Productivity Improvement in Automated Material Handling System of Liquor Manufacturing Plant

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ABSTRACT

Material handling systems are commonly used in almost all the industries in all over the world. It is an art and science involving moving, packaging and storing of substances in any form. In the field of engineering and technology, the term material handling is used with reference to industrial activity. This report contains an automated material handling system used for manufacturing alcohol from agricultural products (grain, sugar and flour etc.). It consists of PLC (Programmable Logic Controller), SCADA (Supervisory Control and Data Acquisition System) or DCS (Distributed Control System) to visualize and control the system. Modifications are carried out in this automated material handling system used in liquor manufacturing plant, one at conveyor system and other at crushing section. These modifications have resulted in a great productivity improvement.

***Keywords* -** Automation, Liquor manufacturing plant, Material handling system, Productivity improvement.

I. INTRODUCTION

Automation is concerned with the application of electro-mechanical devices, electronics and computer-based systems to operate and control production and service activities. It suggests the linking of multiple mechanical operations to create a system that can be controlled by programmed instructions [1, 2]. Material handling operations should be mechanized and/or automated where feasible to improve operational efficiency, increase responsiveness, and improve consistency and unsafe manual labor [3, 4]. Still there is scope for improvement by preventing frequent breakdowns, occurring due to some design level parameters [5], as shown in this paper.

II. PROBLEM STATEMENT

2.1. Case study 1: Pipe leakage problem of conveying pipe (Material: M.S.) at the bend section (Plant 1)

The problem was severe as pneumatic conveying system was not working properly and was facing the problem of leakage of conveying pipe at the bend section. The target to be achieved was productivity improvement by removal of the above problem [6, 7].

2.2. Case study 2: Chocking of bags of bag filter (Plant 1)

The problem was severe as bag filter /product separator was not working properly and was facing the problem of chocking of bags of bag filter. The target to be achieved was productivity improvement by removal of the above problem [6, 7].

2.3. Case study 3: Vibration of hammer mill (Plant 2)

During commissioning of plant at No load trial (i.e. empty equipment trail), the hammer mill was facing the problem of vibration. The target to be achieved was reducing the vibration of hammer mill [6, 7].

III. METHODOLOGY AND COST-BENEFIT ANALYSIS

3.1. Methodology and Cost-Benefit Analysis of Case study 1: Pipe leakage

3.1.1. Methodology

It was understood from a consultant that during commissioning of plant 1, at full load trail, pneumatic conveying pipe (Material: M.S.) was causing wear and tear at the bend section. Due to this, M.S. pipe was getting hole at the bend sections and material i.e. grain, was coming out from that holes with high pressure. The problem was examined in the shop floor area in detail. To find out the various causes of pipe leakage, brainstorming session was carried out with the guide and experienced people in the company. At the same time data was collected regarding break down and studied the types of break downs. Following points were note down and causes of leakage of pipe were found out. These things are arranged in the form of “Cause and effect diagram”, as follows [8]:

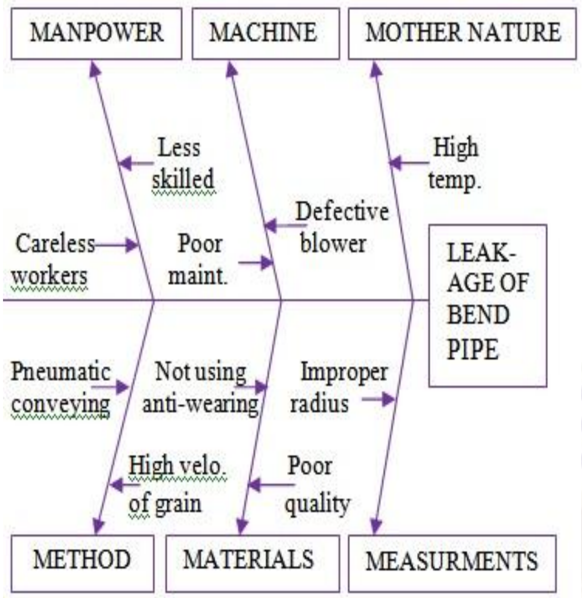

Fig.1.Cause and effect diagram of leakage of bend pipe

It was concluded that, at the bend section, the bend pipe material should be anti-corrosion, anti-wearing, good hardness, high chemical stability, of which the leakage of bend pipe is avoided. In-depth literature review was carried out on different anti-corrosion, anti-wearing materials, "Cast Basalt" was selected for the bend pipe because of its following excellent features, benefits and applications [9].

3.1.2. Features

i. Cast basalt is having outstanding wear resistance.
ii. 8 on the Mohs hardness scale, diamond has a value of 10.
Iii. Service temperatures up to 700^0 F or down to -40^0 F.
iv. Maintains a smooth even surface for favorable flow conditions.
v. Available in straight pipes, bends and fittings.
vi. Multiple end options available, including flanges and weld ends.

3.1.3. Benefits

i. Long life in highly abrasive and corrosive applications.
ii. Excellent service life at cost effective pricing.
iii. Improved performance compared to alternate linings.

3.1.4. Applications

Cast basalt applications include hydraulic piping systems for materials such as bottom ash, fly ash, pulverized coal, lime and many other abrasive transport applications. Cast basalt is ideal for improving system performance and life.

TABLE 1
Breakdown Data of Leakage of Bend Pipe

Sr. No.	Break down (after hrs.)	Time reqd. (hrs. /day)	Procedure carried out
1.	5	6	Bend pipe was welded at the leakage section and set up the system.
2.	2	5	Bend pipe was welded at the leakage section and set up the system.
3.	4	5	Bend pipe was welded at the leakage section and set up the system.
4.	5	1	Bend pipe of original shape was changed.
5.	1	8	Bend pipe of new shape was Installed in the pneumatic conveying system.
6.	2	5	Bend pipe of new shape was welded and installed in the pneumatic conveying system
7.	1	5	Again Bend pipe of new shape was welded and installed in the pneumatic conveying system.
8.	3	20 days	M.S bend pipe having inside Coating of cast basalt was ordered from Pune and was installed in the pneumatic conveying system.

Fig.2.Inside coating of cast basalt bend pipe

Fig.3.Before implementing M.S. bend pipe having inside cast basalt coating

Fig.4.After implementing M.S. bend pipe having inside cast cast basalt coating

For movement of grains, as per design considerations, the radius of bend pipe was made 5D times where D is the diameter of pneumatic conveying pipe. Then grains are moving through the bend section. In this way the problem is solved and the system is working successfully.

3.1.5. Cost-Benefit Analysis

Calculation of monetary loss during breakdown period (including all the expenditures):

Breakdown period is of six hrs. Capacity of alcohol production is 100 KLPD. During breakdown period of six hrs. The total expenditure (i.e. Total loss) was Rs. 13, 38,200.00. But due to complete solution on leakage problem, the company is now benefitted by Rs.13, 38,200.00.

TABLE 2
Cost Analysis of Leakage of Bend Pipe

Sr. No.	Descri-ption	Charges/ Shift	Cost in Rs.	Qty. /per-sons	Total Rs.
1.	Labor Charges	200	-----	06	1200/-
2.	Maintenance Charges:				
	a) Elect. Engineer	1000	-----	01	1000/-
	b) Elect. Assistant	400	------	02	800/-
	c) Mech. Engineer	1000	------	01	1000/-
	d) Mech. Assistant	400	------	03	1200/-
3.	Removal of broken piece cost	-------	1500	02	3000 /-
4.	Alcohol Produc-tion loss cost	------	50 Per liter	25 KL PD	12,50,000/-
5.	Cast basalt bend pipe cost	------	40,000	02	80,000 /-
				Total	13,38,200/-

3.2. Methodology and Cost-Benefit Analysis for case study 2: Chocking of bags

3.2.1. Methodology

It was understood from Consultant that during commissioning of plant 1 at full load trail, when the material moves through pneumatic conveying pipe (Material: M.S.) and enter into Product separator (Bag filter) for separation of air and grain, there was a problem of chocking of bags of bag filter after every two to three hrs. and the system was tripping.

To find out the various causes of chocking of bags of bag filter, brainstorming sessions were carried out with the guide and experienced people in the company.

It was concluded that, the grain and air before entering into bag filter should be separated out. Finally, it was decided to install **"Cyclone Separator"** in between bag filter and blower on the pneumatic conveying pipe.

ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 4, Jul-Aug 2013, pp.2530-2537

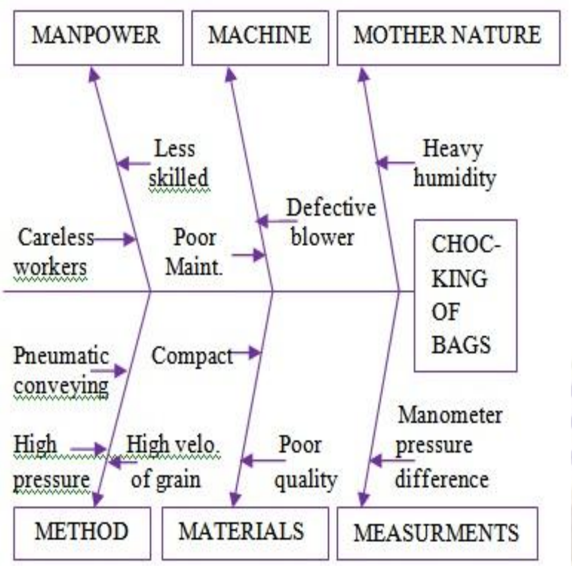

Fig.5. Cause and effect diagram of chocking of bags

3.2.2. Operation of Cyclone Separator

A cyclone is centrifugal separator, where the particles are swung by the centrifugal force to the outside, as a result of their mass. The entering air is automatically forced a rapidly spinning double vortex movement, so-called "double vortex". This double vortex movement exists from the outside stream that flows spirally down and the inside stream, which flows spirally up. Both the airs flow from one to the other on the border area. The particles that are present in the air flow swung to the outside wall and leave the separator through a reception space situated to the base.

Fig.6.Before implementing cyclone separator in between bag filter and blower

It's salient features are, simple construction, no moving components, little maintenance, constant pressure drop and low investment and functioning costs. It's applications are in cement, chemicals, petrochemicals, pharmaceuticals, distillery or brewery, food industry, paint and pigment handling, mineral processing plants.

TABLE 3
Breakdown Data of Chocking of Bags of Bag Filter

Sr. No.	Break down After Hrs.	Time Reqd. (Hrs.)	Procedure carried out
1.	2	5	Chocked bags were taken out from bag filter, cleaned and again put into bag filter.
2.	2	6	Chocked bags were taken out from bag filter, cleaned and again put into bag filter.
3.	3	5	Chocked bags were taken out from bag filter, cleaned and again put into bag filter.
4.	2	4	Chocked bags were taken out from bag filter, cleaned and again put into bag filter.
5.	2	25 days	New cyclone separator was fabricated at consultant and installed at plant 1.

Fig.7A. After implementing cyclone separator in between bag filter and blower (With bend pipe and cyclone separator)

Fig.7B. After implementing cyclone separator in between bag filter and blower (With cyclone separator, duct and bag filter)

3.2.3. Cost-Benefit Analysis

Calculation of monetary loss during breakdown period (including all the expenditures):

Breakdown period is four hrs. Capacity of alcohol production ═ 100 KLPD

TABLE 4
Cost Analysis of Chocking of Bags

Sr No.	**Descrip-tion**	**Charges per Shift**	**Cost in Rs.**	**Qty./ per-sons**	**Total Rs.**
1.	Labor Charges	200	-----	04	800 /-
2.	Maintenance Charges:				
	a) Elect. Engineer	1000	-----	01	1000 /-
	b) Elect. Assistant	400	------	02	800 /-
	c) Mech. Engineer	1000	------	01	1000 /-
	d) Mech. Assistant	400	------	03	1200 /-
3.	Alcohol Product-ion loss cost	----	50 Per liter	16.6 KL PD	8,33,333/-
4.	Cyclone separator cost	----	1,70,000	01	1,70,000/-
5.	Duct and stand cost		40,000	01	40,000/-
				Total	10,48,133/

During breakdown period of four hrs, the total expenditure (i.e. Total loss) was Rs.10, 48,133.00. But due to complete solution on chocking of bags problem, the company is now benefitted by Rs.10, 48,133.00.

3.3. Methodology and Cost-Benefit Analysis for Case Study 3: Vibration of hammer mill

3.3.1. Methodology

It was understood from consultant that plant 3 is ready for commissioning. The vibration of hammer mill was reduced step by step by doing following improvements [10]:

Step I: Improvements on first day

i. Checking of all the loose parts and tightening the nut bolts.
ii. Initially, some of the belts of the motor pulley were in overlapped condition, so they were arranged in proper manner.
iii. Align motor pulley and hammer mill pulley. Again trial was taken but due to above improvements, 5 to 10% vibrations are reduced. After a close examination over it, the author suggested to reduce the vibration by making the base strong.

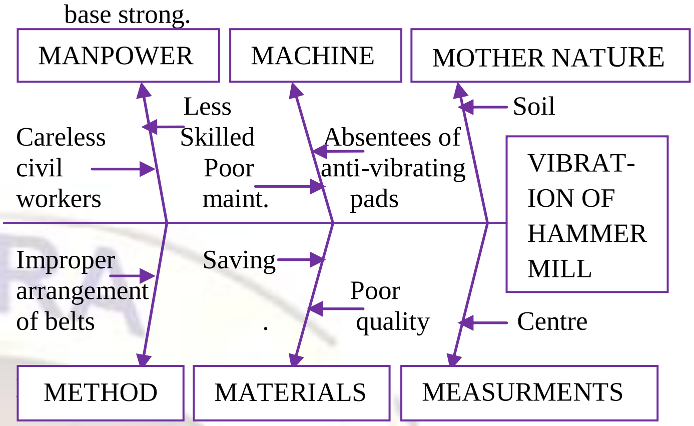

Fig.8. Cause and effect diagram of vibration of hammer mill

Fig.9. Hammer mill after vibration and breakage of concrete base

Step II: Improvements on second day

i. Measurements were taken between each two leg supports of hammer mill [11].
ii. Four 'I' beams were cut into suitable lengths and connected in between the leg supports by welding.

Fig.10. Hammer mill after connecting 'I' beams between the Supports

Again trial was taken but due to above improvements, 30 to 40 % vibrations are reduced.

For controlling more vibration, the author was suggested to put anti-vibrating pads wherever required and increase the number of eye foundation bolts.

Step III: Improvements on fourth day

i. With the help of chain block, the jaws of mill were opened and the anti-vibrating pads were kept between the two jaws
ii. Also anti-vibrating pads were kept as per the requirements
iii. Four iron plates were cut into suitable sizes and drilled near the corners for the passage of eye foundation bolts.
iv. The plates were kept below each support and welded.
v. Four eye foundation bolts were fixed to each plate in the concrete base.

After eight days, when trial was taken, it was observed that 85 to 90 % vibration is reduced. Remaining 10 to 15% vibration is allowed.

3.3.2. Cost-Benefit Analysis

Calculation of monetary loss during controlling of vibration of hammer mill (including all expenditures):

Considering six days period:

TABLE 5
Cost Analysis of Vibration of Hammer Mill

Sr. No.	Description	Charges per day	Cost per Kg.	Qty in Kg	Persons	Total Rs.
1.	Labor Charges	150	-----	----	05	4500/-
2.	Maintenance Charges:					
	a) Elect. Engineer	1000	-----	----	01	6000/-
	b)Elect. Assistant	350	------	----	02	4200/-
	c) Mech. Engineer	1000	------	----	01	6000/-
	d) Mech. Assistant	350	------	----	03	6300/-
	e) Civil Engineer	1000	------	----	01	6000/-
	f) Civil Assistant	350	------	----	01	2100/-
3.	12”Eye foundati-on bolts	------	45	10	------	450/-
4.	Cement	------	----	----	----	1000/-
5.	‘I’ beam	------	55	60		3300/-
6.	Anti-vibrating pads	----	---	----	-----	1000/-
Total						40,850/-

So during trial period of six days, the total expenditure (i.e. Total loss) was Rs.40, 850/-. But due to 85 to 90% solution on vibration problem, the company is now benefitted by Rs. 40,850/-

IV. PROJECT MILESTONES

Total work done during the project may be summarized in the form of DMAIC methodology of Six Sigma as follows [8]:

TABLE 6
Project Milestones

Sr. No.	Phases \ Plant	Plant 1 A	Plant 1 B	Plant 2
	Problem	Leakage of bend pipe of conveying system	Chocking of bags of bag filter.	Vibration of hammer mill
1.	Define	One week	One week	One day
2.	Measure	One week	One week	Two days
3.	Analysis	Two weeks	Two week	Three days
4.	Improve-ment	Two weeks	One week	Six days
5.	Control	Two weeks	One week	Two days
	Total duration	Eight weeks	Six weeks	Two weeks

Frequently occurring breakdowns like leakage of bend pipe, chocking of bags and vibration of hammer mill may be quantified for drawing Pareto chart [8].

TABLE 7
Analysis Sheet for Pareto Chart

Sr.	Types of Breakdown	Freq. of Breakdown	% of Total Breakdown	Cumul-ative %
1.	Leakage of bend pipe	8	50%	50 %
2.	Chocking of bags	5	31.25%	81.25%
3.	Vibration of hammer mill	3	18.75%	100%
	Total	16	100%	100%

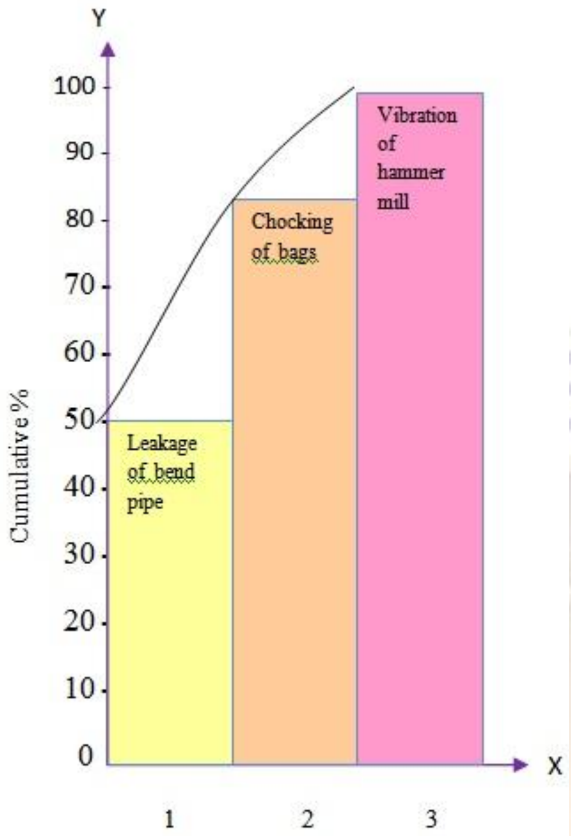

Fig.11.Pareto chart

V. FINAL COST-BENEFIT ANALYSIS

We can summarize profit obtained by two plants as follows:

TABLE 8
Final Cost- Benefit Analysis

Sr.	Problems faced	Cost before solving the problem (Rs.)	Benefit after solving the problem (Rs.)
1.	Leakage of bend pipe	13,38,800/-	13,38,800/-
2.	Choking of bags	10,48,133/-	10,48,133/-
3.	Vibration of hammer mill	40,850/-	40,850/-
	Total	24,27,753/-	24,27,753/-

VI. CONCLUSION

After completing above said improvements in automated material handling system of liquor manufacturing plants, the productivity increased to a great extent in monitory terms. Workers were extremely satisfied due to removal of regular problems viz. leakage of bend pipe, chocking of bags of bag filter and vibration of hammer mill. There were intangible benefits like smooth co-ordination between management and workers, overall employee satisfaction, external customer requirement fulfillment, etc. Due to this project, the employee-employer relationship has also strengthened to a large extent.

VII. ACKNOWLEDGEMENT

Authors are thankful to all the authors and contributors of the papers which are referred while preparing this paper.

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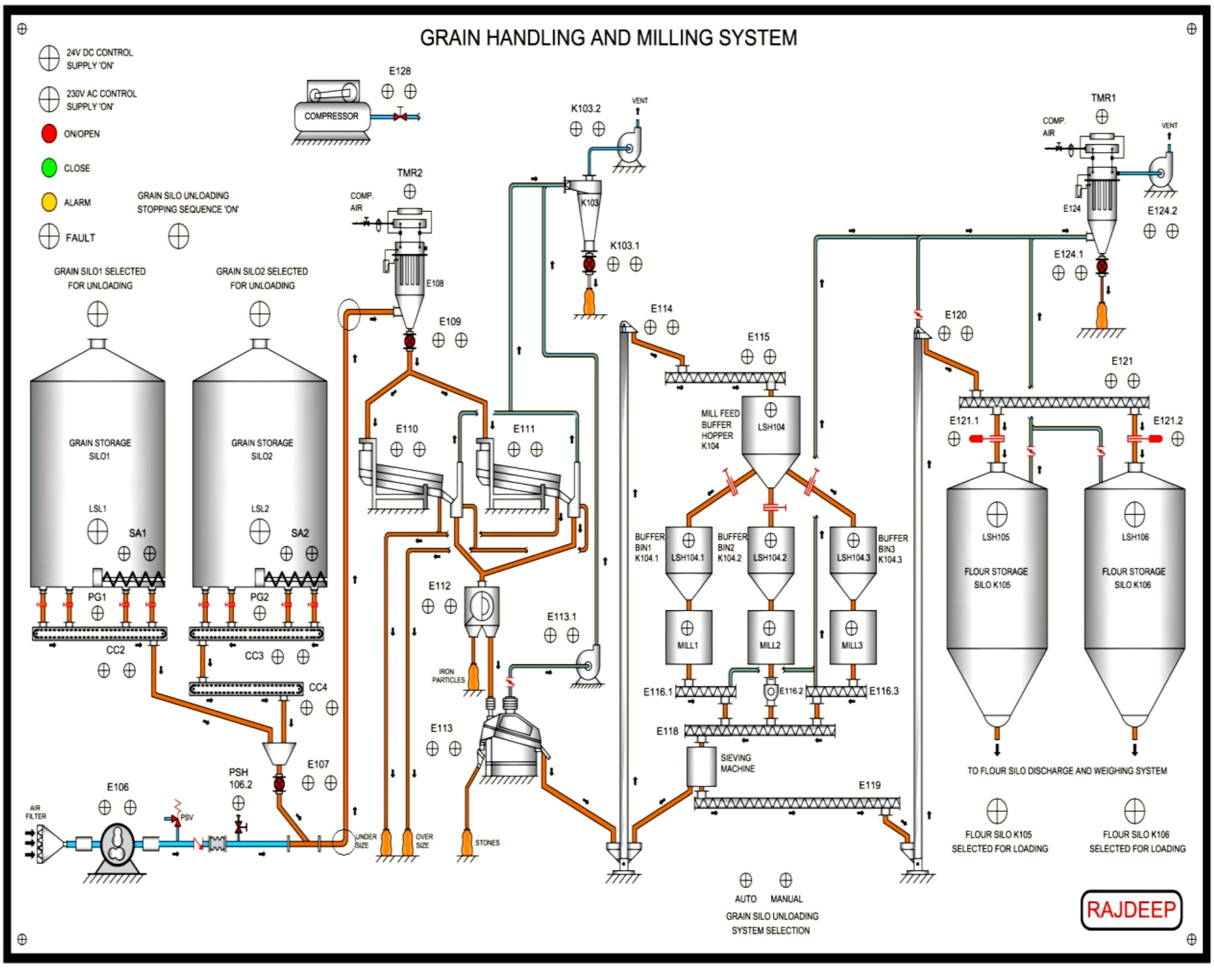

Fig. 12. Automated material handling system of liquor manufacturing plant (Using Pneumatic Conveying System)