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Research Article

Influence of Modern Technology on Cost Optimization of Sugar Processing in Kenya

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Abstract
Technology in the sugar subsector in Kenya has remained virtually static in the last five decades. In some companies the mills are as old as fifty years. This has lead to increased maintenance cost because their spares are customized and are produced as per the order. The old mills have made the companies to have relatively low grinding hours leading to high cost of production in essence reducing productivity ranges per input. Increased productivity is the key goal and any production concern must put effort for its optimization. It is related to the efficient use of resources, including energy, equipment design reliability and performance optimization. In effort to incorporate new technology, it is important to note technology is divided into two types: Primary technology, which includes new equipment and operations, and secondary technology, which includes all knowledge and data based systems such as design, automation, performance evaluation and optimization. In Kenya, it is important that the various companies should outline this requirement to improve on cost optimization.

Keywords: Technology, Cost optimization, Sugar Processing, Kenya.

Introduction

Organizations, small or big have at their disposal, men, machines, money and materials, the supply of which may be limited [1]. If the supply were unlimited then, the need for optimization model may be unnecessary, but the supply being limited, any organization must find a way of how to allocate resources in order to maximize profit or minimize cost. Modern technology as a factor of production must be optimized to manufacture products competitively so that the organization can survive and continue in operation in the global market [2]. Technology should be adopted that improves on efficiency.

Emerging technologies related to sugar factory operations need to be reviewed in the context of the potential impact of new factory technology itself on the overall operation cost. Increased productivity is the key goal and is a more complex issue than factory output alone. The technology should result into the efficient use of resources, including energy, equipment design, reliability and performance [4]. New technology is divided into two types: Primary technology, which includes new equipment and operations, and secondary technology, which includes all knowledge and data based systems such as design, automation, performance evaluation and optimization. The potential of these technologies and their application to each stage of sugar production processes should be outlined well by operations management teams so as to improve efficiency and reduce cost. This analysis will also help to establish the relevant areas that need automation immediately for cost reduction.

Sugarcane as a crop was introduced in Kenya in 1905 [5-7]. The first sugarcane factory was set up at Miwani in Kisumu County in 1922 and later at Ramisi in the coast province in 1927. The government of Kenya has been widely involved in the expansion of sugar production through investments in sugarcane growing schemes and factories.

Kenya sugar industry has not performed according to the expectations of the government's goal of self-sufficiency in sugar production [9-11]. This objective has remained elusive especially since the 1980s despite the government's massive investments in seven joint

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ventures in sugar-milling factories in collaboration with private companies. The target has also remained elusive despite the involvement of factories themselves in actual sugar-cane production through the nucleus estates [12]. The study adopted the conceptual framework in figure 1. Figure 1 shows the relationships between the dependent variable and independent variables.

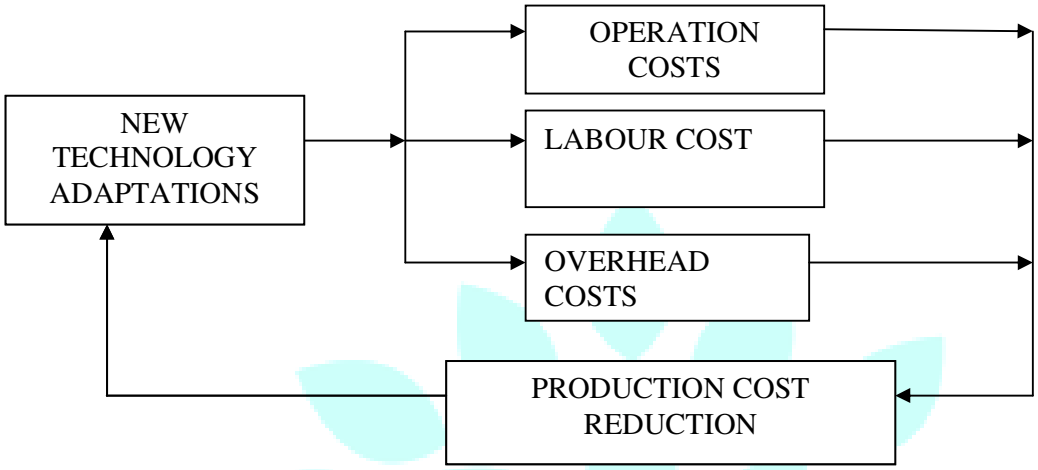

Figure 1. Conceptual framework

Research Methodology

The study used descriptive survey design. The methodology involved time study analysis on site for a day, use of factor operation trend analysis as quantified in previous reports and use of questionnaires. The data was collected based on the management system model, technology, operation cost drivers and process structure and procedures. The study evaluated the current management models adopted, established their limitations and proposed use of stochastic optimization model with goal programming. Sensitivity analysis based on 'what if' or scenario analysis was conducted using pre emptive values to establish working accuracy of goal programming based production objectives [7-10].

The modelling was done based on maximization and minimization of the expected value of the proposed objective variables of the system. The problem setting contained the usual optimization components; decision variables, objective function and constraints. Based on trend analysis, the design parameters of the real system was be set to optimal values for analysis.

The population of study was drawn from sugar companies, that included: Mumias Sugar company, Sony Sugar company, Chemelil sugar company, Sukari Industries and Muhoroni. The selection of the five sugar companies in western Kenya was done based on the level of technology, profits or loss level, operation schedules and market segment occupied within the last three years in Kenya.

The study focused basically on the techical staff specifically; logistics and supply chain staff, maintenance staff, operations and financial saff of the identified sugar companies. The study population was 921 technical staffs. A sample is a finite number of an item (or individual) taken from a population having identical characteristics with those of the population from which it was taken. According to [9] a large sample size reduces the sampling error. The sample size was 271 technical staffs.

In this study both purposive and stratified sampling technique was adopted since the study targeted only certain cadre of personnel in the five sugar factories. The report by the Kenya sugar Board [12] on processing and grinding parameters indicated that there were 921 specialised personnel in the five sugar factories in the following departments which were of interest to the study; finance, maintenance, transport and operations. When the population is more than 10,000 individuals, 384 of them are recommended as the desired sample size. The accessible population in this study was 921 technical workers. Mugenda and Mugenda [12] recommended the formula in equation 1.

$$nf = \frac{384}{1+n/N} \quad \text{.....(1)}$$

According to the equation 1

nf = desired sample size when the population is less than 10,000,
n = desired sample when the population is more than 10,000,
N = estimate of the population size.
Using the above formula sample size is:

$$nf = \frac{384}{1+384/921} = 271$$

but since Mumias, Chemelil, Sony, Sukari & Muhoroni constituted the number as; 26%, 21%, 23%,13% and 17% respectively. The sampled distribution will be as shown in table 1.

Table 1. Study population sample distribution per company of technical personnel

S. No.	Company	Departments sampled (Population)				Sample Size	Percentage %
		General Admin	Operations	Transport	Manufact-uring		
1.	Mumias sugar Co.	12	20	24	30	70	26
2.	Chemelil Sugar Co.	10	14	15	17	56	21
3.	Sony Co.	10	17	15	20	62	23
4.	Sukari	6	8	8	12	34	13
5.	Muhoroni	10	13	12	14	49	17
	Total	48	72	74	93	271	100

Results and discussions

Technology levels enhance production efficiency and reduce the overall operational cost. In the light of this statement, the study sought to find out the extent to which new technology adoption can reduce the cost of maintenance. The mean variable from the questionnaire was 3.98, approximately 4, which means to a great extent. This implies that the technical personnel approve that technology as a factor in manufacturing needs to be modernised to reduce the maintenance cost.

Secondly, the study sought to find out the extent to which new technology improves productivity in essence reducing costs, the approval rate was 3.95, approximately 4, which means that technology reduces cost to a great extent. This is a good approval rate for technology in the sugar industry to be modernized. With modern technology, there is a high chance that efficiency in production will be improved per given input, resulting into overall reduction in operation cost.

Third, the study sought to find out the extent to which technology enhances efficiency, the approval rate is 4.16, which means that technology enhances efficiency to a great extent.
Fourth, the study sought to rate the extent to which use of computer integrated manufacture (CIM) can reduce overall logistic costs, the result on approval rate is 4.20, which means that, that CIM is a tool that reduce cost of logistics, therefore it is appropriate that there is every need to incorporate this platform in the overall logistics management.

Finally, study sought to rate the extent to which automation of harvesting, loading and off loading can reduce the overall production cost, the approval rate is 4.09, which means automation can reduce the overall cost of harvesting, loading and of loading, which in effects reduces the overall production cost of sugar to a great extent. It is important from these findings that the companies should strive to automate their processes as this definitely will reduce production cost.

From table 2, the overall mean is 4.09, which means that technology modernisation is to a great extent a factor that can reduce the cost of operation. Mumias sugar which have adopted diffuser technology has overall production cost of 445USD per tonne compared to Muhoroni which has overall cost of operation of 752 USD per tonne because they still use a mill that is fairly old technology. New technology adoption will finally translates to relatively cheap production of sugar in Kenya, enhancing the competitiveness of the Kenyan sugar in global market and even locally.

Table 2. Evaluation of technology on cost of operation

Response	Mean per Variable μ	Not at all f	%	Little extent f	%	Moderate extent f	%	Great extent f	%	Very great ext. f	%	Total ∑f	%
Rate the extent to which new or technology reduces maintenance costs	3.98			9	4.7	36	18.8	96	50	51	26	192	100
Rate the extent to which new technology improves productivity in essence reducing costs	3.95			6	3.1	42	21.9	99	51.6	45	23.4	192	100
Rate the extent to which enhance efficiency	4.16			-	-	33	17.2	96	50	63	32.8	192	100
Rate the extent to which use of computer integrated manufacture (CIM) can reduce overall logistic costs	4.20			3	1.6	9	4.7	126	65.6	54	28.1	192	100
Rate the extent to which automation of harvesting, loading and off loading can reduce the overall production cost.	4.14			6	3.1	18	9.4	111	57.8	57	29.7	192	100
Overall mean	4.09												

Table 3 shows that the study also evaluated the cost of labour, operations, and factory overhead costs based on the age of technology per company. Grinding hours was also established on this basis. The findings on operation per ton depending on level of technology were established to favour Mumias Sugar Company which has diffuser technology which is relatively new.

The study also sought establish the stoppage in time in hours based on the age of technology, the findings from table 4 indicated that the companies with relatively old technology have more stoppage time due factory repair and maintenance as compared to companies with relatively new technology or mills. Sukari industries which have a fairly new technology and new mill has little stoppage time compared to the other mills.

These findings from table 5 confirms that there is need to improve on the technology as stoppage means idle time in many of the department in the process line that results high cost of producing a tone of sugar. It is important that each company invests on the new technology to compete effectively.

Table 3. Variables of cost based on the age of technology per company

	Sugar Company(cost in USD per ton)				
Variable	SUKARI	SONY	MUSCO.	CHEMELIL	MUMIAS
Labour	128	230	224	152	150
Operations	170	190	200	240	100
Overheads	120	190	170	132	125
Total cost	418	610	594	524	375

Table 4. Stoppage in hours against approximate age of technology or mill

	Sugar Company				
Variable	SUKARI	SONY	MUSCO.	CHEMELIL	MUMIAS
Approx. Age	5yrs	40 yrs	50 yrs	45 yrs	30 yrs
stoppage hrs	561 hrs	1893	2471 hrs	2532	807 hrs

Table 5. Stoppage in hours against approximate age of technology or mill

Variable	Sugar Company SUKARI	SONY	MUSCO.	CHEMELIL	MUMIAS
Approx. Age	5yrs	40 yrs	50 yrs	45 yrs	30 yrs
stoppage hrs	561 hrs	1893	2471 hrs	2532	807 hrs

The spearman's rank correlation method was adopted to calculate the correlation of technology and stoppage hours due to factory factors [6] as shown in table 6 and the coefficients were computed using equation 2.

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad \ldots\ldots(2)$$

$$= 1 - \frac{6 \times 2}{5(5^2-1)}$$

$= 1 - 0.1 \quad = 0.9$

From the result it is evident that the age of the mill or technology adopted contributes to long stoppage of the plant due factory factor rather than the absence of cane up to 90%, other factors account for only 10%, this is a strong indication that other than working on other issues to improve on efficiency and cost, technology is a major contributor to high production cost of sugar processing in Kenya.

The researcher also conducted interviews with the CEOs of the five companies or their representatives about the technology adopted by each company and the results from question schedule to CEOs or their representatives of the five sugar companies were documented.

Table 6. Correlations for stoppage in hours against approximate age of technology or mill

Company	Age of technology	Stoppage due to factory factors	Age ranking X_i	Stoppage ranking Y_i	$d_i = (X_i - Y_i)$	d_i^2
Sukari	5	561	1	1	0	0
Sony	40	1893	3	3	0	0
Muhoroni	50	2471	5	4	1	1
Chemelil	45	2532	4	5	-1	1
Mumias	30	807	2	2	0	0
					$\sum d_i^2 = 2$	

Table 7. Technology adoption results

Question	COMPANY RESPONSES SUKARI	SONY	MUHORONI	CHEMELIL	MUMIAS
What can you say about the technology you are using?	The technology is fairly modern. The company uses PLC and VDF (variable frequency drivers to reduce power consumption. -Most processes are semi automated with a common control room for most of the processes	The technology is old and needs proper overhaul, if money could be available. Manual or operator interaction is still too much in process line and this increases cost and decreases efficiency	The technology is old and needs proper overhaul, if money could be available.	The technology is old and needs replacement.	The technology they have is comparatively modern i.e. diffuser technology but there is need to improve on the same.

From the findings in table 7, it is clear that technology modernization is a big issue that needs to be looked upon, though it is evident that most of the companies lack the cash to improve the same. The companies with a fairly new technology have improved grinding parameters and overall cost is relatively low.

Conclusions

The potential for productivity improvement in the cane sugar industry in Kenya by application of new technology is very significant. The benefits will be gained primarily by application of knowledge based technologies for design and process optimization. The challenge therefore will be how to diffuse this technology properly amongst the personnel through proper training and exposure rather bringing expatriates to manage the technology which still may be counterproductive in the long run. It evident that there is need to improve on or totally change to new sugar production technology to reduce the overall operation cost of processing sugar as this will make the local sugar more competitive in the global economy.

Conflict of Interest

Authors declare there are no conflicts of interest.

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