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Productivity Improvement of Cylinder Filling Plant by Semi-Telescopic Conveyor for Loading Filled Liquefied Petroleum Gas (LPG) Cylinders for Transportation and Distribution

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Productivity improvement of cylinder filling plant by semi-telescopic conveyor for loading filled liquefied petroleum gas (LPG) cylinders for transportation and distribution.

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Abstract: Moving liquefied petroleum gas (LPG) filled cylinders through the conveyor which is at the floor level and reaching the loading area of the filling plant deck is one of the links of reverse logistics operation in LPG industry irrespective of the territory. The trucks to be parked with the opening of rear side to the deck enabling loading of LPG filled cylinders. The cylinders reaching the loading area of the plant deck are taken by the manual loaders and placed on the truck deck one on top of the other. Then so made pairs moved to the front end of the truck and stacked in three levels compatible with operational configuration practiced in LITRO gas lanka cylinder filling plants. It has been the normal practice for labourers to complete the loading of a 40ft full truck within one hour in the past periods of time. With incorporation of new system into the reverse logistic operation, LITRO was able to reduce 40% on labour and 40% on time enabling the loading of more number of trucks and thus more assurance in serving the community's clean fuel with a wider availability. This has been assessed by own HSE department and has come to the conclusion that this contributes to the productivity improvement of the business while reducing risk of taking lifetime treatments to their back bone related diseases caused by heavy duty handling by about 40% which is a remarkable achievement in the LITRO history for promoting facilitation of worker friendly workplace.

Keywords: Reverse logistics, LPG Filling, Telescopic Conveyor, and Productivity Improvement.

1. Introduction

Logistics of Liquefied Petroleum Gas (LPG) has different operational features in different territorial contexts. Mainly, LPG is imported to Sri Lanka and delivered through small to medium gas careers and taken into the country through port or some off shore operation such as CBM which is 6.5 km away from the west coast in the closer proximity to Colombo port. Thus, LPG storage will feed the filling plant for cylinderization of gas for delivery to customer end and again the empty cylinders are sent to re-filling operation to the filling plant which is a part of revers logistics. During this reverse logistic operation, the heaviest manual operation experienced was the loading filled cylinders to the trucks for transport and distribution. It was labour intensive and thus resulted in less workers turn over. Litro Gas Lanka Limited has decided to implement a comprehensive loading mechanism to get rid of all negative puffs related to the loading process and has achieved remarkable productivity improvement. This presents before and after productivity while elaborating the telescopic loading conveyor. . With incorporation of new system into the reverse logistic operation, LITRO was able to reduce 40% on labour and 40% on time enabling the loading of more number of trucks and thus more assurance in serving the community's clean fuel with a wider availability. The process improvement has not only evaluated by the operations department but also evaluated by the HSE department and confirmed that this contributes to the productivity improvement of the business while reducing risk of taking lifetime treatments to their back bone related diseases caused by heavy duty handling by about 40% which is a remarkable achievement in the LITRO history for promoting facilitation of worker friendly workplace

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2. The Problem

All the cylinders loaded to trucks manually. This is a very tedious exercise. Due to the nature of the job, attendance of loading employees is very poor. ~~40,000~~ 60000 to 75000 ~~50,000~~ numbers of 12.5kg filled cylinders to be loaded to trucks daily. Most of the employees cannot work for a long time as they face various health issues after engaging with loading works and various complications given rise to unacceptable loading system. This practice had been carried out since the company had started this operation for over 20 years. Less attendance and high labour turnover has resulted in increasing payment to loading labour than double that for a heavy duty labour in other industries and absenteeism was a recurring issue.

The activities involved in the loading of trucks are as follows;

- Taking the cylinders from floor conveyor and keeping on the truck deck end at the back of the truck.
- Keeping the second cylinder on top of the first one
- Rolling the two cylinders together to the loading point
- Packing two cylinder sets against the previously packed cylinders stacks
- Taking a cylinder from sets of two and throwing to stack at the third level

The loading operation was the bottleneck of the entire process. The excess amounts of cylinders received to loading bay are stacked in the space provided. This stacking process and taking them again and loading to trucks is an additional work making the loaders further tired. With the development of the loading system in the current study the requirement of such excessive cylinders stacking is minimized.

3. Literature Review

Rogers and Tibben-Lembke in 1999, Reverse logistics has been identified as the process of planning, implementing and controlling the efficient and economical flow of raw materials, work in progress, finished goods and information from the consumption point to the point of origin in order to recapture values or for proper disposal of products. Operational performances are co-related with reverse logistics are explained in theories such as resource based view theory, natural resource based view theory, stakeholder theory and institutional theory. This paper has based on an approach aligned with institutional theory and stakeholder theory and has developed process lines with telescopic conveyor system which has not been there for over 50 year duration. The institutional theory proposes that normative, mimetic and coercive forces play an important role in the adoption of reverse logistics (Di Maggio & Powell, 1983) The stakeholders theory shows the relationship of plant with the stakeholders (say the workers here) may change from time to time depending on the plants behaviour (Freeman, 1984). In order to increase the productivity of the filling plant at Kerawalapitiya, a new cylinder conveyance system designed at the plant itself was brought into operation and efficiencies are measured. This was the plant behaviour to be matched with increased demand from LPG market.

The single most effective process for establishing a reliable, objective matrix for performance is the classical engineered standard developed through time study (Peter Drucker, 2006). According to that, the areas which should be focused could be listed out as follows.

- Best Practices
- Building standards
- Capturing actual performance data
- Calculating Utilization
- Productivity Calculations

As defined in the OECD (Organization for Economic Co-operation and Development) Manual for Measuring Productivity in 2001, A production function relates the maximum the maximum quantity of gross output (Q) that can be produced by all inputs, primary ones (X) i.e. labour and capital and intermediate ones (M). A production function also contains a parameter (A (t)) that captures disembodied technological shifts.

$$Q=H(A,X,M)=A(t).\ F(X,M) \qquad \text{....(01)}$$

The parameter A(t) is not physically tied to any specific factor of production and it affects inputs proportionally and thus is called "Hicks-natural".

When the level of technology is Hicks-Natural, this shift just equals the rate of change of technological parameter with the change in the production. (OECD, Productivity Measuring Manual)

$$\frac{\partial lnH}{\partial t} = \frac{\partial lnA}{\partial t} \qquad \text{..(02)}$$

The conveyance system designed as a Hicks-natural parameter at filling plant is neither a horizontal conveyance nor a vertical conveyance. Also, it is neither a fixed nor a movable. It consists of all above features in it in such a manner that all possible configurations are to be used whenever needs. By the definition of this Hicks-natural shifting, it inherently accounts for required inputs proportionally.

4. Approach and Methodology

Initially, the system of cylinder loading has been investigated and identified following points of importance.

4.1 Need Justification

There are conveyors called "telescopic conveyors" those could be extended into the trucks but only moves to and fro and not developed beyond that. The construction is very heavy as it is a cantilever type design. Installation of a cantilever system for the existing plant is not a proper solution as operation has to be stopped for few weeks for construction works. Additionally such conventional telescopic designs require comparatively a bigger investment. The solution to have semi-telescopic conveyor which could be moved into and out from the truck and deliver cylinders to the exact loading point. This conveyor is running in parallel to the existing floor conveyor which delivers the cylinders to the end of the plant deck only. The advantage is that the movable conveyor is capable of moving to into and out of the truck at any moment independent of floor conveyor operation. This conveyor is moving into and out from the truck by using a friction drive which is less noisy operational. The weight of the conveyor entered to the truck partly stands on the truck sharing part of the load to the truck. Therefore this is not either heavy or has cantilever actions as conventional telescopic conveyors.

4.2 Design Exercise

The design consists of two conveyors namely lifting conveyor and moving conveyor. The length of the conveyors, lifting height for the lifting conveyor are decided purely based on operational requirements.

4.2.1 Power Requirements

Power requirement determined for the lifting conveyor by considering overcoming of three forces and for the moving conveyor by a practical test of towing similar weight to the required length. Since an abandoned drive unit to be used for driving, a cross check has been done to assess the torque of the drive friction at the wheel periphery. Table 01 gives the final results of the power requirement for two different sections of the newly designed semi-telescopic conveyor.

Table 01. Power Requirements.

Conveyor type	Total power requirement (W)
Lifting	746
Moving	3000

4.2.2. Materials Used

Since the design was aimed at chain conveyor configuration, chain segments already removed from service has been used since those are cable enough to handle cylinder conveyance systems. In management point of view, since the only requirement is determining power to transfer the loads, the system doesn't need any further design since there were abandoned parts which were used in the fabrication stage.

4.3 MOC and ALARP Studies

Management of Change (MOC) has been approved and risks have been evaluated in this connection. It has been prepared Risk Assessment Matrices (RAM) in the implementation stage before and after the change and they are presented in annex.

4.4 Productivity Improvements

The function A (t) in productivity measurements has correlations with primary (X) and intermediate (M) functions as described in equation (1). In comparison of previous loading system, for loading a 40ft long truck, 5 loaders (manpower) required. Two loaders were for making pairs of cylinders taken from the floor conveyor. And other three loaders were for rolling the pairs and stacking cylinders at three heights. The time taken for loading was 60 minutes.

In improved loading system, the number of labour required for loading was reduced to 3. And this is 40% reduction. The time taken was reduced to 36 minutes and this is a reduction of

40%. Clearly an improvement in function X which leads to productivity improvements

Table 02. Comparison of factors .

Parameter	Contribution to Function X	
	Before	After
Manpower	5	3
Process time	60	36
Loading rate trucks per hour	3.69	4.84
Loadable number of cylinders per 12 hour	47291	62029
Average time to load 67500 cylinders	17 hours	13 hours

Refer to Annexure: Calculations of savings For detailed calculations

4.5 Payback period

The amount spent for the construction was 2.2 million rupees. The saving from all aspects is Rs. 66105/= rupees per day. Average number of days working is 26 days a month. Therefore the payback period is 33 days. (Approximately 1.1 months)

4.6 Non-monetary benefits such as HSE concerns

Due to handling of heavy filled LPG cylinders, with time non-curable damages occur to the backbone and related bones specially. From this improvement, such risks are reduced directly by 40%, simply the number of people affected reduced by 40%.

5. Conclusion

By deploying this improved loading conveyor, there are improvements in productivity and thereby a considerable saving in cost and safeguards health aspects loaders and time remarkable time saving for the loading operation. This improvement can be considered as a simple but very cost effective and attractive one.

6. References

1. Randenburg, M., Kuhn, H., Schilling, R., & Seuring, S. (2014). Performance-and value-oriented decision support for supply chain configuration: A discrete-event simulation model and a case study of an FMCG manufacturer. *Logistic Research, 7*(118), 1–16.
2. Dowlatshahi, S. (2000). Developing a theory of reverse logistics. *Interfaces, 30*,143–155.10.1287/inte.30.3.143.1167
3. Geethan, K. A. V., Jose, S., & Sunil Chandar, C. (2011). Methodology for performance evaluation of reverse supply chain. *International Journal of Engineering and Technology, 3*, 213–224.
4. Gooley, T. B. (1998). Reverse logistics: Five steps to success. *Logistics Management and Distribution Report, 37*, 49–55.
5. Jhawar, A., Garg, S.K., & Khera, S.N. (2014). Analysis of the skilled work force effect on the logistics performance index—Case study from India. *Logistics Research, 7*(117), 1–10.
6. Jun, H.-B., & Kim, J.-G. (2006). State of the art: Research issues and framework for enhancing the productivity of reverse logistics using emerging information technologies. In *Proceedings of Asia-Pacific Productivity Council (APPC) 2006*. Seoul.
7. Krikke, H. (1998). *Recovery strategies and reverse logistic network design* (PhD thesis). Institute for Business Engineering and Technology Application, University of Twente, Enschede.
8. Lampe, K., Hofmann, E. (2014). Understandi ng the cost of capital of logistics service providers: An empirical investigation of multiple contingency variables. *Logistics Research,7*(119), 1–25.
9. Nakabi, A., Zitouni, B., & Bouksour, O. (2012). RFID to enhance visibility in a closed loop supply chain: Case of cylinders management in a Moroccan LPG distribution Chain. *International Journal of Computer science issues, 9*, 409–418.
10. OECD quality manual
11. Pongadi, P. (2014). A study on impact of LPG on Indian economy. *International Journal of English Language, Literature and Humanities, 1*, 108–117.
12. Shepherd, C., & Gunter, H. (2006). Measuring supply chain performance: Current research and future directions. *International Journal of Productivity and Performance Management, 55*, 242–258.

13. Sriyogi, K. (2012). Reverse logistics: A comparative study of LPG agencies in urban and rural area. *The IUP Journal of Supply Chain Management, 11*, 33–51.

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Annex

Table 03. RAM With earlier loading system (Before implementation)

	Consequences								
	People	Assets	Environment	Reputation	A	B	C	D	E
					Never heard of in the industry	Heard of in the industry	has happened within a year	Has happened in the location	Has happened more than once per year in the location
0	No injury	No Damage	No Effect	No impact					
1	Slight injury	Slight Damage	Slight Effect	Slight Impact					
2	Minor Injury	Minor Damage	Minor Effect	Minor Impact			3A,4A	1A,2A	1P
3	Major Injury	Modarate Damage	Moderate Effect	Moderate Impact			3P	2P,4P	1E
4	!-3 fatalities TPD	Major Damage	Major Effect	Major Impact					
5	More than 3 fatalities	Massive damage	Massive Effect	Massive Inpact					
				Low	2	Medium	0	High	0

Table 04. RAM with new loading system (after implementation)

	Consequences								
	People	Assets	Environment	Reputation	A	B	C	D	E
					Never heard of in the industry	Heard of in the industry	Has happened in the organisation or more than once per year in the industry	Has happened in the location or more than once per year in the industry	Has happened more than once per year in the location
0	No injury	No Damage	No Effect	No impact			3P,3A,4A	4P	1P
1	Slight injury	Slight Damage	Slight Effect	Slight Impact				1A,2A,2P	1E
2	Minor Injury	Minor Damage	Minor Effect	Minor Impact					
3	Major Injury	Modarate Damage	Moderate Effect	Moderate Impact					
4	!-3 fatalities TPD	Major Damage	Major Effect	Major Impact					
5	More than 3 fatalities	Massive damage	Massive Effect	Massive Inpact					
				Low	2	Medium	0	High	0

Calculations of savings

Cost saving from reduction in loading labour = Rs 5000/= per day

Most importantly the number of operation hours of the filing plant depends upon the total number of 12.5kg cylinders to be loaded on that day and it is determined by the loading rate of 12.5kg LPG filled cylinders.

Previous loading rate:
Assumptions;

- All the trucks are 40ft (in practice it is about 85% - 90% of the fleet)
- Capacity of a 40ft truck is 1068 numbers of 12.5kg cylinders(in practice there may be 1 to 5 cylinders differences)
- Trucks change over time in a loading bay 5 minutes
- Number of cylinders to be loaded per day on average is 67500

Number of loading bays: 4
Loading rate of two old loading systems:
One truck per 65 minutes (including changing over time)
Loading rate of two new type loading systems:
40 minutes (including changing over time)

Number of trucks loaded per hour by 4 loading systems (present combination): (60/65*2)+(60/40*2)= 4.84
Time taken to load 67500 cylinders = 67500/1068/4.84 = 13 hours

Number of trucks loaded per hour by 4 loading systems (previous combination): (60/65*4) = 3.69
Time taken to load 67500 cylinders = 67500/1068/3.69 = 17 hours

With the above reduction of the operation time of the filling plant (17 – 13 = 4), labour overtime cost and electricity cost savings are significant:

Saving on overtime labour cost:
Overtime rate of permanent employees (on average) Rs. 475/= per hour).Number of permanent cadre employees present for overtime (on average) = 25 Saving from overtime of permanent cadre employees = Rs. 475*25/day = Rs. 11875/= per day
Number of contract employees present for overtime = 100 Overtime rate of a contract employees Rs 110/= per hour
Number of contract employees present for overtime = 100
Saving from overtime of contract employees = Rs. 110*100/day= Rs. 11000/=/ day
Saving on electricity
Average electricity consumption per day = 5350 units (operation hours 16)
Average electricity consumption per hour = 334.4 units (including the consumption for new loading system components).

By reducing the number of operation hours from 17 to 13, the reduction in electricity consumption = 331 *4 = 1324 units

The reduction in electricity bill = 1324 * Rs 20/= (commercial rate) = 26480/=

Saving from the reduction of wear and tear of rotating machinery and equipment:
(Assume cost of wear and tear is 10 million rupees per annum and 26 days a month and 16 hours a day).
Saving from reduction of 4 hours wear and tear daily = 10,000,000/12/26*4 = Rs 2000 *4= 8000/=

Total saving from reduction of labour, labour overtime, electricity and wear and tear as a result of introduction of new loading machines = 5000/= +11875/=+ 11000/=+ 26480/=+8000/= = 62355/= Approximately Rs 1.621 million a month

In addition to the above savings, the dinner supply cost saving:
The dinner for all staff of filling plant is supplied if operation runs after 7.30pm.
According to the previous loading system only 47291 cylinders could be loaded by 7.30pm.
But with the introduction of new loading system the number of cylinders that could be loaded by 7.30pm increased to 62029.

If the total number of cylinders drops below 62029 (A drop of 8.1% of average), the cost of dinner for filling plant staff can be saved with the introduction of new loading system.

Cost for the dinner for filling plant staff per day = number of staff @ Rs 130/= = (100+25)*130 = 16250/=
If we assume 6 days a month dinner cost could be saved= Rs. 97500/=

Therefore the total reasonably estimated saving as a result of introduction of new loading system = (Approximately) Rs 1.718 million a month and annually about Rs. 20.6 million