INTEGRATING THE QUALITY COST REPORT WITH THE TQM TOOLS CASE STUDY: AT THE BAR AND ROD MILL (TS-4) LISCO

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***Abstract* – Contemporarily, the vigorous competition between organizations in the age of globalization, increased concern was directed towards the total quality management, and the cost of quality became a considerable portion of the total production cost. Thus, many of these organizations try hard to decrease their costs in order to survive in this cruel market.**

This study aimed to highlight and bring into focus the importance of measuring and reporting the Costs of Quality (COQ) within the Bar and Rod Plant to diagnose the quality problems, motivate continuous quality-improvement activities, and evaluate its effectiveness by using both of the quality control and improvement tools; Pareto and the Cause-and-effect diagram analyses. Accordingly, the pertinent data to assemble the report was collected mainly from the TS-4 plant management, the quality control department, and the cost department. The collected data covered only the years of 2008, 2009, and 2010. In addition, several interviews were conducted with some of the prominent personnel involved in the Plant's activities. To achieve this aim, a descriptive analytic method was used.

Consequently, it was found out that the TS-4 plant managed to achieve a considerable internal failure cost reduction by investing more in the prevention and appraisal activities, which meant that the COQ measuring and reporting system within the TS-4 plant was adequate and efficient which was clearly shown in the critical performance indicator, the sales index, which declined from 0.99 % in 2008 to 0.81% in 2010.

I. INTRODUCTION

In an effort to combat the stiff competition, companies have increasingly paid more attention to quality and productivity, especially given the potential to reduce costs and improve product quality simultaneously [1]. Improving quality can produce significant improvements in profitability and overall efficiency as well as reducing the total quality costs. In order to survive in today's competitive environment, companies need to implement quality - improvement programs under the TQM philosophy which is rooted in the belief that preventing defects is cheaper than dealing with the costs of quality failures [2]. In other words, total quality costs are minimized when managers strive to reach zero defects in the organization. In order to monitor and report on the progress of these programs a quality cost reporting system is essential. The quality costing is a substantial source of significant savings because it helps the company to reduce manufacturing costs by identifying the excessive costs, waste, and the non-value adding activities [3]. As a way to evaluate the effectiveness of the company's quality system, quality costing can discover problems, develop measures, and improve the overall system. In addition, COQ control supports company decision making on quality inputs and product improvements and gain higher profitability. To effectively reduce internal and external failure costs in implementing quality cost control under TQM, the company can invest more on prevention and appraisal costs in order to reduce the failure costs and improve key problems through a careful analysis of contributing factors [4,5]. A widely used rule of thumb says if a defect costs $ 100 to fix in the field it would only cost $ 10 to fix in your facility and only $ 1 to prevent [6], so in this case an ounce of prevention is definitely greater than the pound of cure. This means in the manufacturing process defects must be stopped before they are created.

II. PROBLEM STATEMENT

The success of a company largely depends on the profit that it can realize. The profit is determined by the costs that are made and the extent in which these costs are recovered. Therefore, it is essential for a company to know the costs and be able to control them. When the costs are known and well traced throughout the entire product development cycle, the engineers can benefit from the cost information during the decision-making processes. The Libyan and Iron Steel Company (LISCO), as a largest steel manufacturing industry in the country, has to consider the fact that Reporting and measuring quality costs are absolutely essential to the success of ongoing quality-improvement program in order to survive and remain in the market especially in the current exceptional situation. Even though LISCO has received the ISO-9001:2000 Certificate, it still does not adopt a quality cost control system which reveals that there is lack of knowledge of how to track quality costs. So implementing a quality cost reporting system

besides applying TQM tools are absolutely essential to LISCO in order to improve its overall quality as well as the production operations , and reduce the total costs.

III. Reason For Measuring Costs Of Quality

The measurement of the COQ allows quality-related activities to be expressed in the language of top management i.e. money. The COQ measurement focuses attention on areas of high expenditure and identifies potential cost-reduction opportunities [7]. It allows measurement of performance and provides a basis for internal comparison between products, services, Processes and departments. Measurement of quality-related costs also reveals anomalies in cost allocation and standards which may remain undetected by the used production, operation and labor-based analyses. In addition, measuring the COQ helps find out where the unnecessary costs are occurred which urges the top management to take the proper corrective actions to eliminate such costs in other words COQ serves the management to determine which area of operation that requires either preventive or corrective measures[2].

IV. APPROACHING THE RESEARCH TARGETS

The purpose of this research is to highlight the significant role of reporting the COQ of the TS-4 plant, to make the plant's management aware of the magnitude of these costs, to motivate the continuous improvement in COQ, and to provide a baseline against the impact of quality-improvement investments, which would allow the opportunity to know how well is the TS-4 plant performing. To achieve this target, the two main stages were followed:

-The First Stage: Assemble a detailed COQ report based on the pertinent data that came mainly from the quality and accounting departments.

-The second Stage: Analyze this data to clarify the magnitude of these costs and their impact on the overall performance of the TS-4 plant using the Pareto Charting and the Cause-and-effect diagram.

A- THE COST OF QUALITY REPORT

The COQ reporting plays an important role in achieving customer satisfaction, in addition it can identify, analyze and quantify quality related costs which could be used as a performance indicator, in order to prioritize quality improvement initiatives and as a cost reduction tool [5]. In addition the COQ reporting is able to identify costs of quality improvement activities as well as cost benefits of those improvement activities to the organization which means COQ reporting is an important tool for managers to quantify their quality related activities and benefits in monetary values [7], which enables them to achieve the competitiveness needed in the competitive market.

In order to prepare the detailed COQ report which would provide a clear picture for LISCO top management of how well the plant is performing; the pertinent data was gathered and collected mainly from: the quality department, accounting department, and the production and planning department.

The internal failure costs included mainly the costs of the out of spec. and scrap. These costs are summarized in the tables 1,2, and 3 [8].

TABLE 1. The Out of Spec. and Scrap 2008

Total Production = 443,850 Tons				
Out of Spec Standard Cost = 52 LYD				
Scarp Standard Cost = 531 LYD				
The Defect	**The Out Of Specification Per Ton**	**%**	**The Scrap Per Ton**	**%**
UNS	3,002	0.69	10	0.002
UNF	6,195	1.40	0	0.00
OUW	3,721	0.84	0	0.00
IRL	5,928	1.34	0	0.00
OVF	1,514	0.34	9	0.002
OLP	843	0.19	0	0.00
ROM	706	0.159	41	0.009
UNF+UNS	1,789	0.40	0	0.00
DET	0	0.00	142	0.045
FLP	0	0.00	408	0.092
SFN	0	0.00	212	0.048
DFN	0	0.00	199	0.045
UNF+OUW	1,829	0.41	0	0.00
DTR	1360			
Total	**26,887**	**6.079**	**1,021**	**0.243**
Total Failure Costs (LYD)	**Out Of Spec**		**Scrap**	
	1,398,124		**550,647**	
Total Costs (LYD)	**1,948,771**			

TABLE 2. The Out of Spec. and Scrap 2009

Total Production = 467,467 Tons				
Out of Spec Standard Cost = 52 LYD				
Scarp Standard Cost = 531 LYD				
The Defect	**The Out Of Specification Per Ton**	**%**	**The Scrap Per Ton**	**%**
UNS	1,517	0.32	0	0.00
UNF	5,438	1.16	0	0.00
OUW	2,861	0.61	0	0.00
IRL	3,246	0.69	0	0.00
OVF	1,435	0.31	0	0.00
Low y.p	0	0.00	531	0.11
UNF+UNS	889	0.19	0	0.00
DET	501	0.11	0	0.00
FLP	0	0.00	474	0.10
SFN	0	0.00	167	0.04
DFN	0	0.00	116	0.02
UNF+ OUW	577	0.12	0	0.00
Total	**16,464**	**3.51**	**1,369**	**0.27**
Total Failure Costs (LYD)	**Out Of Spec**		**Scrap**	
	856,128		**726,939**	
Total Costs (LYD)	**1,583,067**			

TABLE 3. THE OUT OF SPEC. AND SCRAP 2010

Total Production = 458,627 Tons				
Out of Spec Standard Cost = 52 LYD				
Scarp Standard Cost = 531 LYD				
The Defect	**The Out Of Specification Per Ton**	**%**	**The Scrap Per Ton**	**%**
UNS	4,463	0.97	88	0.02
UNF	3,651	0.80	0	0.00
OUW	2,583	0.56	0	0.00
IRL	1,602	0.35	0	0.00
OVF	1,173	0.26	0	0.00
OLP	653	0.14	35	0.01
ROM	647	0.14	47	0.01
UNF+UNS	1,138	0.25	0	0.00
DET	370	0.08	13	0.003
FLP	0	0.00	472	0.10
SFN	0	0.00	152	0.03
DFN	0	0.00	75	0.02
Total	**16825**	**3.67**	**882**	**0.193**
Total Failure Costs (LYD)	**Out Of Spec**		**Scrap**	
	874,900		**468,342**	
Total Costs (LYD)	**1,343,242**			

The external failure costs were not calculated due to the fact that the external failure did not exist within the Bar and Rod plant during the allocated period when the data was collected.

The Appraisal costs included mainly the costs of the following activities: inspection, chemical analysis & mechanical testing, and the costs of the scrapped samples resulting from the mechanical tests. These costs are summarized in table 4 [9].

TABLE 4. THE APPRAISAL COSTS

	2008	**2009**	**2010**
Inspection	838,211	936,563	872,591
Analysis & Testing	86,930	135,563	82,745
Samples Scrap	9,910	12,089	10,755
Total costs (LYD)	**935,051**	**1,084,215**	**966,091**

The Prevention costs included the training costs, studies related to the Bar and Rod plant activities provided by the Research and development, new equipment to reduce failure and increase quality, and activities of continuous improvement. These costs are summarized in table 5 [9].

TABLE 5. THE PREVENTION COSTS

	2008	**2009**	**2010**
Training	17,715	3,240	7,560
R & D	90,789	94,549	-
New Equipment	45,585	-	341,678
Total Costs (LYD)	**154,089**	**97,789**	**349,238**

The table 6 summarizes the whole details of the COQ categories of the different activities performed at the Bar and Rod plant.

TALE 6. THE FINAL COST OF QUALITY REPORT

Bar & Rod Plant COQ Report			
	2008	**2009**	**2010**
	LYD	**LYD**	**LYD**
Prevention			
Quality Training	17,715	3,240	7,560
New Equipment	45,585	NA	341,678
Research & Development	90,789	94,549	NA
Subtotal	**154,089**	**97,789**	**349,238**
Appraisal			
Inspection	838,211	936,563	872,591
Analyses & Testing	86,930	135,563	82,745
Scrapped Samples	9,910	12.089	10,755
Subtotal	**935,051**	**1,084,215**	**966,091**
Internal Failure			
Out of Spec.	1,398,124	856,128	874,900
Scrap	550,647	726,939	468,342
Subtotal	**1,948,771**	**1,538,067**	**1,343,242**
External Failure			
Not Available	NA	NA	NA
Total Quality Costs	**3,037,911**	**2,720,071**	**2,658,571**
Total Sales	313,453,611	323,872,688	330,159,019
Total Production Costs	270,180,466	241,744,323	267,381,600
Total Labor Costs	6,017,841	7,052,489	10,917,471
Sales Index	**0.969 %**	**0.840 %**	**0.805 %**
Costs Index	**1.124 %**	**1.125 %**	**0.994 %**
Labor Index	**50.84 %**	**38.57 %**	**24.35 %**

B- THE QUALITY MANAGEMENT TOOLS FOR IMPROVEMENT

At this stage it was imperative to characterize the potential defects and their root-causes by using the Pareto and the cause-and-effect diagrams (Ishikawa Diagram).

Pareto Analysis not only identifies the most significant factors leading to the most important problem , it also gives a score showing how severe the problem is. Pareto chart was done based on the data that was gathered via interviews and reports provided by the quality control department. After identifying the list of the major defects and their causes, the team managed to break the bigger problems into smaller pieces and knew where to focus efforts.

Fig.1 showed the Out of Spec. for the year of 2008 where the defects of UNF, IRL, OUW, and UNS caused the 80 % of the total defects while Fig.2 exhibited that the UNF, IRL, OUW, and the UNS remained the main causes representing the 80 % of total Out of Spec for the second year; and Fig.3 illustrated that the UNS, UNF, IRL,OUW, and OFV represented the 80 % of total Out of Spec. for the year of 2010.

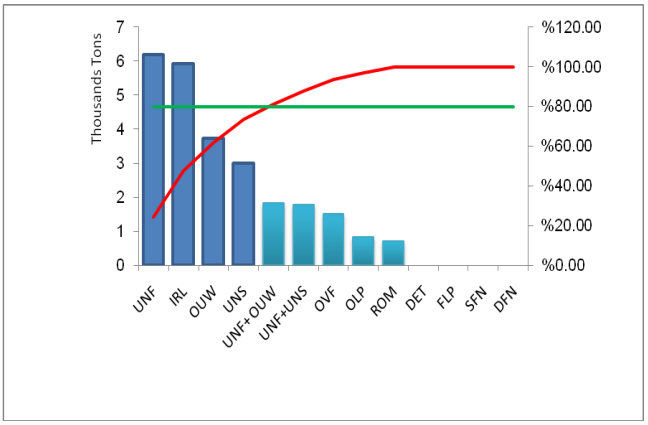

Fig. 1: The Out Of Spec. 2008

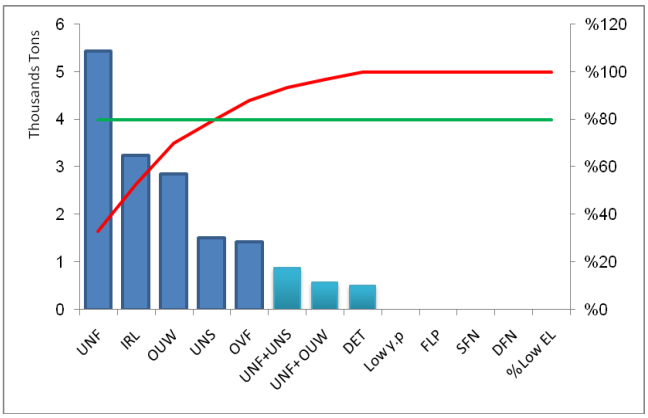

Fig. 2: Out Of Spec. 2009

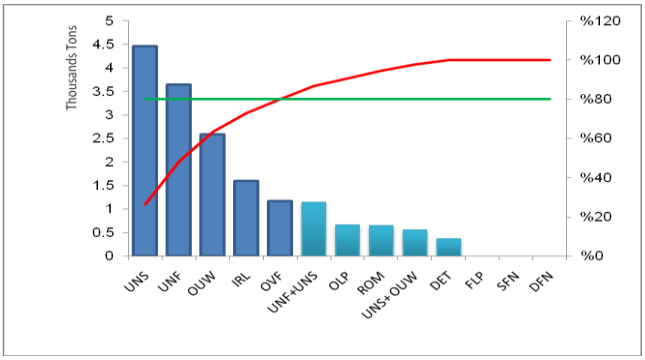

Fig. 3: the Out of Spec. 2010

The same steps were used to identify the defects which caused the scrap where it was found that the FLP, SFN, DFN were the predominant causes which led to the 80 % of total defects.

After organizing and prioritizing the major defects and their most likely reasons from the Pareto diagrams ,it was decided to carry out a mapping of the fishbone in order to illustrate the various potential causes that affected the rolling process. A brainstorming session was set to diagnose the key factors that had led to the Out Of Spec. and Scrap so that to suggest to the TS-4 management to take the proper corrective actions to eliminate these defects. The brainstorming was based on the team members' prior experiences. After a prolonged discussion it was agreed on the most likely potential causes that were thought to have led to the Out of Spec. and scrap, after eliminating the unnecessary ones.

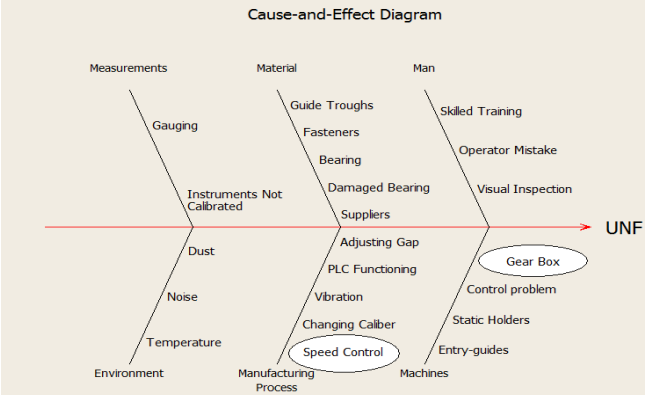

Fig.4: The potential causes of the UNF defect 2008

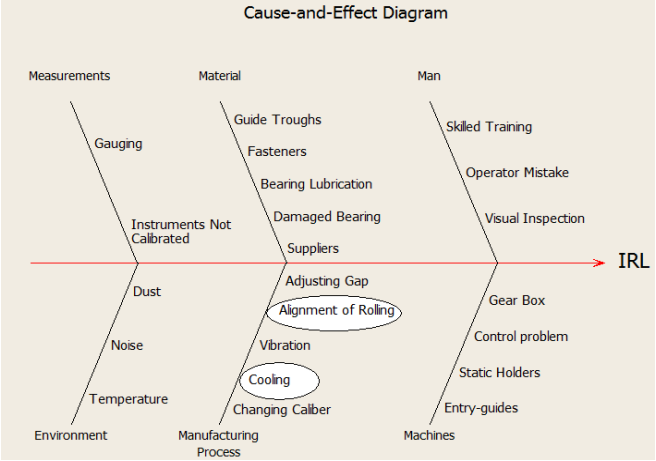

Fig. 5: The potential causes of the IRL defect 2008

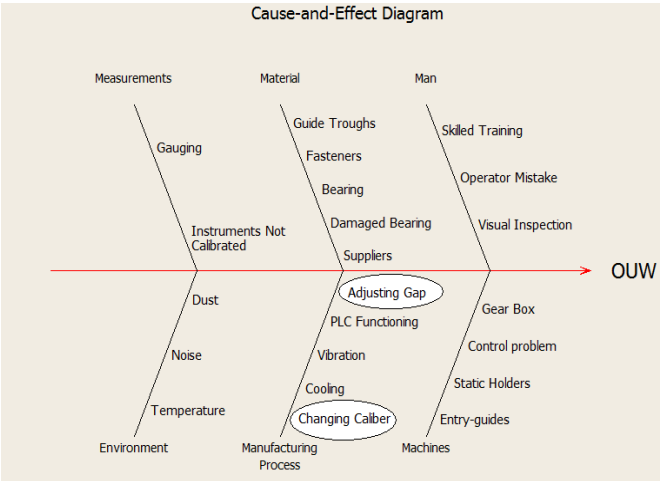

Fig. 6: The potential causes of the OUW defect 2008

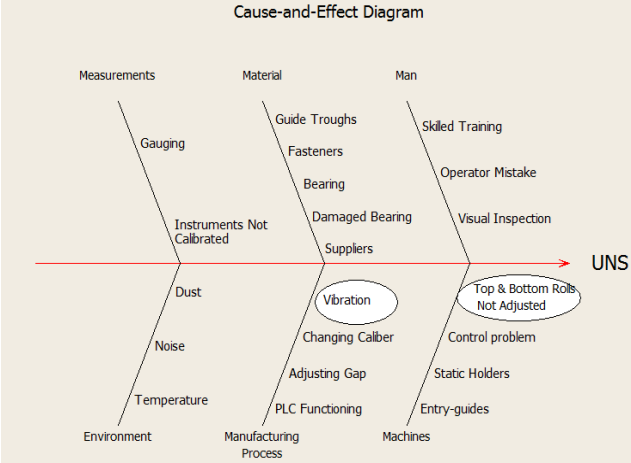

Fig. 7: The potential causes of the UNS defect 2008

Both, Pareto and the cause-and-effect analyses, were very useful tools in identifying the major key factors which helped to reveal a clear picture on the effectiveness of the measures that were taken by the management to solve the problems; and indicating that the investment in both the prevention and appraisal activities was reflected in the remarkable improvement in internal failure which meant that the measures taken by the TS-4 management were adequate and efficient. Fig. 9 shows that UNF, IRL, OUW, and the UNS decreased considerably. However, the UNS increased unexpectedly in the last year due to the vibration which was the major obstacle leading to this defect.

While Fig. 10 illustrates the decrease of both SFN and DFN; however, the FLP defect increased due to the problems of the gear box, tension in line, and speed control. In addition, the Low y.p appeared only in 2009, which was found due to Carbon excess in its chemical composition; further investigations revealed that the main supplier was responsible for the problem.

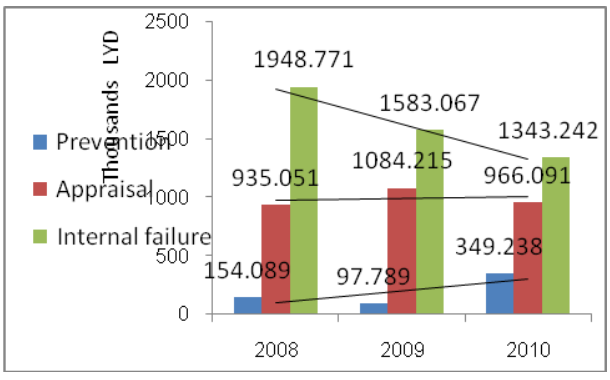

Fig. 8: COQ distribution

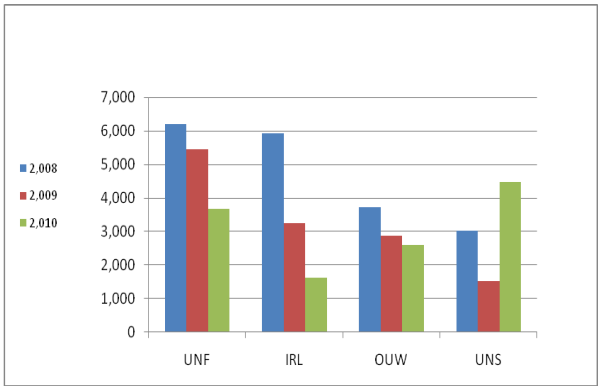

Fig. 9: Decrease in the defects causing the Out of Spec

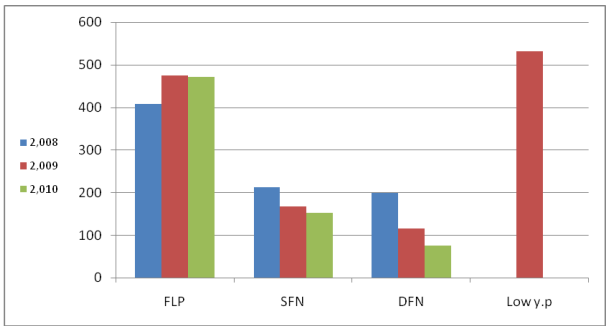

Fig. 10: Decrease in the defects causing the Out of Spec

V. DISCUSSION AND RECOMMENDATIONS

Even though the Sales index appears to fall out of the competitive standard range, which is between 1 and 5 % since LISCO considered as ordinary mechanical industry with regular variances, it went down from 0.97 % to 0.84 % for 2009 and to 0.81% for the year of 2010; which indicates that the corrective actions taken by the TS-4 management were really effective. The management increased the investment in the appraisal and prevention activities which helped reduce the internal failure costs from 1,948,771 LYD (64 % of the total COQ) in 2008 to 1,343,242 LYD (51 %) in 2010 as shown in Fig.8. Table.7. shows that the appraisal costs fell within the desired standard range with an average percentage of 35.33 % of the total COQ while the average percentage of Prevention costs was slightly higher with 7.33 %.

Although the internal failure costs decreased considerably in the two successive years, 2009 and 2010, by almost 21 % and 13 % respectively, its average percentage,57.33 %, is still far away from the standard percentage; which means that the TS-4 management should focus more on investing in the prevention and appraisal activities in order to reach, at least, the standard percentage of the internal failure, 40 %.

TABLE.7: COMPARES EACH % COQ ELEMENT TO THE STANDARD ONES

COQ Elements	Standard % of Total Quality Costs	Average % of each element at the TS-4 plant
1- Prevention Costs	0.5 ---5 %	7.33 %
2- Appraisal Costs	10--- 50 %	35.33 %
3- Internal Failure Costs	25--- 40 %	57.33 %
4- External Failure Costs	20--- 40 %	-

VI. CONCLUSION

In this research, the COQ report was found to be a very helpful tool to LISCO's top management as a performance measurement system and failure planning strategy. It proved to be a good way to evaluate the effectiveness of the Bar and Rod Plant's quality system, since it helped discover problems, develop measures, provide solutions, and improve the overall system by studying and analyzing the different factors that affected the quality of products. In addition, this research has come up with the following results:

- The internal failure had decreased considerably which indicates that LISCO had gained a competitive advantage.
- The increase in prevention and appraisal costs had contributed to the increase of sales and the decrease of the ratio of the total COQ to the total sales revenue.
- The UNF, IRL, OUW, and the USN were the major potential defects that caused the Out Of Spec. while the FLP, SFN, and the DFN were the major defects that caused the scrap. Thus, the Bar and Rod plant's management had to set the right priorities to eliminate these defects or at least to mitigate them to the lowest level.

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