International Journal of Investment Management and Financial Innovations
2018; 4(1): 9-17
http://www.aascit.org/journal/ijimfi
ISSN: 2381-1196 (Print); ISSN: 2381-120X (Online)

AASCIT American Association for Science and Technology

Materials Management Strategy in Sugar Industry in Sudan

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Citation

Muna Tag Elsir Mohammed Khair Ahmed. Materials Management Strategy in Sugar Industry in Sudan. *International Journal of Investment Management and Financial Innovations.* Vol. 4, No. 1, 2018, pp. 9-17.

Received: February 27, 2018; **Accepted**: March 21, 2018; **Published**: May 16, 2018

Abstract: The purpose of this study is to identify relationship between the working situation of sugar industries in Sudan and their engineering management strategies, considering one of the biggest sugar industries which faces a problem of strategy execution/ engineering management role performance capability, of materials management system in venture-joint organizations-sector (multinational organization/ Sudanese and International shareholders), as a one of development profit indicators when taking into consideration the growth and consumer satisfaction, beside the long term profit by transformation process of byproducts into new valuable products. To analyze, investigate and evaluate the engineering management performance, clear links have been established between the strategies: Audit, Integration and Optimization and the summary of findings derived from the assumed activities, relationships and mechanism framework, by using the Retroductive method represented by hypothesized model, qualitative and quantitative data collection, evidence of existence, replication and generalization a theory, which confirms the prediction, that the chosen sample was suffering directly from engineering management strategies execution (52.1%), for materials management systems and weak performance potentiality (engineering management role), although they were applying the proper strategy.

Keywords: Alternatives and Byproducts, Engineering Management Skills, Strategy Execution, Technical Facilities

1. Introduction

This paper analyses one of the most important chemical industries in Sudan (Sugar industry), which is managed through multinational organization system (international shareholders) and focuses on investigating how a multinational company can attract the most diverse and optimum workforce, integrate it into their working culture and improve productivity and management system, reflected in engineering management strategy execution system

1.1. Sugar Industry

Sugar is a broad term applied to a large number of carbohydrates present in many plants and characterized by a more or less sweet taste, beet sugar is generally much less sweet than cane sugar which these two sugar crops are the main sources of commercial sucrose.

The reed accumulates sugar to about 15 percent of its weight. Sugarcane yields about 2,600,000 tons of sugar per year [1]. The general steps of sugar manufacturing process [2] are shown on the following flow chart:

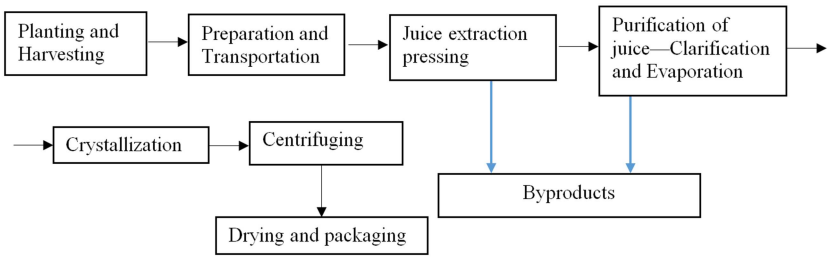

Figure 1. *Sugar Manufacturing Process Flow Diagram.*

1.1.1. Sugar Byproducts

Sugar byproducts produced during and after the processing steps, include the bagasse produced after extracting the juice from sugar cane which used as fuel to generate steam in factories. Increasingly large amounts of bagasse are being made into paper, insulating board, and hardboard, as well as furfural, a chemical intermediate for the synthesis of furan and tetrahydrofuran. The beet tops and extracted slices as well the molasses are used as feed for cattle. It has been shown that more feed for cattle and other such animals can be produced per acre-year from beets than from any other crop widely grown in the United States. The beet strips are also treated chemically to facilitate the extraction of commercial pectin. The end product derived from sugar refining is molasses. It is used in the production of industrial alcohol (Ethanol), yeast, organic chemicals and others [3].

1.1.2. Sugar Company/ Case -Study

This paper choose one of the largest producer of white sugar in Sudan as case -study, their factory crushes and processes more than 20,000 tons of cane per day, which represent 30% of the local market share based on the annual need of 1,200,000 ton [4]. Financial status, Annual revenue of approximately US$ 400 million, the company is owned by a group of 11 shareholders, of which the Government of Sudan has the large share of (35.17%). Other shareholders include the Government of Kuwait, the Government of Saudi Arabia, the Arab Investment Company, and the state-owned Sudan Development Corporation, while several other Arab and Sudanese trade and development organizations and local banks hold the rest of the shares. Working with total number of employees over 12,000 people, drawn from all regions of Sudan, with a further 4,000 seasonal workers also employed.

1.2. Engineering Management System / Materials

Engineering management combines the application of the practice of management to the practice of engineering, which is a career that brings together the technological problem-solving savvy of engineering and the organizational, administrative, and planning abilities of management in order to oversee the operational performance of complex engineering driven enterprises, which engineering management areas are: Operations management, operations research, and supply chain management, Management of technology, New product development and product engineering, Systems engineering, Industrial engineering and Management science [5].

Materials management System can deal with planning, designing and controlling the movement of materials, where the importance of material management system is represented in losses savings and cost minimization through, by products recycle, quality goes up and purchase, receive, transport and store materials efficiently, the following figure show the crucial check points during managing materials processing flow [6]:

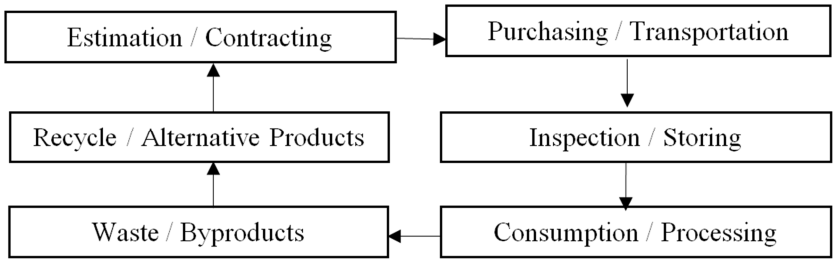

Figure 2. *Material Management/ General Flow Diagram.*

2. Materials and Method

2.1. Materials

All variables here are categorized into two types of data:

2.1.1. Quantitative Data and Further Subdivision

Continuous: represent measurable quantities but are not restricted to taking on certain specified values (such as integers) having values on a continuum.

Discrete: represent measurable quantities taking only specified values (integers) that differ by fixed amounts; no intermediate values are possible.

2.1.2. Qualitative Data and Further Subdivision

Dichotomous only 2 possible values (gender, yes/no)
Nominal Data (no ordering) & Ordinal Data [7]

2.2. Data Collection

To interpreted the process of data collection; starting with the assumed materials management flow chart (steps and stages) shown in figure 3, which represent the critical and core points- in the engineering management system and their relationships, which the structure, boundaries and the strategic interactions between departments in the case are conducted as a first step for analyze the management strategies performance.

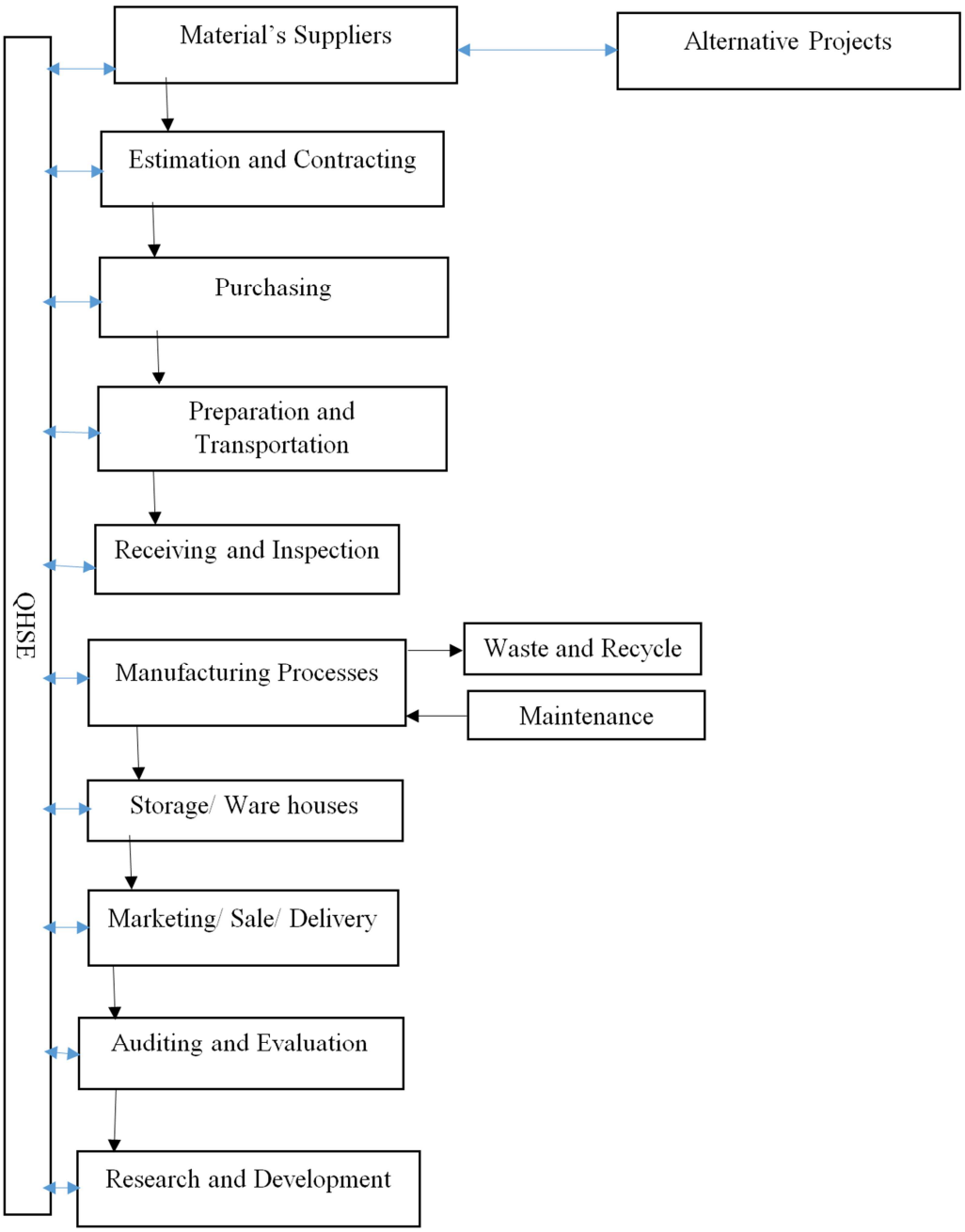

Figure 3. *Material Management Model/ Steps & Stages.*

Secondly: the targeted areas or departments, which the collected data from it help the transforming of applications and execution of engineering management strategy from intangible to tangible results, for example production, technical support, sale and market, financial and human resources departments.

2.3. Method

Since the problem nature here is social – technical phenomena, the appropriate research's method (strategy method) is the Retroductive Strategy Method (Retroductive inference are innovative tools of analysis which enable researchers to refine and redevelop social theory). Which the Retroductive Strategy Method selection, connects objective/ questions, data, findings and the contribution to the knowledge [8].

In this approach the particular strategy which relates to event or change can be investigated to understand how the ultimate objective is determine the extent of the achievement of an organizations' strategy [9], which is dependent on having an adequate engineering management system in place, through verifying the existence of instruction & mechanism which selected depend on all procedures and techniques of data selection, collection and analysis (qualitative, quantitative, case study, experiment, survey, mathematical modelling and simulation.).

The following flow chart in figure 4 summarizes the Retroductive Strategy Method steps:

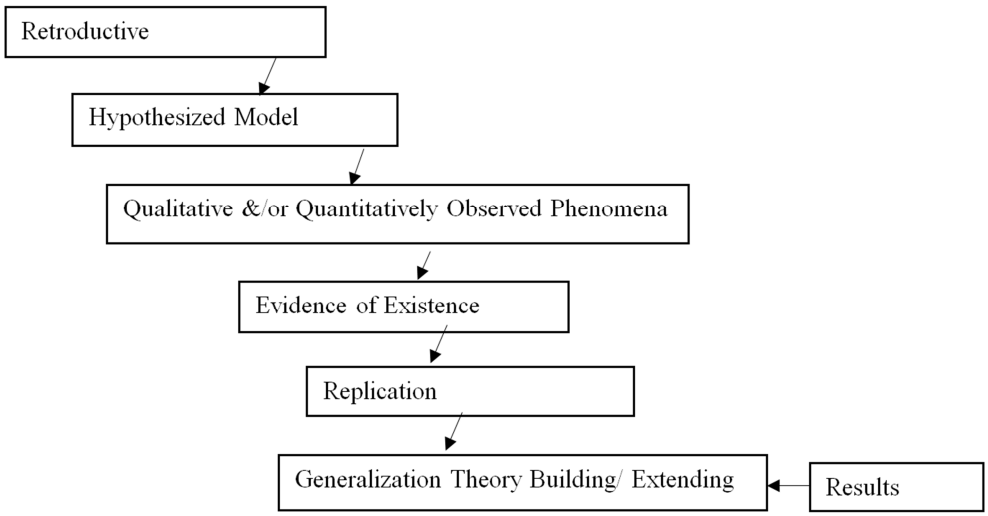

Figure 4. *Retroductive Strategy Method Flow Chart.*

2.3.1. Hypothesized Model

The hypothesized model constructed on the hypothesis itself and the hypothesis formulation.

The Hypothesis of Management strategy in sugar industries in Sudan: limits the role of engineering management (materials management) due to the general policy or the strategy execution (efficiencies/ staff & resources) which led to an absences or an inadequate of the basics factors which needed to succeed the structure of engineering management strategies in these industry, and classify it as one of the most low performance industry when compared to the global manufacturing developments' core factors (profit, safety, job opportunities …), and faraway of the predictive percentages of prices and availability of products (locally inside Sudan or out for export).

2.3.2. Hypothesis Formulation

Firstly, the collection and analysis of data need to be guided by clearly articulated theoretical frame work, to clarify and reflect the functional system of the engineering management and the effectiveness of relations with the other related business units. Figure 5 shows the assumed Engineering Management System Functional Model which covers the case under study:

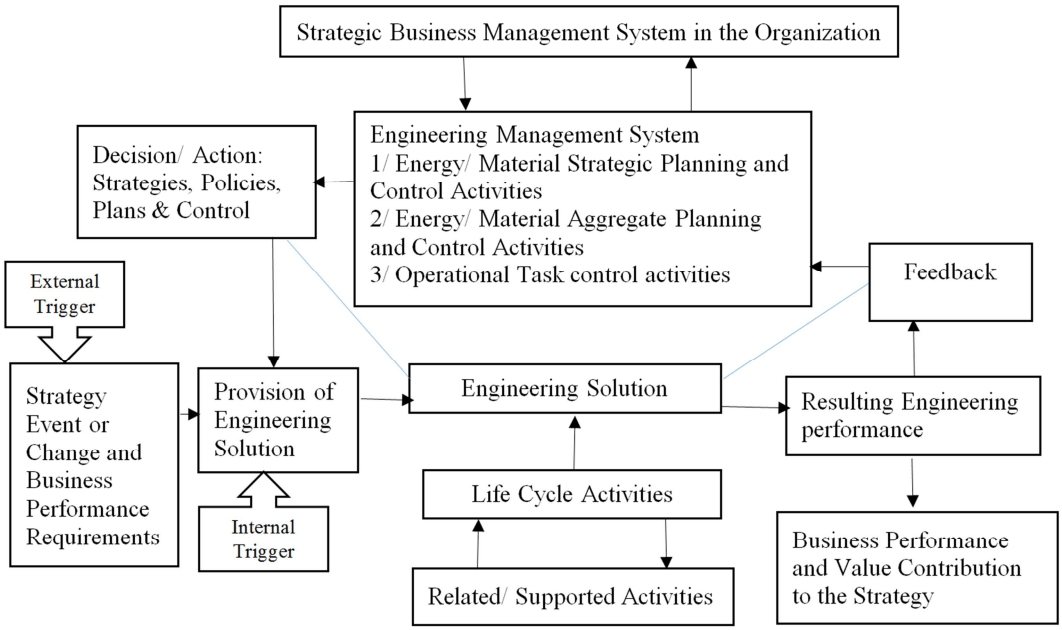

Figure 5. *Engineering Management System Functional Model.*

Secondly, proceed very important step of formulation, which is verifying the hypothesized model by structuring data and procedures into activities, relationships and mechanism to design and build the Engineering Management System Frame Work shown in figure 6:

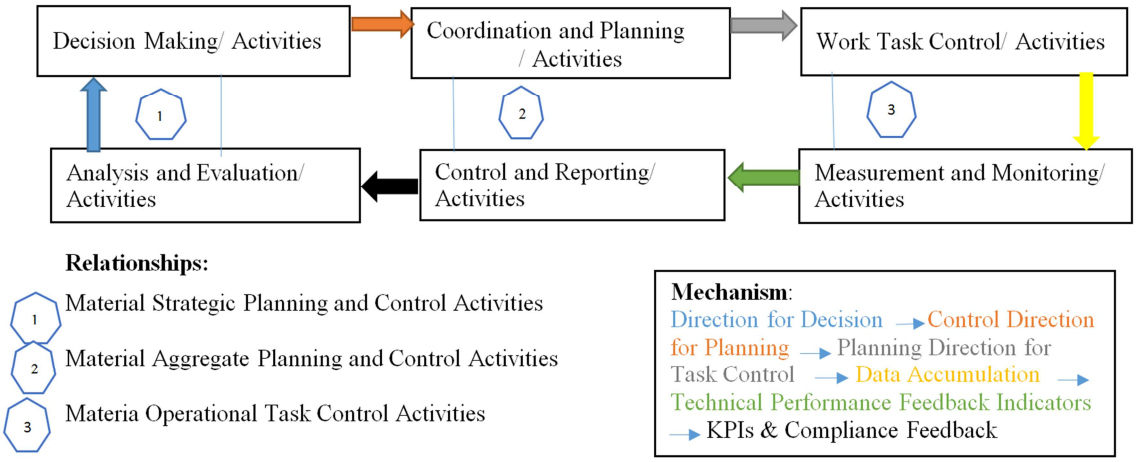

Figure 6. *Engineering Management System Frame work: Activities, Relationship and Mechanism.*

Finally, the data had been organized into organization categories (data collection, sorting, analysis, frame work factors, indicators….), to adapt with the objective/ question through context, process and outcome.

3. Results & Discussions

Objectivity and reliability of calculations and results follow three designed phases: engineering management strategy: Audit, Integration and Optimization

Each phase analyzes one factor or more of these roadmaps' factors or elements until reach the ultimate objective of this study: Strategy event, Engineering management solutions (the action in response to this strategy event, changes activities relationship between them), Provision of the requirements. Resulting performance derived from technical performance relative to engineering management resulting business performance and Control system of this constitutes activities mechanism and relationship to direct action for the provision of the solution achievement of performance business outcomes, planning, feedback control, decision making, managing technical tasks and sorting activity.

3.1. Phase One: Engineering Management Strategy Audit in Case-Study

This audit demonstrate the management controls (strategy formulation), and the engineering management evaluations' factors which resulting in operation and effectively to achieve the organization's goals or objectives (strategy execution), through customizing the operation management strategy map which provided by chosen tools for measurement. The following tables 1, 2 & 3 explain the strategy audit relationships into final summary picture after collecting the suitable data for this purpose:

Table 1. *Strategy Events and Materials Solution in Case-study.*

Strategy Events	Strategy Solution	Material Solution
Establishment of an integrated agricultural industrial organization for the production of sugar and the alternative products to achieve highly economic and environmental growth	1/ Establish sugar factory crushes and processes more than 20,000 tons of cane a day (design capacity), established on some 100,000-acre of irrigated land.	1/Production under quality systems umbrella (safety, processing, specification…) with control losses
	2/Establish new alternative projects support the main Sugar Business unit (Milk products, Animal feed, Produce farm, Certified seeds and equipment manufacturing Business unit)	2/Provision of raw materials, store conditions and distribution risk assessment scenarios
	3/ Establish by products Business unit, such as; (bagasse) which its unit for generates 75 MWs of power from co-generating stations to meet all its power demands, Ethanol from (molasses) Business unit: operate an ethanol plant with 200,000 lit /day capacity to produce 65 million liters of anhydrous ethanol for both domestic and export market	3/Production with high transforming efficiencies percentages to produce high quality products under controlled accurate calculated parameters
	4/Establish an estate encompasses a township complete services (schools, hospital, training center …) with accommodation services nearly 100,000 people are estimated to be dependent on the project. with a further 4,000 seasonal workers	4/ Factory running by well-educated and multiskilling engineers, so the chemical engineers' performance represented here as a one of material solutions

Table 2. *Resulting of Materials Solution and the Indications of Material Management Performance in Case-1 / Years from 2010 to 2015.*

Resulting Materials Solution	Provision Indications	Indications of Resulting Material Management Performance
1/Production: Crop days 152 Feddans harvested 81.000 Age month 13 Tonnes cane 3.25 million	1/Production daily, weekly and yearly reports.	-Productivity depends on availability of raw materials for 360 day per year, (approximately 45% of the total days and/ or 93% of the total crop days) -The efficiencies to produce sugar from cane and T.C.F/ T.S.F on the range of the international standards -Control Losses: no existence of control losses system led to increase losses

Resulting Materials Solution	Provision Indications	Indications of Resulting Material Management Performance
Tonnes sugar 330.000 Sugar % cane 10.2% T.C.F 40.00 T.S.F 4.00 Losses: Milling loss 4.9% Time loss 6.68% Factory loss 2.2%		Harvesting & Transportation loss (not calculated)
2/Quality control/ assurance Average results: for Brix, Color, pH, Pol, Purity, P_2O_3 & RATIO analysis tests, during process have non-confirmative results with notice percentages, which sometimes force to re-process or re-mix final products	2/Specification results standardized with the Sudanese Standards and Metrology Organization's standards (SSMO)	2/Some different specification ranges in the international standards which indicate to validation issue in SSMO standards -lack of quality assurance control system goes down of store house conditions, distribution, market survey, products development performance -Benchmarking system not valid yet in the company which making problem facing export -No ISO certification awarded, which effected directly on controlling the quality during processes check points
3/Safety: traditional method to safe products and machinery	3/Safety audit: they are planning for implementing a system as soon as possible, so no documents found	3/ safety system not implemented which had direct effect into wastes, losses, hygiene, machinery, labor and product safety
Alternative products units: Productivity rates:	-Production and financial yearly reports	-Due to raw materials suppliers problem and change of the prices of the major inputs (such as sorghum, oil cake, wheat and bran) some crucial variances in the budget affected on production process -Applying risk measurement system managing and controlling all risk scenarios and turn off crop days to production days
By products: 1/Bagasse: Energy (electricity power) from bagasse/kw per crop days 2/Molasses: 270 lit Ethanol from one ton Molasses 3/ Others: disposal as a waste without documentations	-Yearly reports - Heat and mass balance calculations -Purchasing electricity bills	The transforming performance: 1/The generation energy cover approximately 70% from factory total need and the other 30% was purchased during crop days 2/The raw molasses quantity less than unit capacity, so some new needs quantities were bought 3/ Waste quantities need analysis and environmental approval before disposal
Accommodation: -Different evaluation and points of view between chemical engineers (not attracted) and other staff (almost ideal environment)	-Hiring every year fresh chemical engineers -Rarely resignation from the other staff /HR reports	-Engineers' turnover, create sort of non-innovation team with low loyalty and sustainability in the junior staff

Provision indications: measurement tool from Material documents
Losses percentages calculation: traditional chemical engineering equations [10].

Table 3. *Resulting Business Outcome and Contribution to Strategy in Case-1.*

Materials Solution	Business Outcome Indicators	Value Contribution Indicators
Production under quality systems umbrella (safety, processing, specification) with control losses	-Market share % (Local and Export)	-The intent is to cover the local market and export to Gulf countries, but the contribution didn't cover the strategy by local share market 30% and raw sugar for export sometime
	-Products' price & quality	- The expectation as a national product is a cheaper product with high quality, which No cheaper prices than the market beside the quality in between especially the desire specification of white color
	-Production rate	- The production had average rates: 915 MT/crop day, which didn't reach the optimum and didn't cover what strategy intent
	-Profitability rate	-The company had changeable profitability rates due to on/off alternative products productivity, with high amount of losses in materials
Provision of raw materials, store conditions and distribution risk assessment scenarios	-Shareholders new percentages	-Strategy intent to maximize the shareholder percentages when establish the new alternative projects and start running the new business units which maximize the total profit, unfortunately most of these units stopped/running with low capacities after great beginning either due to policy or strategy execution, so they keep on with the same shareholders percentages
	-Projects development	-They have an international institute for development
Production with high transforming efficiencies percentages to produce high quality products under controlled accurate calculated parameters (for by products)	-Market share % (Local and Export)	- Due to internal policy all quantities of high quality ethanol (99.8%) for export with 0% in the local market
	-Electricity purchasing %	-Contribution of bagasse in generating power for factory, so electricity purchasing 3.4% of the total cost per year
	-Byproducts disposal cost	-Calculated cost 3.1% for disposal the waste
Chemical engineers' performance	-Employee satisfaction	-The strategy intent and success to keep most staff, except the fresh and senior staff of chemical engineers who are looking for good work environment beside good living environment

3.2. Phase Two: Engineering Management Strategy Integration in Case-Study

Integration process to describes the process of transforming intangible strategy elements into tangible factors (customer, financial outcomes and engineering management purpose in a knowledge of economy), through mapping this transforming, to clarify the missing link between strategy formulation and strategy execution in the Case-Study, the following tables 4, 5 & 6 classify the frame work elements/ factors which they had the direct effect on the: role of engineering management strategic process, status, indication of action and resulting outcome

Table 4. *Mapping of Material Management Related Activities Related to Actions in Case-1.*

Elements / Factors	Status	Indication of Action and/or Resulting Outcome
Research and development	Exist/ Inadequate	-Majority of researches for develop the crops, irrigation and agricultural pests -Researches on waste quantities haven't had tangible results -No market survey studies for adding new brands for ex. Sugar for industrial uses, sugar for export... etc.
Utilization operation	Exist / Inadequate	- Some of processing by products release without taking consideration of environmental conditions -Provision of steam and water supply (chilled, cold, hot) all working days was calculated around 80%
Maintenance	Exist / Inadequate	-Yearly plan exit for general maintenance, without preventative maintenance -No design team for innovation
QHSE department: a) QC b) QA & HSE	a) Exist / Inadequate	a) Central lab proceed analysis system for all units' check points, documented by (yearly, monthly, daily) reports to control the materials processing flow with assumed non- confirmative percentages around 35% per year, which decision maker of these cases the production director is not referring to quality system procedures
	b) Absent/ Inadequate	b) Planning for applying quality systems as soon as possible to add and activate all of quality assurance and safety aspects and principles
HR	Exist /Inadequate	-Chemical engineer training in engineering and technology without training in management aspects for senior and leader level
Purchase and technical support	Exist	-Clear procedures for transporting and receiving the raw materials with proper estimated cost
Finance and accounting control	Exist	-Financial cost center calculation program monitoring all materials movements

Table 5. *System Planning and Control Activities Relative to in Case-Study.*

Elements/ Factors	Status	Indication of action and/or Resulting outcome
Analysis and evaluation	Exist / Inadequate	-Kind of problem facing alternative products (provision, production and distribution) due to lack of analysis and evaluation of availability selection -Environmental safety and health evaluation inadequate (don't follow quality system) -Functionality selection and promotion process due to vacant post instead of performance evaluation result -The existence of R & D department without portfolio contents' of waste materials risk management studies led to incorrect evaluation
Decision making	Exist / Inadequate	-Decisions taken based on managers' opinions and internal policies -Lack of material management core factors' analysis and evaluation led to poor decisions -Products decisions' made by General Manager in 45%, directly -Chemical engineer levels had no authority to take final decisions due to their weak management skills
Coordination and planning	Exist / Inadequate	-Coordination, exists at the aggregated level between the departments and teams, but need some changes in 34% of cases which related to just on time law -Poor planning to produce product and minimize losses in the same time -Production plan not real and changeable in 26%
Work task control	Adequate	-Operational tasks clear for each member of team -Work task control always followed the plan
Measurement and monitoring	Exist / Inadequate	-Many of measure parameters, but lacking/lagging to indicators -Weak evaluation led to flat monitoring -Engineers' performance was measured through line managers' report rather than KPIs which in 82% depend on the personal line manger opinions.
Control and reporting	Exist/ Inadequate	-Materials control checkpoints for weight and quality not sufficient -Controls' reports mostly not followed by immediate decisions -Reports documentation semi manually

Table 6. *System Strategic Relationships and Mapping the Feed-Forward and Feedback Control Links in Case-Study.*

Elements/ Factors	Status/	Indication of action and/or resulting outcome
Vision	Exist / Inadequate	-Company's vision need more clarification and awareness about it for 65% of their employee
Goals and Values	Exist	- Existence as a common practice
Required performance resources	Inadequate	-The IT systems simple and normal for more than 70% of users and didn't achieve the efficient requirements -74% of engineers' training (seniors and leader/manger) is Technical/ Quality training which didn't add value to their management skills

Elements/ Factors	Status/	Indication of action and/or resulting outcome
Setting strategies, policies annual business targets and overall planning	Exist / Inadequate	-The motivation policy follow constant monetary incentives per year, which multiskilling engineers had no motivation to provide the company any new development plans or changes -Although 74% of engineers believe that the work under any of the suitable quality systems umbrella will affect directly into: productivity with minimum risks 44% and in employee sustainability 30%, no application for quality system -The crucial reason force fresh engineers leave, is the high salary in another company 52%, beside 13% they have a history and they didn't leave, which reflect some weakness in the human resource strategic plan
Feed-forward and feedback control links:		
a) KPIs	Absent	-Feedback on KPIs absent from performance reports, which misleading the analysis and performances' evaluation
b) Results as direction for strategic decision	Inadequate	-Feed-forward as direction of strategic decision absent or Inadequate because of the absence of the appropriate analysis and evaluation -Inadequate strategic decisions (no motivation decisions) for 34% of engineers whom provide the company new development projects beside 26% have intention
c) Control direction for planning	Exist /Adequate	-Planning control start from higher level to minimum level
d) Direction for task control	Exist / Adequate	-Control of tasks start from minimum level to higher level
e) Data accumulation	Exist	-Documentation exist on daily bases, representing materials flow and technical performance parameters -More than 82% of the engineers agree on; no work plan without the daily, monthly and yearly reports

3.3. Phase Three: Engineering Management Strategy Optimization in Case-Study

Optimization can be defined as an act, process, or methodology of making a design, system and decision as fully perfect, functional, or effective as possible; specifically: the mathematical procedures such as finding the maximum of a function which involved in it, the following table present the optimum performance with the alternative solutions and indication parameters for contribution

Table 7. *Optimum Performance Indicators.*

Strategic Objectives	Alternative Solutions	Parameter	Contribution	
			Current Situation	Optimum
-Long-term shareholder value	Design: Development project for: -Produce new alternative products -Transform/ Manufacturing byproducts	-Working days -Renewable quantities (energy/ materials)	- Operation days 62% per year -Produce Ethanol and Power	- Goes up to 90% - Reuse Vinasse and filter mud
-Proper work environment	System: Applying quality management system to define risks and help the management strategy execution's challenges	-Management aspects -Strategy execution %	-Traditional criteria of management -Strategy execution less than 70%	- Certified quality management system - More than 75%
-Increase the capital	Decision: Establish new clear policy tracing the decision making procedures	-Existence of engineering management role -Growth%	-Exist, understood, weak effectiveness -Same percentages of establishment share	- Activation from 60% to 100% - Assume 5% - 8% growth in 2020

High savings achieving by being closed to the optimum life/ financial performance supported by growth and sustainability

4. Recommendations

The following table summarizes the problems and recommendations of the Case-Study

Table 8. *Problems and Recommendations.*

Problems	Recommendations
-No existence of total quality management systems as a one of strategy execution monitoring factors	-Applying proper and suitable system to translate the strategy to operation term, make strategy a continual process and make strategy every ones every day job
-Research and Development department didn't provide any study about mass transfer, control and design for materials, process, by product and environment, recently	-Hiring professional team for these researches supported with good fund
-The confusion policy of Export all quantities of pure Ethanol (national product), and import new quantities for local consumption	-Create new policy and agreements
-The management skills of engineers limited and didn't achieve the role of engineering management	-Applying competency trainings which mobilize chemical engineer to executive leadership engineer -Promotion and incentives policy should follow the key performance indicators (KPIs)
-Provision of basic raw materials (sugar cane)	-Invest in new/ expanded agricultural areas

5. Conclusions

Overall finding expressed in the following ways:

The existence or adequacy of the elements of the proposed frame work explains the material management performance which is proved necessary to achieve the organizational strategy. The absence or inadequacy of these elements explains the material management low performance and the resulting outcomes that doesn't allow to achieve its strategies.

The tables of results reflect that the strategy execution result is: 52.1% which approve on: the interaction between strategies and activities: decides which the development level of organization to be in. Beside the leadership potentiality for execute the role of engineering management, customized as a link between all finding results (40% of engineering staff over 55 years old with 34% didn't have any material/ industrial management training courses, beside the expert engineers/ manager staff), which indicate to normal potentiality when perform the role of engineering management. (Unfortunately, very weak presence (4%) of female engineers in these kind of industries).

The ultimate implication of research findings in hypothesis and practice represented through: The development of chemical industries in Sudan depend on the interaction between the quality of the strategy and the ability to execute strategy, which was more important than the strategy itself, the case under study had a problem in the strategy execution. And on the existence of engineering management role activated by internal policy and performed by adequate and multi-skills engineers.

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