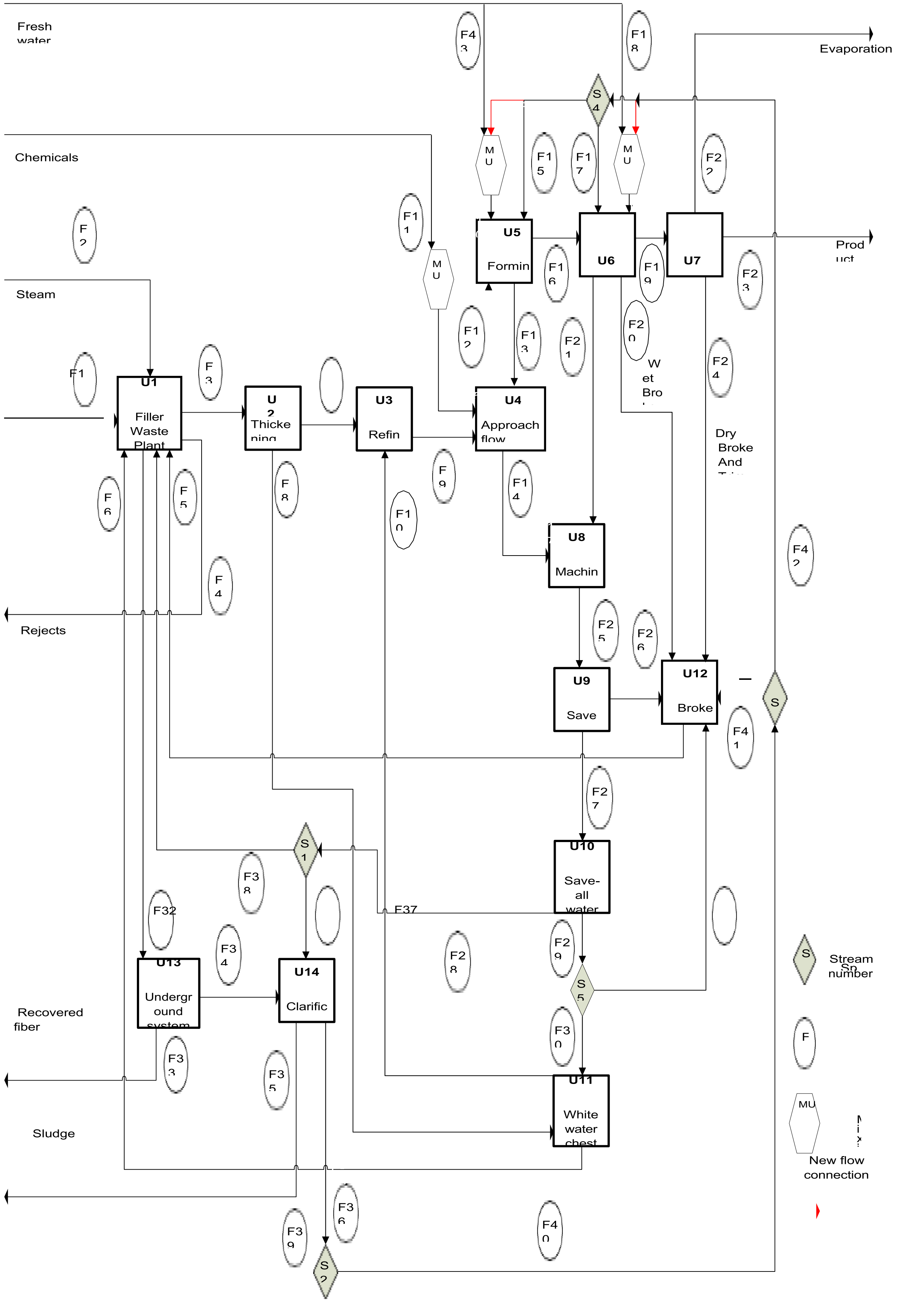

Figure.2. Optimized process diagram

VI. CONCLUSIONS

In this paper a retrofit was made for water treatment network in an Egyptian pulp and paper industry to reduce both of fresh water and contaminates. A MINLP was established by using GAMS which is user- friendly software. The Model was verified to assure its validation. It was found that we can retrofit the water treatment network by installing a small TSS unit and reduce contaminants as well as, reduce fresh water consumption. It's recommended to make a feasibility study to know pay pack period and project indicators for similar industries. Finally, this paper helps the top management in this company or any similar industry to proceed on optimize water treatment network.

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