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Failure Analysis of Brake System in Light Commercial Vehicles using SQC Tools

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***Abstract*— Brake system is one of the most important sub systems in an automobile. The safe operation of a vehicle is very much determined by brakes. Disc brake and Drum brake are the two different types of brakes used in automobiles. Drum brakes are one of the very commonly used rear brake in today's automobiles. There are varieties of drum brakes available and each has its own advantages and disadvantages. The current system brakes running in the field has the complaint of frequent brake adjustment which leads to higher vehicle down time. Further, the other problems in using this manual adjuster hydraulic brakes are wheel cylinder kit leak, wheel cylinder jam etc.**

Due to lining wear of the brakes during usage, often the pedal bottoms up while driving. The driver has to adjust all the wheel cylinders and make the pedal to come up. The boots may get damaged during adjustment, and it leads to dust and other impurities entering into the system and consequently leads to leak in system. Also as the brakes are operating at higher temperature (especially in hilly regions), there is a possibility for the seals and boot to be damaged and may result in leak. Due to these leaks, the system failure can occur and it may lead to major fatal accidents.

Even though these brakes are well established, there is continuous research by brake manufacturers to improve the performance and effectiveness of drum brakes. Questionnaire was prepared for collecting data from 120 customers. Survey method was used to collect the data. The data was analyzed by applying statistical tools and Statistical Quality Control tools.

Keywords—Disc brake, Drum brake, Hydraulic brake, lining wear, automobile

I. INTRODUCTION

Brakes function because of a special hydraulic, or liquid-based, system. Brake fluid moves from the pedal through the brake-line system. Because liquids can't be compressed, they move. It is this movement that pushes against the mechanism that stops the vehicle. So when this fluid runs low, brake problems will occur. If the brake system is failing, the vehicle may pull to one side. This situation can cause accidents that range from fender-benders to serious collisions. Early automotive brake systems, after the era of hand levers of course, used a drum design at all four wheels. They were called drum brakes because the components were housed in a round drum that rotated along with the wheel. Inside was a set of shoes that, when the brake pedal was pressed, would force the shoes against the drum and slow the wheel. Fluid was used to transfer the movement of the brake pedal into the movement of the brake shoes, while the shoes themselves were made of a heat-resistant friction material similar to that used on clutch plates. The National Transport Safety Board (NTSB) study found that many motor carriers and drivers of commercial vehicles fail to understand the need for well-maintained brake systems. This lack of understanding is easy to comprehend - poorly-adjusted brake systems give little driver "feedback" and in routine operations may perform adequately - but in emergency situations, with high brake temperatures and hard applications, adequate braking may not be available [1]. Brake systems require routine checks of fluid levels and pad condition, leading to periodic brake pad replacement.[2]. To enhance the braking safety and improving the braking performance of the tractor/trailer vehicle a slip-rate-based braking force distribution algorithm is proposed for the electronic braking system of tractor/trailer combination vehicle. The algorithm controls the slip-rates of the tractor's rear wheels and the semi-trailer's wheels changing with the slip-rate of tractor's front wheels, making tractor's front wheels lock up ahead of the tractor's rear wheels and the semi-trailer's wheels. The algorithm protects the combination vehicle from jackknifing and swing, guaranteeing that the combination vehicle has better driving stability and steering capability. The simulation results shows that the algorithm can control the wheels' slip-rate changing in the settled range and shorten the braking time, thus improves braking performance of tractor/trailer combination vehicle. [3] A new hydraulic booster concept with internal ratio is working with the CC-principle. In case of a failure the required secondary braking performance will be achieved with ergonomically pedal effort and pedal travel. Different brake splits will be obtained with a minimum of changes.

This is also the reason why the ABS booster requires the same number of modulators and control channels independent of the brake split. The control philosophy with MIR (modified individual control) at the front axle and individual control at the rear axle is recommended for all drive train concepts. Even with locked differentials the ABS-control remains active. The special booster concept permits easily a system extension for the purposes of drive slip control [4]. Two commercially available alternatives that produce higher output are Air Disc brakes and larger sized S-Cam brakes. Using one type, or a combination of these brakes (discs and drums on different axles) warrants a comparative study. The goal is to improve the effectiveness of the brake system, while maintaining or improving upon vehicle stability during braking. Richard L.Hoover et al reported the effect of the semitrailer brake on dry surface stopping performance and stability of combination tractor-semitrailer rigs. The data analyses include the effect of semitrailer and brake type on the rankings of full combination braking tests [5].

In this study the researcher has made an attempt to analyze the performance of existing brake system used in light commercial vehicles. The current system brakes running in the field has the complaint of frequent brake adjustment which leads to higher vehicle down time. Further the other problems in using this manual adjuster hydraulic brakes are wheel cylinder kit leak, wheel cylinder jam etc.

Hence to identify the various problems in the manual adjuster hydraulic brake system the researcher wants to collect the feed backs from the clients who manufacture the commercial vehicles and from the end users of the vehicles. In this study the researcher used descriptive and analytical type of research. The data from end users can be collected through the structured questionnaires given to end users or from the customers to whom the brakes are being supplied. The researcher can use both the primary data and secondary data for the analysis. The main scope of the study is to find out the issues in the manual adjuster brakes.

1.1 PROBLEM IDENTIFIED

The current system brake of light commercial vehicle running in the field has the complaint of frequent brake adjustment which leads to higher vehicle down time. Further the other problems in using this manual adjuster hydraulic brakes are wheel cylinder kit leak, wheel cylinder jam etc.

Due to lining wear of the brakes during usage, often the pedal bottoms up, while driving. The driver has to adjust all the wheel cylinders and make the pedal to come up. The boots may get damaged during adjustment, and it leads to dust and other impurities entering into the system and consequently leads to leak in system. Also as the brakes are operating at higher temperature especially in hilly regions, there is a possibility for the seals and boot to be damaged and may result in leak. Due to these leaks, the system failure can occur and it may lead to major fatal accidents.

1.2 NEED FOR THE STUDY

India opened its doors to the automobile companies from all parts of the world to revolutionize the Indian transportation scenario. The de-licensing of the industry twenty years ago allowed many multinational automobile companies to penetrate the market, making it a highly competitive and beneficial market for the consumers. Over the years, several companies have established their production units in the country, offering a wide range of automobiles to the vast population.

India is one of the biggest automobile hubs in South East Asia catering to the automobile needs of India, China, Sri Lanka, Nepal, Thailand etc. The commercial vehicle segment of the Indian automobile industry has shown great recovery after fending off the effects of the global economic crisis. The most profitable and quickly growing segments have been goods and passenger carriers. This can be attributed to the rapid expansion of cities and suburban areas, which is expected to continue in future as well. The projected growth rate is at 14.5% for 2011 – 2012.

Brake system is one of the safety critical parameter in the commercial vehicle. Reducing the downtime of the commercial vehicle will help improving the profitability of the customer. Complaints in brakes will make the vehicle to stop completely causing loss to customer and consequently customer dissatisfaction. More over the transportation of good and services will affect resulting in the customer losing business as well. The current brake system running in the light commercial vehicles have complaints like frequent brake adjustment, kit leak, boot damage and system failure. This study will help the company to know the advantages and disadvantages of current brake system in light commercial vehicles.

I. Identify the possible areas of improvement and suggesting improvement methods / new concepts to satisfy the customer needs keep the competition at bay and improve the business.
II. Help in finding out the issues in the manual adjuster brakes and suggest a possible solution to overcome the same.
III. By doing so, not only we can solve the problems in the existing products, we can also bring about satisfaction to customers, eventually leading to a platform for customer retention, attracting new customers and increasing the profit margin of the company.
IV. Based on the study, researcher can suggest suitable solution / alternatives to reduce / eliminate the cause of issues.

2.0 OBJECTIVES & SCOPE OF THE STUDY

2.1 Primary objective

The primary objective is to identify and analyze the risks in the brake systems for light commercial vehicles .

2.2 Secondary objective

a) The secondary objective of the study is to find out the root cause for the problems in the current manual adjuster brake systems.
b) To find out the impact of the problems.

3.0 RESEARCH METHODOLOGY

3.1 Type of Research design

Research design is the basic frame work which provides guidelines for whole research methodology. The researcher has used descriptive type research. Descriptive research includes surveys and fact-finding enquiries of different kinds.

3.2 Sources of data

Both primary and secondary data are to be collected. Primary data is collected directly from the field by distributing standard questionnaire for understanding the customer feedback about the current brake system.

Secondary data was collected from previous literature .

3.3 Sampling Design

The procedure of selecting people for taking part in answering the questionnaire is based on simple random sampling method.

The respondents for the study are the end users of light commercial vehicles..

In case of end users the study is restricted to Ernakulum and Kottayam district in Kerala.

3.4 Sample Size

Total of 600 Light commercial vehicle owners from two districts were approached by the researcher for the survey.

120 Respondents were selected from the total 600 vehicles and fixed as the sample size for the research work conducted.

3.5 Tools for Data Collection

Questionnaire is used for collecting the data. This questionnaire method is also known as survey method. The questions are of form open ended and close ended.

3.6 Tools for Analysis

Different type of analysis for studying the hypothesis of this research has been used as following:

- Percentage Analysis
- Cause and effect diagram
- Weighted average method
- Chi-square Test
- Pareto chart
- QFD process

4. DATA ANALYSIS AND INTERPRETATION

4.1 Percentage Analysis

Sl.no	Response	No of respondents	(%)
1	yes	90	75
2	No	30	25

Table 4.1.1. Response of customer towards problem in brakes

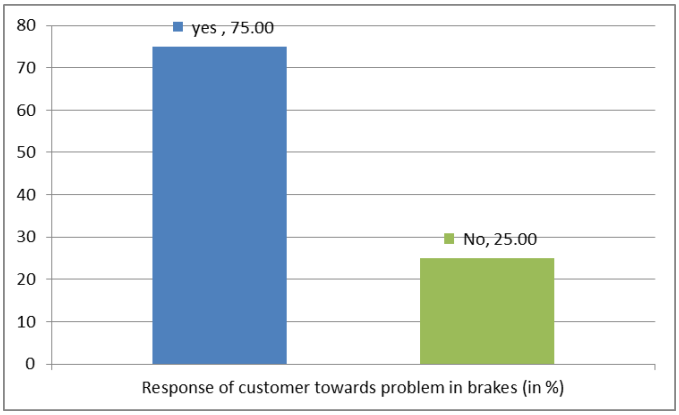


Figure 4.1.1 Response of customer towards problem in brakes

INTERPATATION: From the above chart and table, it was inferred that majority (75%) of the customers faced problems in the brakes followed by 25% responded that they does not face any problems in the brakes

s.no	Opinion	No of respondents	Percentage (%)
1	yes	30	25
2	No	90	75

Table 4.1.2 Opinion of customer towards quality of current brake system

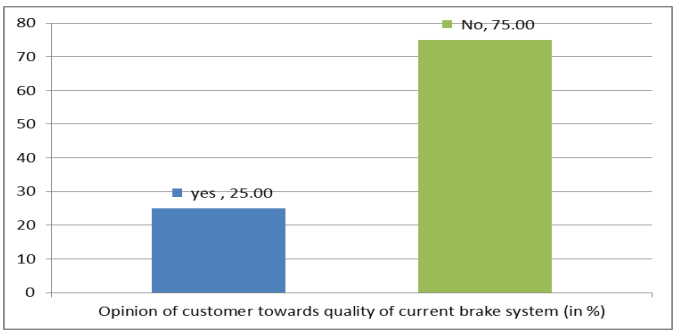


Figure 4.1.2 Opinion of customer towards quality of current brake system

INTERPATATION: From the above chart and table , it was inferred that majority (75%) of the customers were not satisfied with the quality of brake systems Only 25% of the customers are satisfied with the Quality of brake systems .

Sl.no	Opinion	No of respondents	Percentage (%)
1	15 min	30	25
2	15-30 min	70	58.33
3	30-45 min	10	8.33
4	> 45 min	10	8.33

Table 4.1.3 Opinion of customer towards time taken for wheel cylinder adjustment

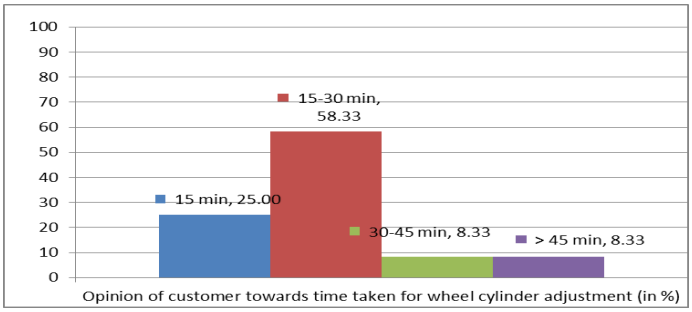


Figure 4.1.3 Opinion of customer towards time taken for wheel cylinder adjustment

INTERPATATION: From the above chart and table most (58%) of the customers responded that 15-30 min time would be taken for wheel cylinder adjustment followed by 25% of customers responded with 15min , 8% of customers with 30 - 45min and only 8% of customers responded that it took less than 45 minutes for wheel cylinder adjustment.

Sl.no	Response	No of respondents	Percentage (%)
1	3-5 stops	10	8.33
2	5-8 stops	60	50
3	8-10 stops	40	33.33
4	> 10 stops	10	8.33
	Total	120	

Table 4.1.4 Response of customers towards brake application (approx) per km

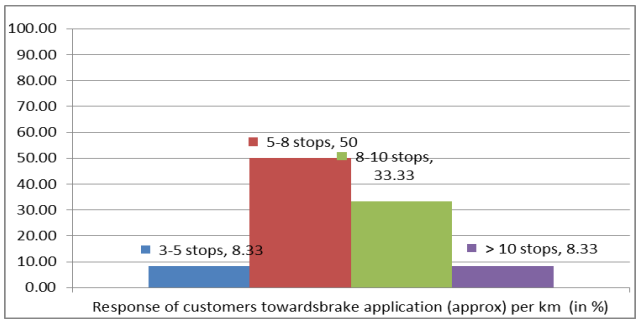


Figure 4.1.4 Response of customers towards brake application (approx) per km

INTERPATATION: From the above chart and table most (50%) of the customers responded that 5-8 stops per km followed by 8% of customers with 3-5 stops , 8% of customers with 8-10 stops and 8% of customers with >10 stops.

Sl.no	Response	No of respondents	Percentage (%)
1	Highways	20	16.7
2	city roads	20	16.7
3	hilly areas	15	12.5
4	all type of roads	65	54.2

Table 4.1.5 Response of customers about the vehicle plying roads

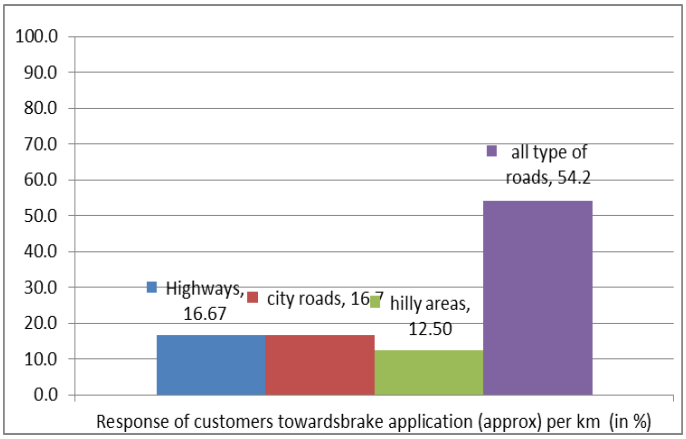


Figure 4.1.5 Response of customers about the vehicle plying roads

INTERPATATION: From the above chart and table most (54%) of the customers responded that they used all type of road followed by 17% of highways, 17% of city roads and 12% of hilly areas.

Sl.no	Response	No of respondents	Percentage (%)
1	100- 200 km	10	8.33
2	200-300 km	20	16.67
3	300-400 km	20	16.67
4	400 - 500 km	60	50.00
5	> 500 km	10	8.33

Table 4.1.6 Response of customer towards the wheel cylinder adjustment interval

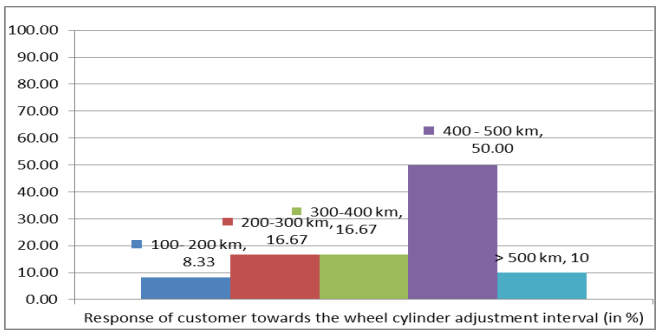


Figure 4.1.6 Response of customer towards the wheel cylinder adjustment interval

INTERPATATION: From the above chart and table most (50%) of the customers responded that they frequently adjusted the wheel cylinder once in 400-500 km

4.2 CAUSE AND EFFECT DIAGRAM

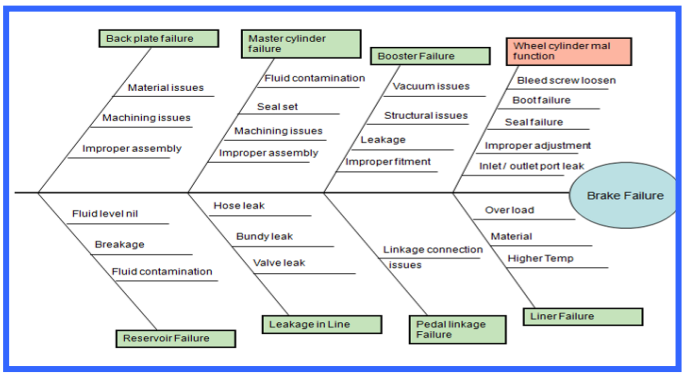


Figure 4.2.1 CAUSES OF BRAKE FAILURE

INFERENCE: From the cause and effect diagram we inferred the root causes for the brake failure and the effects for the same.

4.3 PARETO CHART

Sl.no	Nature of Failure	Respondents	Percentage (%)
1	Brake Failure	78	65
2	Clutch Failure	26	21.67
3	Accelerator Failure	10	8.33
4	Engine Problem	6	5

Table 4.3.1 Response of customers towards the brake failure in the vehicle

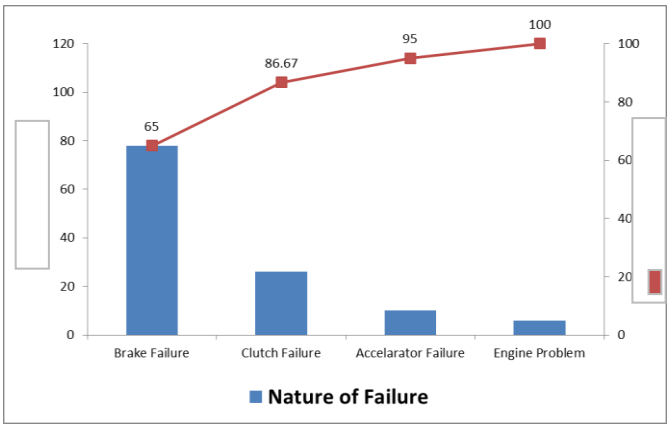
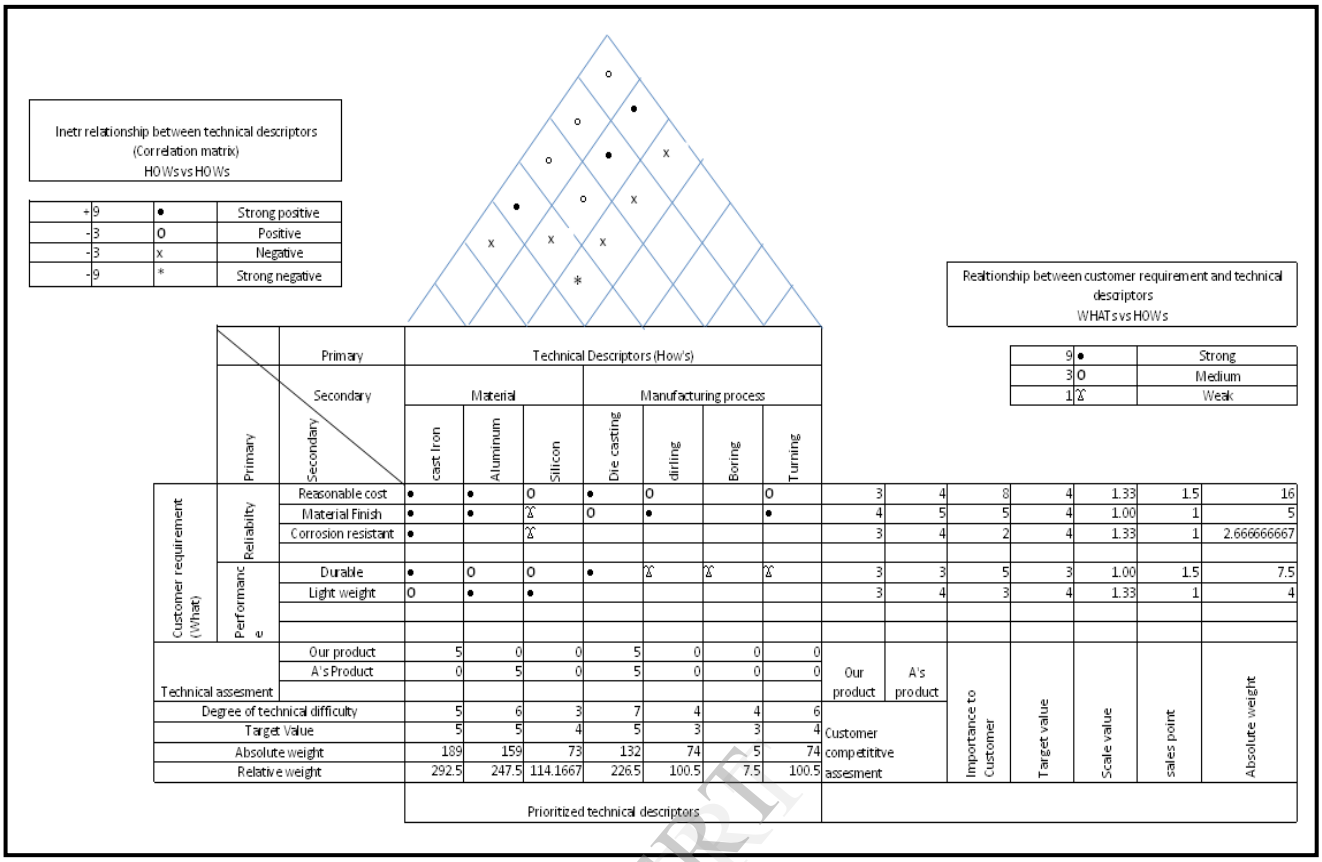


Figure 4.3.1 Response of customers towards the brake failure in the vehicle

INFERENCE: From the Pareto analysis it was inferred that the major problems in the vehicle was brake failure and clutch failure (It accounts together 87%). If more effective measure to be taken to eliminate this then the majority of problems will be solved.

4.4 QFD Chart:



Inetr relationship between technical descriptors
(Correlation matrix)
HOWs vs HOWs

+9	•	Strong positive
-3	o	Positive
-3	x	Negative
-9	*	Strong negative

Realtionship between customer requirement and technical descriptors
WHATs vs HOWs

9	•	Strong
3	o	Medium
1	▽	Weak

Primary	Secondary	Technical Descriptors (How's)													
		Material			Manufacturing process										
		cast iron	Aluminum	Silicon	Die casting	drilling	Boring	Turning							
Customer requirement (What)	Reliability: Reasonable cost	•	•	o	•	o		o	3	4	8	4	1.33	1.5	16
	Reliability: Material Finish	•	•	▽	o	•		•	4	5	5	4	1.00	1	5
	Reliability: Corrosion resistant	•		▽					3	4	2	4	1.33	1	2.666666667
	Performance: Durable	•	o	o	•	▽	▽	▽	3	3	5	3	1.00	1.5	7.5
	Performance: Light weight	o	•	•					3	4	3	4	1.33	1	4
Technical assesment	Our product	5	0	0	5	0	0	0	Our product	A's product	Importance to Customer	Target value	Scale value	sales point	Absolute weight
	A's Product	0	5	0	5	0	0	0							
Degree of technical difficulty		5	6	3	7	4	4	6	Customer competitive assesment						
Target Value		5	5	4	5	3	3	4							
Absolute weight		189	159	73	132	74	5	74							
Relative weight		292.5	247.5	114.1667	226.5	100.5	7.5	100.5							
Prioritized technical descriptors															

INFERENCE: From this QFD chart we inferred that the customer requirements, and enables the design phase to concentrate on customer requirements thereby spending less time on redesign and modification. Higher the absolute and relative ratings identify the areas where the engineering efforts need to be concentrated.

5.0 FINDINGS FROM VARIOUS SQC TECHNIQUES

- From the study it was identified that most of the respondents faced problem in the brake system used in the light commercial vehicles.
- Most of the customers were not satisfied with the quality and performance of the current brake system in the light commercial vehicles.
- The study reveals various problems in light commercial vehicle brake system and some of the main problems are wheel cylinder adjustment pedal travel, seal failure and boot failure.
- From the study it was found that many customers find it very difficult to adjust the wheel cylinder due to no better accessibility. It takes more time for the customers to do the wheel cylinder adjustment.
- It was found that many customers faced the problem of pedal going down followed by seal failure and boot failure.
- The study reveals that many customers does not follow the maintenance schedule of the vehicle.

6.0 CONCLUSION

This study shows that the light commercial vehicle manufacturers should design and develop the new self-adjusted brake system which will deliver the following benefits to customers. The self-adjusted brake will deliver better quality and performance in the brake system of light commercial vehicles. This new system will satisfy the customer needs which will improve the customer satisfaction level higher.

7.0 REFERENCE

[1] Hank Seiff, "Heavy Truck Brake Adjustment-Problems and Solutions" ATA Foundation, Trucking Research Institute, USA, Journal of Truck safety, - Volume 1, April 1992; Page no 575

[2].Michael Knowles "Through life Management of electrical vehicles "2nd International Through-life Engineering Services Conference, Elsevier, Science direct November 2013 , Procedia CIRP 11 (2013) 260 – 265

[3]Wang, L. and Zheng, H., "A Slip-Rate-Based Braking Force Distribution Algorithm for the Electronic Braking System of Combination Vehicle," SAE Technical Paper 2014-01-2385, 2014.

[4]H.Leffler, E.Peterson, B.Shilton "A New Anti-Lock-System (Abs) for Light Commercial Vehicles and Passenger Cars With Integrated Hydraulic Brake Booster" Paper No : 865140, 1987-02-01

[5] Richard L.Hoover, Scott B. Zaggrski, Air Disc and S-Cam Brake Stopping Performance Comparison for Class 8 Tractor and Trailer Combinations, SAE paper number 2005-01-3614