ICMIEE-PI-140337

APPLICATION OF REENGINEERING PRINCIPLES IN A LOCAL INDUSTRY

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ABSTRACT:
This paper proposes a redesigned plant layout for the plant as the overall performance of an industrial firm is significantly affected by the design of its manufacturing facility. Also attempt was given to determine the standard time of doing the jobs through the use of time study principles to increase the production efficiency and thus finding out the appropriate production time to meet the ultimate production goal of the industry, and attempts have also been made for analyzing and maintaining safety of workers in time of production and on other hazardous issues of the organization. Finally some safety standards for the plant have been recommended. The findings have been recommended for implementation and improvement. The case study was made in a local industry located at Tejgaon area of Dhaka. It is hoped that if the industry implements the findings, productivity will increase.

Keywords: Re-engineering, Time study, Plant Layout, Safety Engineering.

1. Introduction: [1] – [5]

There are many problems in industries in our country, which in the opinion of the authors, reduce overall performance of the industry. Often every industry overlooks many related problems, as a result the cost of the production increases. The main problem of many industries is production time loss the main cause of which might be for not following the use of the standard time for the purpose. In many cases the industries follow thumb rule in every process which violates Taylor's Scientific Management theory directly. So we think, the industry faces huge productivity & efficiency loss in the process. In this study and research work standard time for making different products by applying time study principles in a renowned local ice cream industry was found. Application of time study might help in reducing the actual time loss of the process. Further, we think, many of the industries don't usually follow the necessary safety precautions. As a result number of accidents has been increasing day by day. As the cost of the accident is quite large, this might affect the overall profit of the industry. In this study an appropriate plant layout for reducing process time as well as for avoiding accident has been found and recommended some safety instructions, which might reduce the accident and overall total production cost of the industry. So finally we can say that these findings might help the industry to increase profit and efficiency by following standard time and maintaining safety of the worker and machine. It might be further noted that many industries sometimes don't follow many standard theories related to Production Planning & Control. Moreover we have also observed that, location / layout /material handing etc. too initiated problems in many cases. The management people of the industry did not allow us to study the selected industrial organization in detail. Even we have been asked not to disclose the name and identity of the industry.

In the following analysis and discussions, the recommendations and comments for improvement have been mentioned separately (after discussions) in each section.

2. Present Layout and its improvement: [2], [4]

The overall performance of an industrial firm is significantly affected by the design of its manufacturing facility. As Local Ice Cream Company under study has an existing layout, we observed and studied the existing layout critically. The total area of the plant is too small and non-expandable, as for this the decision making of layout change will be too hard because it will cost high monetary value and hamper the production time. It was found that products of production floor 2 have to be moved through production floor 1 and ultimately to be placed into the cold storage, which is situated beside production floor 1. As a result during transportation in production floor 2 of products towards cold storage a haphazard situation is created which can be considered as waste as this requires extra movement of materials. A well-designed facility layout might help in efficient material handling requiring small transportation time, and paths It is hoped that this, in turn, leads to low work-in-process levels, effective production management, decreased cycle times and manufacturing inventory costs, improved on-time delivery performance, and consequently higher product quality. The efficiency of a layout is typically measured in terms of material transportation cost which is directly influenced by the distance a unit load travels.

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2.1 Proposals for improvement:

(i) A conveyor system to move materials of production in floor 2 to be stored in central cold storage may be designed and installed. This might be more efficient if the position of cup filling machine is reversed in product flow direction from presently followed product flow direction and ultimately the packaging place for cup filling machines products, can then be placed in opposite direction by the side of hardening tunnel from the present place of packaging of ice creams. As a result hardening tunnel of production floor 2 will process both cup filling machines products and *Royal Sundae* products and thus these end products will be moved towards cold storage through vertical conveyor which will also convey *Rollo 23 and Mark Line* machines products. The vertical conveyor can easily be inserted to production floor 1 by breaking the wall between production floor 1 and 2. As a result extra material transportation will be reduced, as well as wastes will be reduced in number.

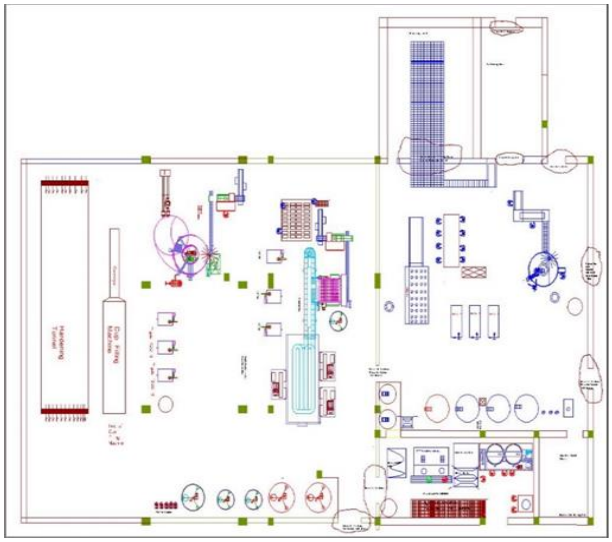

Fig.1: Existing Plant Layout

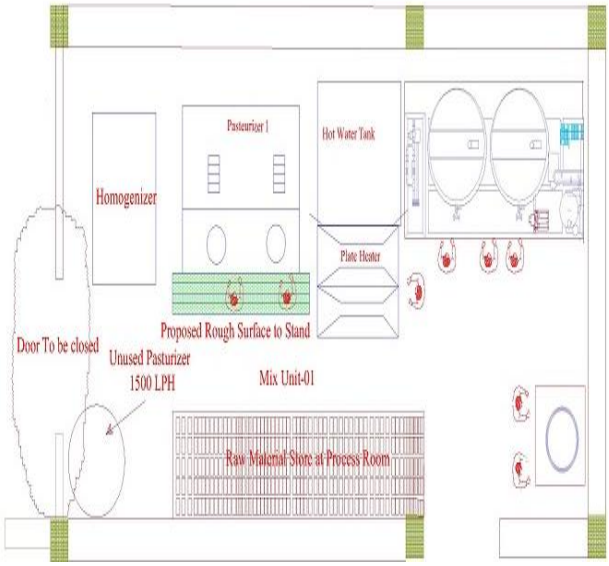

Fig.2: Proposed Mix Units working surface

(ii) The working surface bench used during pouring of raw material into the mix tank was seen as very slippery, which may cause severe accident to workers or damage to raw materials. To prevent this situation the bench where workers stand may be redesigned and rough surface may be introduced, please refer to figure-2.

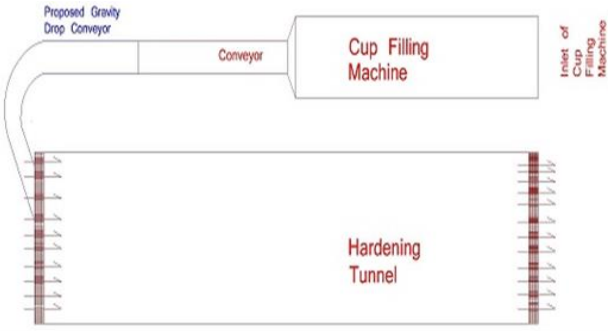

Fig.3: Proposed gravity drop conveyor (top view)

(iii) It was observed that Cup filling machine has a conveyance problem at present. When carnival ice cream gets out from the conveyor of the machine, a worker collects those ice creams in a tray and places this tray in the hardening tunnel. Problem is that during his or her movement towards hardening tunnel with the tray the cup filling machine continues to produce carnival ice cream during the same time as the process is a continuous one. So to prevent end product falling out from the conveyor usually an extra worker seats beside the inspection workers and this extra worker collects those stuck ice cream, during the tray carrier workers movement, with the help of a stick. But if we introduce a gravity drop conveyor from the conveyor of cup filling machine to the hardening tunnel as shown in **figure-3** the extra worker to collect stuck ice creams during tray carrier's movement can be eliminated.

3. Time study: [5]

The objective of doing Time study is to determine standard time of doing a job. In order to carry out time study, a number of interviews were taken of management officials e.g., of Managing director, Chief engineer, Deputy General Manager (DGM), Assistant engineer as well as of many workers of the industry of case study. Standard time is the amount of time a qualified worker should spend to complete a specified task, working at sustainable rate, using set methods, tools and equipment, raw material, workplace arrangement and with allowing adequate time for such items as unavoidable or machine delays, rest to overcome fatigue, and also for personal needs. It is generally done (i) to improve the accuracy of planning of set target (ii) to assign workers in an appropriate manner (iii) to set the direction of efforts aimed at improving skills of workers, etc.

3.1 Calculation of Actual Time for Mix Unit:

Table 1: Actual time required for 1st tank:

Process step	Required time (in minutes)
Start	-
Pouring hot water	4.29
Mixing ingredients	9.56
Mix ready and sending	17.18

Table 2: Actual time required for 2nd tank:

Process step	Required time (in minutes)
Start	-
Pouring hot water	4.42
Mixing ingredients	8.62
Mix ready and sending	18.78

Here, we found that total actual time for sending two mix batches was (17.18+18.78) min = 35.96 minutes.
But by company estimate standard time was found to be 30 minutes. So, time equivalent to 5.96 min per cycle can be saved.

Proposals for improvement:
To yield better production of flow in mix unit the following proposals may be helpful for the company.
As we know from the continuity equation, Q=AV (where, Q=flow rate, A=area, V=velocity). Thus we can make a trade-off between A and V. We can consider the following options:

a) Increasing the area of the delivery pipe
b) Increasing the delivery speed / velocity

- The first option of increasing area is quite expensive because of complex design and use of Stainless Steel (SS) pipe
- The second option of increasing the delivery speed can be done by using high capacity pump(s).

As the first option is costly and complex, so, the velocity of delivery can be increased by using high capacity pumps.

3.2 Allowance factor:

The standard allowance factor is very difficult to determine. So, each industry usually determines allowance factor after thorough study and investigation considering among other factors (i) Degree of skill-ness of worker (ii) Work details (iii) No of processes allotted to workers (iv) Miscellaneous other factors. In this study the allowance factor was calculated by 'Production Study' method. In this method, the worker is continuously monitored for a definite period of time and actual time for normal activity, unavoidable delay and avoidable delays are recorded without letting the worker know about the study. Thus the allowance factor was calculated as follows:

Activity	No. of hours observed	% of Normal Activity
Normal	5.4	100
Unavoidable delay	1.4	25.92
Avoidable delay	1.2	22.22
Total time reqd.	**8**	

Allowance factor = 1 + (unavoidable delays (hours) / normal activity (hours))

$= 1 + (1.4/5.4)$
$= 1.259$
$\cong 1.26$

3.3 Performance Rating (PR):

PR depicts the efficiency of workers. As most of the machines are automatic and semi-automatic, it was not possible to calculate the performance rating of workers. Here, we've used 85% efficiency of the workers to calculate the standard time of doing a work. This value was the estimate of the organization.
In the following calculations as machine processing time remained fixed for every cycle, hence it was excluded in measuring standard time. Here only the actual working times of workers have been considered.

3.4 Calculating Standard Time for various items:

(i) For Chocolate ½ liter box:

Table 3: Data for Chocolate ½ liter box

Activity	Observed time (sec)	Normal time (sec)	Standard time (sec)
Dosing	4	3.4 (4*0.85)	Standard Time (ST) ST = NT(Normal Time)*AF (Allowance Factor) = 16.455*1.26 = 20.73
Placing lid	3.167	2.69	
Collecting box	1.6	1.36	
Labeling	6.53	5.4	
Collecting in tray	2.5	2.125	
Tray to storage	1.75	1.48	
Total time in seconds		**16.455** without machine time	

But, the actual time as it was found by the company in the production floor was 22 sec; so, 1.27 sec per piece can be saved in making this type of ice-cream.

Proposals for improvement:
By given information it was known that the company did not do and apply any time study before. So, the standard time was unknown to the management. By applying thumb rule, the authority assumed that the processing time was 22 sec/piece. But by applying time study method, it has been found the standard time of doing was 20.73 sec/piece. Measurement of the standard time for only one dosing system was done in this study. As two dosing systems are running simultaneously, so output will be about 1120/2 = 560 pieces/hour for each of the dosing system.

If the workers perform their work with care without wasting time, they can produce at least 900 pieces / hour by following standard time, i.e., by saving 1.27 sec per piece of this type of ice cream.

i) For producing ½ liter chocolate box it was observed during study that 14 workers are necessary for the operation. But the company actually uses 16 workers for that operation. So, 2 workers can be reduced from that operation.

ii) For labeling operation and placing lid the management uses 4 and 3 persons respectively. But if the cover is redesigned to serve both as a cover and preservation system, it might save minimum 2 workers. In foreign countries this type of labels are widely used.

(ii) For Doi ice-cream:

For this too similar calculation was done as given below:

Table 4: Data for Doi ice-cream:

Activity	Observed time (sec)	Normal time (sec)	Standard time (sec)
Placing the cup	0.61	0.518 (0.61*0.85)	ST = NT*AF = 19.607*1.26 = 24.70
Cup filling	0.61	0.61 (done by m/c)	
Pouring solid milk	0.61	0.518	
Collecting lid	1.25	1.062	
Placing lid	2.44	2.074	
Collecting cup in tray	1.17	0.9945	
Storing in hardening tunnel	0.75	0.637	
Time elapsed in hardening tunnel	3300	3300 (done by m/c)	
Collecting cup from hardening tunnel	7	5.95	
Preparing packet	0.75	0.637	
Placing cup in the packet	0.94	0.79	
Serving spoon	1.5	1.275	
Taping	1.05	0.89	
Storage	5	4.25	
Total time in seconds		**19.607** (without machine time)	

But, as per present estimate of the company the actual time in the production floor was found to be 30 sec. Therefore, at present the process is taking about more time of 5.30 (i.e., 30.0-24.7) sec per piece in making ice-cream.

(iii) For Ice-cream type 2 in 1:

Table 5: Data for 2 in 1:

Activity	Observed time (sec)	Normal time (sec)	Standard time (sec)
Dosing and slicing	1	1 (done by m/c)	ST = NT*AF = 9.239*1.26 = 11.64
Hardening	1289	1289 (done by m/c)	
Hardening to clamping	20	20 (done by m/c)	
Releasing in conveyor	30	30 (done by m/c)	
Passing by conveyor	30	30 (done by m/c)	
Wrapping	9	7.65 (9*0.85)	
Collecting and placing in a paper box	1.13	0.96	
Packaging	0.68	0.578	
Storing in cold storage	0.06	0.051	
Total time in seconds		**9.239** without machine time	

But, the actual time as found by the company officials in the production floor to be 21 sec Therefore, at present the process is taking about more time of 9.36 sec per piece.

Proposals for improvements:

It was actually seen from the observations made by us that due to improper clamping and distorted holding plate the waste in ice–cream making machine (Mark Line) was about 66 ice-creams per 15 minutes. To reduce these wastes the following proposals can be followed:

i) The clamping unit and releasing unit of mark line seemed to be defective. If the system is redesigned including mechanism of clamping and the way of releasing of ice-cream to conveyor then the waste might be reduced.

ii) The ice-cream holding plate has been found to be distorted due to the repetitive force of the pneumatic hammer. Consequently the clamper sometimes fails to grip ice cream properly in its defined position due to the misaligned position of the plate. So, a rubber pad can be wrapped around the hammer that will dissipate the concentrated force of pneumatic hammer.

iii) If the height of the plastic in the exit section from the hardening tunnel is reduced then it is expected that

the plastic might not produce any scratch on the surface of the ice-cream.

In the conclusion it can be said that if the company improve as per proposals made then the waste of the ice-cream production may reduce. By analysis and observations it can be inferred that by following job rotation, actually 16 workers are sufficient instead of 20**.** And if the problem of clamping unit can be solved then the no of workers might further be reduced to (16-4) = 12 instead of 16. It was seen in the study that the yellow rectangle showed 4 workers engaged in existing clamping problem, if the problem can be solved then these 4 workers can be eliminated from the process.

4. Safety hazards and Recommendations: [3]

In the following the observations have been made from the study relating to safety and hazard. Thus along with the mentioned safety issues the proposals for improvement relating to machines used for making ice-cream, processes and related other issues have been made under each.

a) Mix unit:

Safety issues:

i. Slippery floor due to fat spilling
ii. Standing bench that is made of stainless steel which is used to pour ingredients into mixing tanks, is very slippery and dangerous
iii. Raising loads from the floor in upward direction for supplying ingredients in the mixing tank. This causes back pain of the worker
iv. Liquid glucose is handled with bare hand
v. Unorganized work materials

Recommended proposals for improvement:

i. Rough textured floor surface can be used. It can be considered that adhesive friction is a positive grip due to the penetration of one surface into the other. Textured surfaces and abrasive surfaces are considered as safest.
ii. Texturing of the standing bench surface or carpeting of non-slippery materials like rubber, gratings, diamond or checkered plate, knurled, dimpled corrugated expanding metal can be made.
iii. Semiautomatic lifting system can be used for loading (using hydraulic jack) as we know hydraulic jack is a device that uses force to lift heavy loads. After raising up to a certain height, the workers can use them easily.
iv. Special non-sticky gloves can be used.
v. "5-S", Japanese concept meaning: *Sort, Set in order, Shine, Standardize and Sustain,* method to organize things around the mix unit can be implemented.

b) Rollo 20: (Malai)

Safety issues:

i. Electric wires were found in exposed condition.

Recommended proposals to solve the issue:

i. Contact with electric current is a serious cause of workplace injuries. Electric wires should be insulated from the workers. Consistent monitoring can be done

c) Mark Line: (Rocks, 2 in 1)

Safety issues:

i. When ice-cream is released from clamp, a worker places it in the running conveyor. The worker works with one hand only which causes pain and hand become stiff in the long run.

Recommended proposals for solution:

i. According to principles of motion economy two (2) hands should remain in simultaneous motion as far as possible. Thus this principle is needed to be followed.
ii. The clamping and releasing system can be resigned to remove worker from that point

d) Rollo 23: (Chocobar)

Safety issues:

i. In time of maintenance work, the maintenance person sometimes stand and walk over the machine with unhygienic shoes

Recommended proposals for solution:

i. The person should wear hygienic foot protector / shoes during maintenance and general work period.

e) Royal Sundae/Mango Mellow Machine:

Safety issues:

i. The workers don't put on masks, hand gloves and caps always.

Recommended proposal for solution:

i. Awareness in workers can be created to correctly maintain the safety regulations

f) Light Problems:

Safety issues:

i. In 2nd floor, at nut cutting room, low level of light has been detected measuring only 9.2 lux. Insufficient light can cause serious eye problems and laceration

Recommended proposal for solution:

i. Sufficient light can be ensured to avoid the problems. For seeing requirement, concerned with moderately fine detail and intermittent work, the recommended light level is 322 lux

g) Sound Problems:

Safety issues: Relating to this issue the sound levels were measured as follows:

i. Repetitive force of the pneumatic hammer on the plate which carry ice cream at the Mark Line machine causes continuous sound of 95-98 dB
ii. Hardening section causes sound of around 90 dB
iii. At the Boiler room, there was sound of over 91 dB
iv. In Ammonia plant the range of sound intensity was 88 dB

It is known that, if the range of sound intensity crosses 80 dB it will create risk of hearing loss when worker works over 8 hours per day. It also causes slow deterioration of employees' health.

Recommended proposals for solution:

i. Rubber pad can be a useful solution for the first issue. A rubber pad can be wrapped around the hammer that will dissipate the concentrated force so the sound level may be reduced
ii. Comfortable ear plugs can be supplied to the workers and the workers can be motivated to use the ear plugs

h) Cold Storage problems:

Safety issues:

i. It was found that the temperature of the storage area was actually -28 ^{0}C. If a worker is new in the factory or he joins the work after a vacation at first he needs to adapt to that low temperature. Otherwise he might become sick. Fever or headache might affect him. Usually in the ice cream factory the workers don't get any chance to adapt to that level of low temperature.

Recommended proposals for solution:

i. Acclimatization (the body's gradual adjustment to a change in climate or working conditions and its rapid return to a "normal" state when removed from the stressful situation) process can be maintained and implemented.
ii. Generally, a two week program is required which will gradually get the worker and his body to become used to this cold environment. It is therefore suggested that on the first day the worker can be exposed to 50% of the work load and time which can eventually become the same as the total required. In each day thereafter, a 10% increase in exposure can be scheduled, building up to a 100% of the total exposure on the sixth day. If any worker remain absent from work for nine or more consecutive days for any reason, a four day acclimatization period, beginning with a 50% exposure the first day and with daily increments of 20%, is considered as necessary. His can be practiced for workers working in cold area only.

i) Ammonia Plant:

Safety issues: The following issues were identified:

i. Improper ventilation;
ii. Easily accessible discharge valve;
iii. Safety value can only handle maximum pressure of 17 bar;
iv. Mixture of air and gas occurs;
We know breathing of air containing 500-10000 ppm of ammonia, which can cause sudden death from spasm of inflammation of the larynx. Concentration exceeding 700 ppm of ammonia can cause permanent eye injury.

Recommended Proposals for improvement:

i. Proper ventilation system should be introduced
ii. Discharge valve should be placed in a safe position
iii. Condenser should always be kept clean due to avoid high pressure
iv. If air and gas is mixed together, then the gas can be cooled by air purging
v. There must be a sensor which can detect over 500 ppm of ammonia in the air and capable of sounding an alarm

j) Other Major accident areas:

It was found that in Cone biscuit machine area sometimes remain filled with smoke and heat.

Recommended solutions:

i. Smoke and heat detector can be used to buzz an alarm and a water sprayer can be installed which spill water in case of outbreak of fire.

Conclusion:

About the study relating to productivity increase, safety management, layout improvements, etc., in a word with a view to apply reengineering principles, an attempt has been made to minimize the production time loss, in the industry under case study, by applying Time and Motion Study principles in different processes, by improving the plant layout and also by proposing some safety rules that can be followed to reduce the accident. Thus it is hoped that productivity will certainly increase if all or at least some of the recommendations mentioned in this paper are implemented. This report discussed the existing and modified plant layout. There is no layout that ends to be the best. A given layout can be best in one set of conditions and yet poor in different set of conditions. We feel if this local ice cream company implements the suggestions it might get a better as well as economical solution for overall improvement.

Acknowledgement:

Our sincere thanks go the high officials of local ice cream company who allowed us to use various floor data although they did not allow us to disclose their identity**.**

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