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Findings of Six Sigma "DMAIC Method" For Small Scale Manufacturer/Service Provider of Agricultural Equipment to Control the Defects: A Case Study for Jaipur Based Industry

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Abstract
Purpose: India is a farming country, Here Farmers need modern equipment for farming in optimum way. These equipment are generally produced by small scale industries located in local industrial areas. Most of the farming equipment needs lots of research for better working quality in agriculture fields. The main aim of this study is to apply the DMAIC approach on small scale manufacturer/ Service provider of Agricultural equipment to control the defects of equipment made by machining operations.
Research Methodology: In present study, the research methodology selected is based on two sections, in first section identify the main problem area of the industry which make the industry ill, then find the proper solution for the problem using DMAIC approach. Machining operations are one the most common problems faced by small industries because of the lack of modern machinery. Various DMAIC tools are used in this study like DOE technique "Taguchi Method:, Cause and Effect Diagram, Project Charter etc.
Research Findings: Research findings of the present study is defects control during manufacturing phase of the Agricultural equipment. Design of Experiment techniques are used to find the actual problems during manufacturing of the products and analysis of variance is also performed in this study which help to find the key factors for control the defects.
Limitations: Like other research studies, in present study some limitations are present, although in Agricultural equipment industries large range of equipment are produced but in present study top five selling products are selected for Six Sigma implementations with one assumption that this implementation help to improve all working conditions in industry.
Importance of present work: During literature review on six sigma and its advantages for small scale industries, Some issues covered by researchers. There is a lack for research work on Six sigma implementation in small scale industries, so this study is important go through for these type of industries.

Keywords: Six Sigma, DMAIC methodology, Small Scale Industries, Agricultural equipment, Case Study, Disk Harrow

1. INTRODUCTION

Six Sigma strategy application is broadly utilized after computational turn of events and in present time six sigma assume significant part for assembling and administration businesses. Six Sigma can lessen the different issues associated with typical businesses. So it is extremely normal benefit of the six sigma is the its application for an industry like assembling industry, administration industry, clinical focus, instructive area, NGO and numerous different areas. Six Sigma is best for recognizing the imperfections and issues which decline the presentation of the particular area. Whenever any industry need to carry out the Six Sigma a few focuses need to apply for the best aftereffect of the six Sigma. As a matter of first importance foster legitimate information base which help to apply six sigma in specific industry, Second apply Six Sigma rules in industry successfully. Third is audit the improvement the Six Sigma brings about specific industry. For Small Scale enterprises, these three focuses are more take care on the grounds that overall for limited scope businesses master of Six Sigma is exceptionally uncommon. There are different investigations accessible in which by applying the Six Sigma in limited scope ventures, the outcomes are powerful and creation and its connected time is constrained by engineers. This philosophy is best for associations that need to exploit the upsides of Six-Sigma without huge change in the affiliation.

For better execution of Six Sigma a few affirmations are accessible for master engineers like Green Belt, Black Belt and Mater Belt. These confirmations are help to apply Six Sigma in viable manner for any industry. These master accreditation help to finish Six Sigma rules in particular industry. Six Sigma has a few techniques for making legitimate review on any cycle or industry from this large number of strategies, DMAIC is most normal and successful strategy for Six Sigma application for any industry uncommonly any assembling industry. This approach is utilized for present review for resolve the clients objections of limited scope industry.

The aim of present study is to find the prime defects involved during making of the agricultural products in small scale industries. In this study simple cylindrical roads required for the agricultural products are investigated to control the defects during fabrication and assembly phase by using DMAIC approach of six sigma method. The study is conducted in Jaipur Region only specially small scale industries where Six Sigma implementation is not approved yet.

DMAIC approach is very promising technique to find the defects involved during production of any type of product or service. This method also helps to control the defects during the production phase. The detailed process steps required for DMAIC approach is present in figure 1. To successfully complete the study on DMAIC approach, proper literature is required so proper definition of the Six Sigma and DMAIC is collected from previous research studies. Major research papers selected for the present study is SCI category papers and the research methodology accepted for the literature review is shown in figure 2.

Steps required to Apply Six-Sigma “DMAIC” Approach

In agricultural works, instruments are required to complete all agricultural steps, one most important products is “Disc harrow” which required for preparation of the land for agricultural activities. In Disc harrow, one long cylindrical rod is required to attach the disc harrows as per load requirements.

In present study the defects identified in this cylindrical rods and then investigated to control the defects

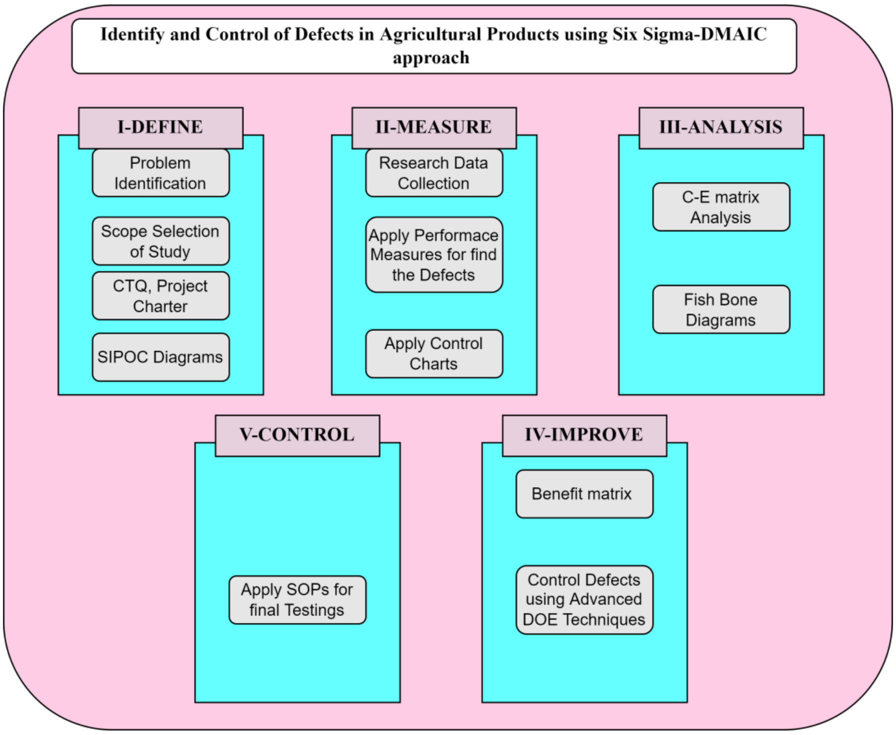

Figure 1 DMAIC approach implementation tools required for research work

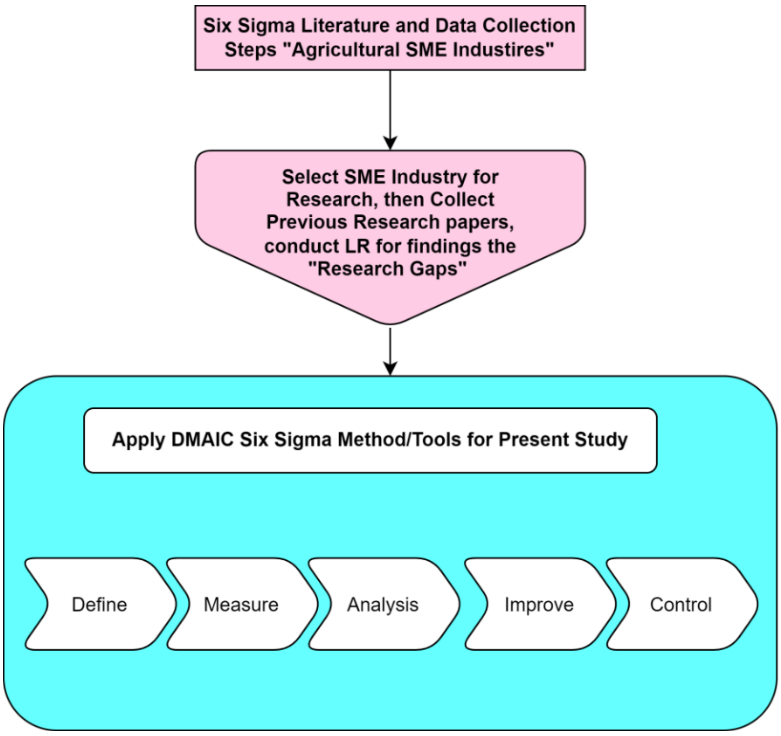

Figure 2 Full Steps required for finding the Research Gap

To control the defects DMAIC approach is selected for the present investigation and detailed steps required for this DMAIC approach is present in figure 1. The reference image of the disk harrow is shown in figure 3.

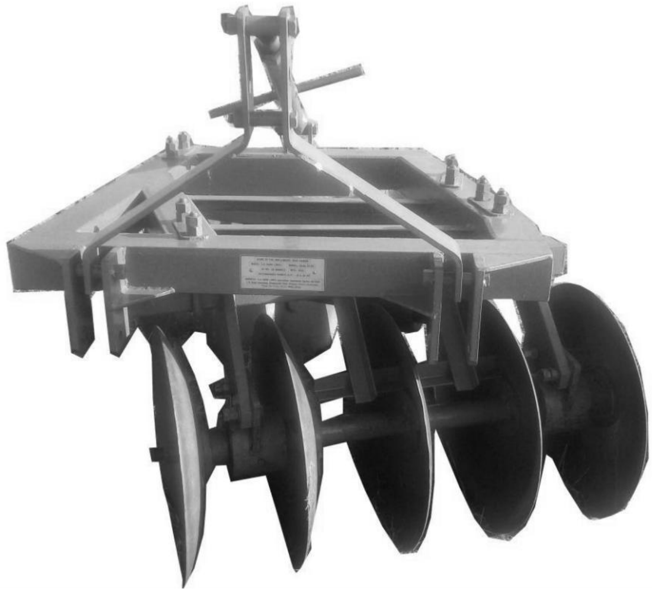

Figure 3 Reference Disk Harrow [Source: S.K. Agro Links, Agriculture Implements Spares and Tools]

In next section of this research work is discussion of the all required DMAIC method which is present here.

2 ILLUSTRATIONS

As shown in figure 1, in define phase scope of the research work is selected using project charter method. In this step proper project charter is developed for one small scale industry which work in Jaipur Region. This industry has staff below 50 so categorized as small scale industry. In present industry, various agricultural instruments are required to made using cylindrical rods. These cylindrical rods are purchased directly from vendors. Some time defects present in these rods makes the final component defective, and company face various issues from customers. So proper scope selection is required for present study. The final project charter developed for present study is list out in table 1.

Table 1 Project Charter for present study on "Agricultural SME Industries"

Project :Identify and control of defects in agricultural products using DMAIC approach		
Research Location:Small Scale Industry located in Jaipur Region, which assembled and manufactured the "Disk harrow" product		
Problem Identification	**Project-Scope**	**Scope-Exclusion**
Defects in cylindrical rods required for Disk harrow products, then control these defects using Six Sigma methods.	Identify and control of defects in cylindrical rods	Full products components are not involved rather than Disk Harrow
Aim/Goal of the Study	**Time Line of the Project**	
Identify the defects in Disk harrow product, and apply Six Sigma tools to control these defects	**D**efine	Three Month whole Cycle
	Measure	
	Analysis	
	Control	

Advantages to Industry	**Advantages to Customer (farmers)**
Make profitability improvement and customer satisfaction with company	Product quality improvement make more selling options among customers
Research Plan	**Stake Holders**
Six Sigma -DMAIC method	Company Owner, Plant manager, Workers
	MTech Candidate, Research Guide
	Vendors, farmers

SIPOC diagram helps to find the all stake holders involved in this research study, as seen in figure 4, the present SIPOC diagram helps researcher to conduct proper study by using DMAIC approach.

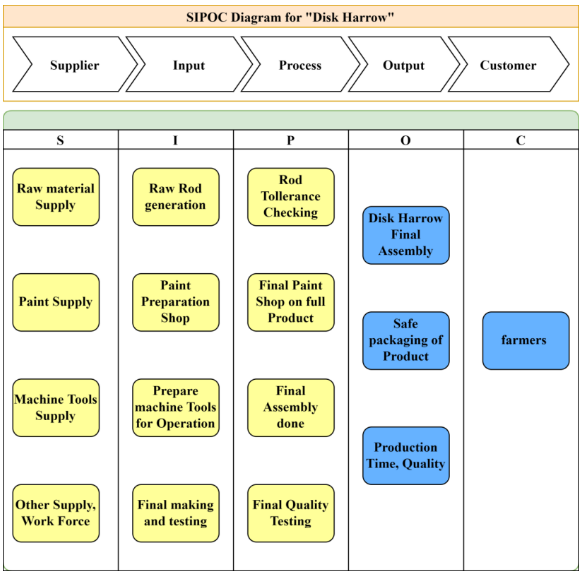

Figure 4 SIPOC diagram for Disk harrow Agricultural Product

Detailed making process of the disk harrow product is shown in figure 5, in which all main required steps are present.

To find the location of the defects in Disk harrow product, deep experience team is selected which help to find the actual defects locations in disk harrow product. The locations of the defects in disk harrow is present in table 2.

Table 2 Locations of Defects in Disk harrow

Designation	**Full terms**
DH01	Nut Bolt Assembly Locations (General)
DH02	**Steel Rods, bars, Disk**
DH03	Paint on Body
DH04	**Welding Locations**
DH05	**Assembly locations with Tractor**
DH06	Disk Assembly Locations

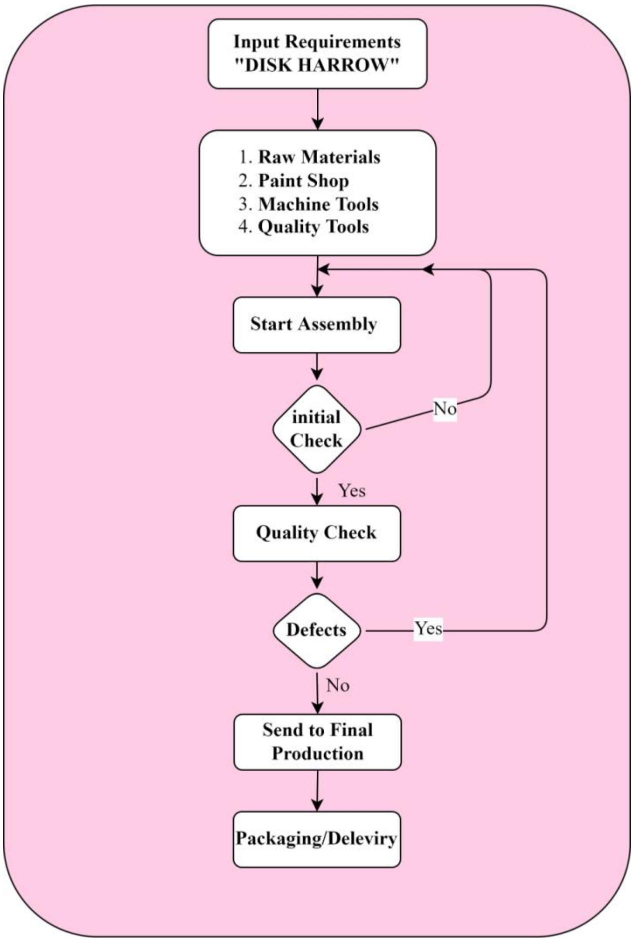

Figure 5 making process of Disk harrow Agricultural Product

III-MEASUREMENTS

In define stage, all important information required for research study is gathered, specially project charter helps to find the proper data required for study. In Define stage, locations of the defects are identified which help to find the main causes and effects of the defects using DEMETAL approach. Total six locations are identified from which three defects locations are main causes for the Disk harrow product which are following as per table 3.

Table 3Classification of Defects Into Cause and Effect Groups (Disk harrow)

Ri	Ci	Ri + Ci	Ri - Ci	C and E
3.367	3.375	6.743	-0.008	Effect
3.104	**2.721**	**5.825**	**0.384**	**Cause**
2.923	3.577	6.500	-0.654	Effect
4.169	**4.120**	**8.289**	**0.049**	**Cause**
3.920	**2.963**	**6.883**	**0.957**	**Cause**
2.616	3.344	5.960	-0.727	Effect

As seen in table 3 total three causes are identified which can make defects in final product of disk harrow, The three final causes are following:

Steel Rods, bars, Disk required for making final product (Disk harrow)

Welding Joints required to assemble the Disk harrow
Assembly location with Tractor.

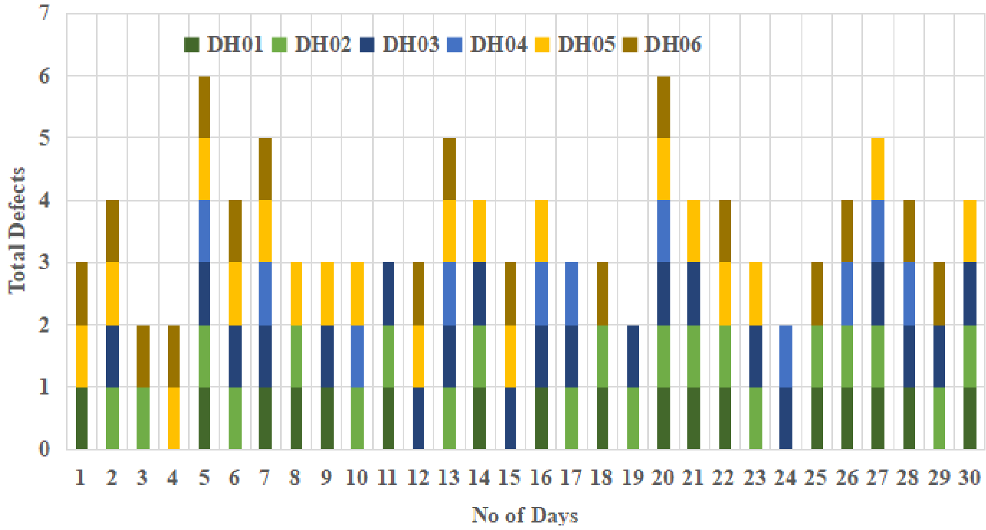

Figure 6 Total Defect identified for Disk harrow agricultural product

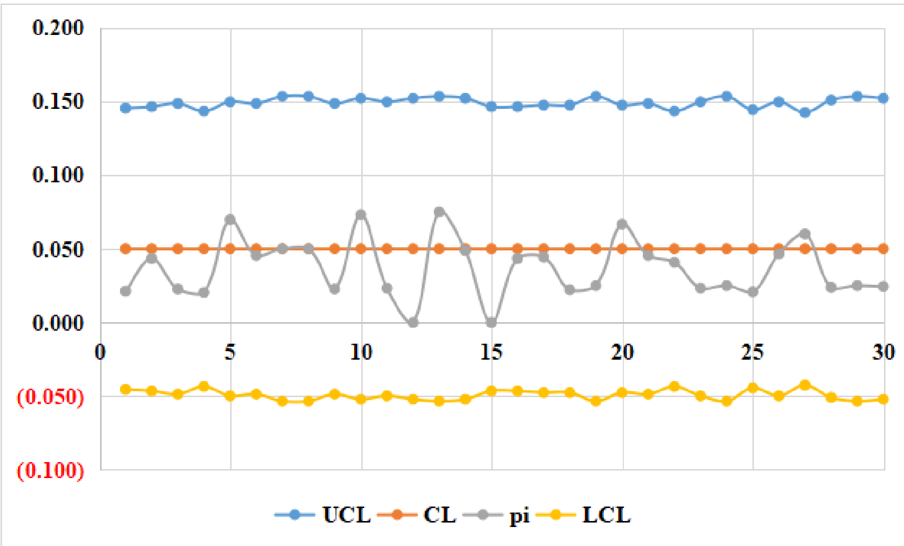

Figure 7 P chart analysis as per sample collections

The formula requirement for calculation of P chart parameters are solved by using these formulas which are following:

$$UCL_i = \bar{p} + \sqrt[3]{\frac{\bar{p}(1-\bar{p})}{n_i}}$$

$$LCL_i = \bar{p} - \sqrt[3]{\frac{\bar{p}(1-\bar{p})}{n_i}}$$

P chart analysis is solved for present study and results are shown in figure 7, as per P chart analysis the UCL is 0.149 and LCL is -0.049 for present sample of the data.

III-ANALYSIS

Analysis phase help to find the most critical defects parameters ,as seen in previous sections three causes are identified from which two most critical parameters are identified in this phase, first most critical cause is " Rod, bars and Disk required for Disk harrow" and second critical parameter is " assembled of joints with tractor". These two causes are identified and then required to control by using control phase available in DMAIC approach. Cause an effect matrix analysis is present in table 4 for critical causes.

Table 4 C and E matrix analysis for Disk harrow product

No	Rating of Importance to Customer						Total	% of total
			8	6	6	9		
	Process Setup	Process Input	Product looking	Safely Packaging	Time Control	Product Quality		
1	Setup	**Raw Materials Collections**	9	6	3	3	**153**	10.74
2	Setup	Assembly Preparations	1	6	3	3	89	6.25
3	Setup	**Components Assembly**	3	3	9	9	**177**	**12.43**
4	Setup	Cross check Assembled Product	1	1	9	5	113	7.94
5	Apply	Testing-Initial	5	3	5	3	115	8.08
6	Apply	Testing-Final	1	9	3	3	107	7.51
7	Apply	Reproduction-Disk Harrow	3	3	5	1	81	5.69
8	Apply	**Assembly-Reproductions**	1	6	9	5	**143**	**10.04**
9	Apply	**Paint-Reproduction**	1	1	3	9	**113**	**7.94**
10	Apply	Size Verification	5	1	1	3	79	5.55
12	Apply	**Final Quality Testing**	1	3	3	5	**89**	**6.25**
13	Apply	Wear and Corrosion testing	0	1	5	9	117	8.22
							1376	

IV-IMPROVEMENTS

After analysis phase, its time to improve the production quality, so Improve phase is required. In this step Improvement is done for making process of Disk harrow product. On the basis of C and E matrix, total five causes are required and these five causes are following:

Defects present in raw materials purchased by Vendors, in most of the cases steel rods and bars are purchased from outside, so various defects related to geometrical issues are present, so this is the most critical issues related with this industry.

Another defect is shown when assembly is done for whole components, the defects is present due to manual labor works and less automation available in industry

Some times reproduction is required but only resolve this issue by using reproduction in assembly process.

Some defects are occur due to improper paint completed on the Disk harrow, so reproduction is required to complete this defect

Some defects are shown when final quality testing is done and customers find these defects

All these defects are resolved by using proper management and development of techniques like Quality testing is performed by professional engineers not the operators rank diploma holders. After applying all improvement measures

IV-CONTROL

In control phase all defects are controlled by implemented it in the industry and total 40% defects are controlled during production phase, only the thing required to do is that the vendors replacement is required for this industry to control the defects available in components used for Disk harrow production. Total defects reductions is present in figure 8, which justify the importance of Six Sigma DMAIC method for Agricultural SME Industries.

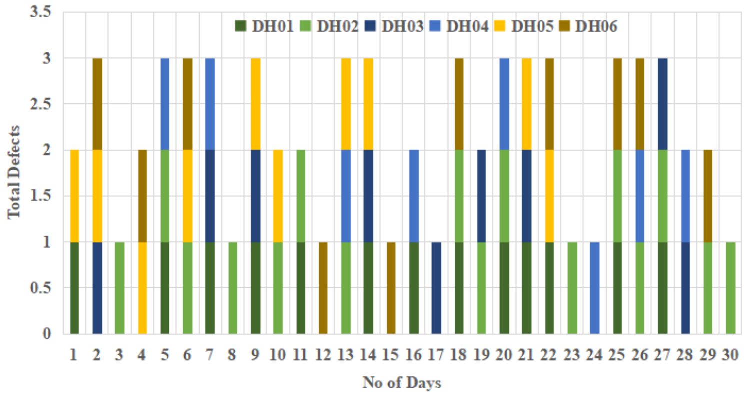

Figure 8 Defects after implementation of DMAIC approach

The control phase is the last step which required to complete the DAMIC technique. In present study measure step is done by only visual analysis, DOE can be used for finding the defects with experiments for better control phase for Disk harrow production quality. Total defects identified before implementation of DMAIC method are equal to 107 for 30 days sample method. But as the DMAIC method is adopted by industry the defects are controlled and reduce to approx 40% and at current condition total defects are equal to 66.

V.CONCLUSION

In present study application of Six Sigma DMAIC method is studied for Agricultural equipment manufacturing SME industry. This study research area is Jaipur Region only. The product which selected for this study is "Disk Harrow". Project charter is developed for present study. Total six

Defects are identified from which three are selected as causes which are following: Raw materials purchased from Vendors (Rod, Bars, Disk), Welding Joints an last defect location is Assembly location with Tractor. These three locations are the major contribution of the Causes of defects. In this Stud DMAIC approach is used to control the defects. Before DMAIC method total 107 defects are identified in 30 days sampling method. After implementation of DMAIC method defects are reduced to 66 which is approx 40% improvement in product quality.

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