Process Improvement in a Plastic Manufacturing Industry using Six Sigma Tools

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Abstract

Improvements are required in any industry to increase the productivity by decreasing the defects in any process and also remove the overall waste produced during any production inside the manufacturing facility. There are many process improvements techniques available for identify the problem causing factors for defects and one of the most famous techniques is Six Sigma technique which is widely used to identify the real problem causing factors by use of different tools such as DMAIC which is nothing but Define, Measure, Analyze, Improve and Control. In this particular plastic manufacturing industry, the main problem was time required for tool change over was very large which result in long waiting time for production as different dies and mold where required for production of fuel tanks. The real reason behind delay in tool or die changeover was required to be found as the overall production was decreasing which resulted in lot of customer unsatisfaction and also company could not reach its daily production targets. By use of Six Sigma tools main aim is to find factors causing time delay in tool and dies change over and to find factors which will solve the problem in analyze phase. It was identified that by SMED i.e. Single Minute Exchange of Dies technology can be used to improve total time required for tools, dies and molds changeover which will increase efficiency by 50%. In the process of Six Sigma tools used in define phase are project charter and SIPOC then cause and effect diagram, pareto chart, and brainstorming tools are used in measure phase, in analyze phase run chart and process capability analysis is used and in improve phase by use of run chart and process capability analysis it is made sure that process is really improved.

Keywords: Process Improvement, Changeover time, Six Sigma, DMAIC process, SMED.

1. Introduction

Six Sigma is always used by many companies and many case studies are available in the literature, e.g. Motorola, General Electric, Honeywell, AlliedSignal, Raytheon, and Delphi Automotive have implemented Six Sigma programs (Treichler, et al., 2002). Six Sigma is a tool which helps to improve the productivity by identifying the waste and removing them in improve phase which helps to increase the overall efficiency of the production and also customer satisfaction in a great way. Any industries they are more interested to remove the waste which causes more inventory and huge investments and also high level of customer satisfaction by use of six sigma tools the root causes are found and they are removed to increase the overall efficiency and customer satisfaction. Six Sigma helps to improve the quality of the product by identifying the defects and after that removing the defects which helps to achieve target of 3.4 defects per million opportunities. The other main motive of using six sigma study is to decrease overall product cycle time and also to increase production rate of the industry. Tools, molds and dies are the most important factor in an any plastic manufacturing industry. In this particular industry different tools and different molds are used as per the requirement for the tanks. The main issue was in the process of tools, molds changeover it used to consume lot of time to do changeover which resulted in loss of customers as target deliver was not at all achieved. In this six-sigma study for process improvement for tool change over it was identified that technology of SMED Single Minute Exchange of Dies can be used to reduce tool changeover time. In this all the tools, molds which are required to be change is targeted to be changed not more than ten minutes or in a single minute, after identifying this in improve phase 5s was implemented for tool by designing a tool chart which will be easier for anyone to change the tool. This helped to reduce the time of tool change over as now it was really very easy to identify different tools and target of single minute tool changeover was achieved. The data was observed and recorded for couple of weeks of each and every process and then all data was examined by using pareto chart, run chart, process capability analysis, cause and effect diagram in Six Sigma implementation.

2. Literature Review

Six Sigma is a well-structured method that helps organizations to reach their goals because of its activity as a problem-solving method (Jirasukprasert, et al., 2014). The investigation talks about the use of the Six Sigma method at home appliance business organization in Egypt. This article is the Six Sigma DMAIC method (define, measurement, reasoning, Improve, and power) to consistently identify and determine the root cause (s) of defects and to provide a reliable solution to reduce/eliminate them. Six Sigma is equal to 3.4 defects per million opportunities (DPMO) (Oakland, 2003). This investigation of Six Sigma (DMAIC) method and the statistical analysis (DOE and regression analysis) decided that this aluminum liquid metal temperature has a considerable effect on those defects' quantity of aluminum parts (Cherrafi, et al., 2016).

Define phase is the initial phase of six sigma where the exact problem is defined by the team so that it would be easy for them to understand on which problem they want to solve (Antony & Banuelas, 2002; Henderson & Evans, 2000). Form of the lean Six Sigma work is a vital part of any work, although it's frequently underestimated in training. This define stage of the define, method, analyze, change, control (DMAIC) operation typically includes three components. In Analyze phase the real causes of the problem is found by use of different tools (Tong, et al., 2004).

DMAIC method is very strong and has been successfully utilized by many organizations to make dramatic improvements. One of 6 sigma's typical approaches to problem-solving and transformation is measuring method investigation (Anthony&Banuelas, 2002) , which is important for organizations as it allows to measure, monitor and evaluate the performance in a continuous manner. However, in order to secure successful information analyses, in all levels and operations, efficient information gathering procedures are essential (Sagnak&Kazancoglu, 2016). The manufacturing industry is a fast-growing the rivalry is intense between the companies running in the part because of the increasing consumer demands (Seleem, et al., 2016).

Single time change of Die (SMED) is one of the more lean production methods for reducing material in the manufacturing operation. It offers a fast and effective means of converting the manufacturing process from working the new product to running the next product. The fast changeover is important to reducing production lot sizes and thereby improving flow which is the 'Lean' goal. It is likewise frequently related to as Quick Changeover (QCO) by Johansen, Mcguire & Kenneth (1986). Performing faster change-overs is critical in manufacturing, or any activity, because they get low price flexible processes possible. In March 1999, Bel-Ron a producer of engineered chain products, hosted SMED software to maintain these profits and make development going forward. These mini-Kaizen tasks were used to continually strengthen the rules of lean and prove to the workforce that Bel-Ron was important about using the way to change the business. The benefits attained after the implementation of SMED at these product levels were significant. (Feld 2001)

3. Problem Statement

The main issue with this plastic manufacturing industry is there is a lot of delay in the operation to changeover of mols, tools and dies which causes delay in manufacturing of the fuel tanks by blow molding process. The expected manufacture fuel tanks where 16 in one shift and changeover takes place four times now as changeover used to take more time the present manufactured tanks are total 8. Therefore, main purpose of this project is to implement six sigma tools in this plastic manufacturing industry which will find the real reason for delay in changeover time and after this to find a solution for this problem in improve phase will eliminate the problem of changeover time which will help to improve overall fuel tank manufacturing of this industry. By eliminating this problem overall manufacturing efficiency of this industry will also increase.

4. Tools Used

Below is the table describing what exactly are the tools used in this six sigma project in different steps, there are many different tools available in each six sigma phases to choose which one to be used depend upon various factors such as what exactly we have to find, how we need to collect the data and after collection of data how are we going to examine the obtained in analyze phase. For this project we have used tools in different phases such as project charter, SIPOC, fishbone diagram, charts, process capability analysis.

	Define	Measure	Analyze	Improve	Control
Tools Used	1. Project Charter	1. Pareto Chart	1. Run Chart	1. Kaizen	1. Confidence Interval 2. Capability analysis
	2.SIPOC	2. Fishbone Diagram	2.Process Capability analysis	2. Process Capability Analysis	
		3. Data Collection			

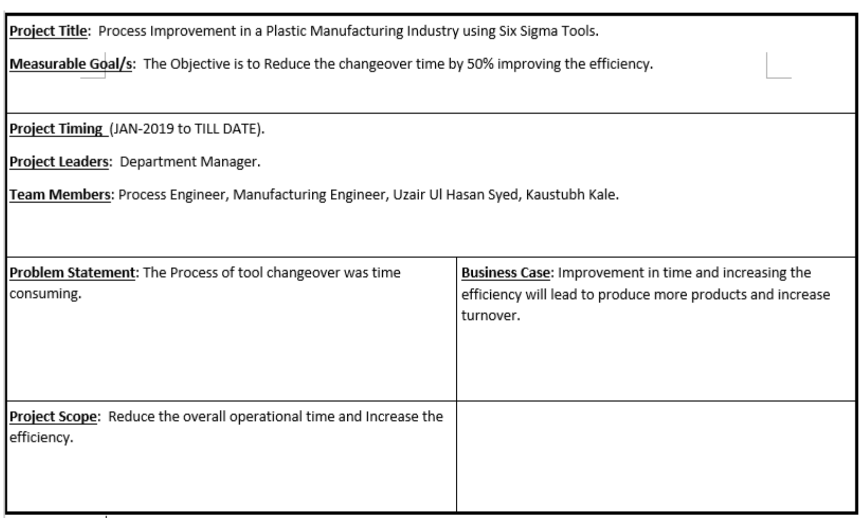
Table 1: Tools used

5. DMAIC Process

5.1 Define

This is the initial stage in DMAIC process where the real problem statement is defined by the six-sigma team where clear idea is given to the team of where exactly the problem is and at which point, they have to focus for the improvement. In define phase the real problem area is defined by the team which helps to give clear idea where exactly the problem is occurred, in this project by use of Project charter and SIPOC it is defined that main objective is to reduce the changeover time of tools and dies by 50% which will help to improve the overall efficiency of this Plastic manufacturing industry.

Project Charter. Project charter is the tool used in define phase which generally contains the basic outline information of who are involved in the overall project from the management, what is the goal of the project to be achieved by applying Six Sigma tools, project charter also defines how much is the total time frame of the project so that target is set by the management which will help them to achieve the target in time frame. It also defines what is the over all project scope which shows what are the constrains a dimension of the project and at the end what will be achieved by implementing six-sigma.



Project Title: Process Improvement in a Plastic Manufacturing Industry using Six Sigma Tools.

Measurable Goal/s: The Objective is to Reduce the changeover time by 50% improving the efficiency.

Project Timing (JAN-2019 to TILL DATE).

Project Leaders: Department Manager.

Team Members: Process Engineer, Manufacturing Engineer, Uzair Ul Hasan Syed, Kaustubh Kale.

Problem Statement: The Process of tool changeover was time consuming.	Business Case: Improvement in time and increasing the efficiency will lead to produce more products and increase turnover.
Project Scope: Reduce the overall operational time and Increase the efficiency.	

Figure 2: Project Charter

The project is being conducted in ABC plastic manufacturing industry in production process of fuel tanks where process of injection molding is performed for the manufacturing of tank. The main goal of the project is implementing six-sigma tools for process improvement in manufacturing of tanks by identifying the problem causing factors and then finding solutions to the problem. The main objective defined in project charter is to reduce the tool, mold change over time which will help to improve overall efficiency of the manufacturing unit. This Project mainly focusses on identifying the root causes of the defects in products and to improve the process and product quality by applying six sigma methodology and using the various six sigma tools available. The team members involved in this project are Dr Ahad Ali, Process engineer, Manufacturing Engineer, Uzair Ul Hasan Syed, Kaustubh Kale. This project has been started on January 2019 and will be commenced by May 2019. The detail scheduling of the project cycle is being mentioned in the project charter diagram and the various milestones of the projects was achieved within time. The project was divided into five phases as Define, Measure, Analyze, Improve and control as per six sigma approach of DMAIC.

SIPOC

SIPOC is a term which stands for Supplier, Inputs, Process, Outputs and Customer. The SIPOC tool helps us decide on the boundaries of the project and recognizes the stakeholders. Furthermore, this tool helps us identify the relevant elements of the project.

<table>
<tr><th>Supplier</th><th>Input</th><th>Process</th><th>Output</th><th>Customer</th></tr>
<tr><td rowspan="5">Design Department
↓
Engineering Department</td><td rowspan="5">Molten Plastic</td><td>Head Tool Change (Two Person)</td><td rowspan="5">Final Product</td><td rowspan="5">OEM'S</td></tr>
<tr><td>Mold Change (Two Person)</td></tr>
<tr><td>Spreader Pins & Pinch Plate</td></tr>
<tr><td>Pneumatic Connection</td></tr>
<tr><td>Hydraulic Connection</td></tr>
</table>

Figure 3: SIPOC Diagram

SIPOC is a very high-level map which gives over all idea of who are involved in this six-sigma project right from raw material to finished product, it basically defines who are the supplier, what exactly inputs need to be given to process manufacturing, what are the different steps in the whole process of manufacturing, what outcome is obtained by implementing the process and who are the final end customer which will have hold in the finished product. In this project from figure 2 in supplier section design department is defined as the major drawing is provided by the design team which have an overlook at all the factors of failure by use of high-end software's and after that engineering department is the next source which manufactures the job. In input section major input identified here is molten plastic as it is the most important factor in manufacturing of fuel tank in this plastic manufacturing industry. In Process section different processes are defined which are involved in changeover of tools, molds and dies for manufacturing different tanks. For the process of changeover whole assembly of injection molding machine is changed as every tank has different demand for different size mold, tools, plates. In this assembly changeover factors are head tool, mold, spreader pin, plate followed by pneumatic connection and then followed by hydraulic connection this is the over all changeover process which sometimes takes long time for changeover as compared to expected time. In next output section here after implementing all the changeover process the final outcome obtained is the final product which is fuel tank is defined in this section. In next section which is the final section customer who exactly the customer is defined in this section here in this project OEM's are the defined customer which will have be using the product which is manufactured in the industry. By listing this factors company can have an overall view of there project and also can identify what will be the outcome from application of six sigma tools.

5.2 Measure

The second phase of DMAIC is measure phase, this is the most important phase in six-sigma process as this phase give the overall idea of how at this moment the process is going, this phase has more numerical and data-oriented analysis as compared to define phase. This phase gives the real measurement of the present system and through that analysis of the system is obtained from variations obtained from the data. In this phase process validation is found by collecting the data that can be of any factor and then by this validation of data takes place where it is very easy to find if the obtained data is valid or not in measure phase.

Data was collected after it was identified that the real problem for delay in production was there is a lot of delay in tool, mold changeover time. In the process of blow molding for each different tank specification there are five fixed elements where are needed to be changed if tank manufactured specifications are different, blow mold consist of five different elements and they are Head tool, Pinch plate, Mold, Pin and final connection which made the whole blow mold assembly. Below figure 4 show the changeover items which are to be changed in the process of blow molding it consists of:

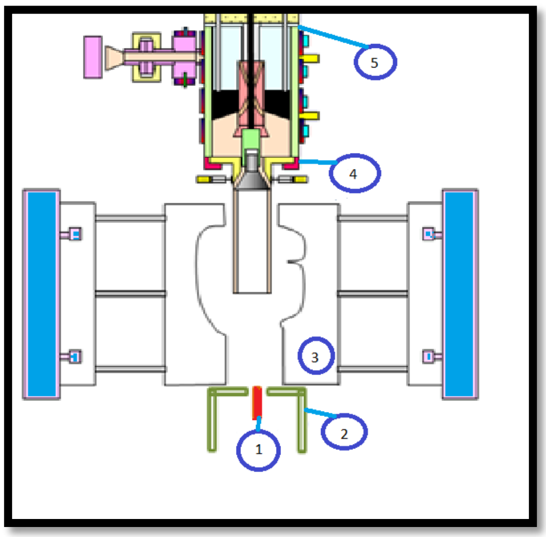


Figure 4: Changeover Items

1. Pins
2. Plate
3. Mold
4. Head Tool
5. Final Connection

The process of change over starts with head tool initially which is done by two people then the next item which is to be changed is mold which is carried out by same two people after head tool is changed, after all this process once mold is changed one person changes the pin and the plate. After completion of change over from head tool till plate then all the hydraulic connections are made and then at the end it is connected to the final connection. The process of changeover is started as soon as production of one type of tank manufacturing stops, then all this part is changed for the production of next assembly. Data was collected for 6 weeks and simple timer watch was taken for counting of the changeover time, for each different process individual time was recorded so that clear picture is obtained of which process takes how much time for the changeover. Timer for each activity starts as soon as the previous activity gets over.

Cause and Effect Diagram

This diagram is used to find what can be the reasons for creation of this problem, in this diagram we find the different causes for the problem which can be produced by man, machine, environment and many more. In this particular project the factors which can cause the problems are listed in the causes and their effect is there is a delay in changeover time which is more time consuming as compared to the required time.

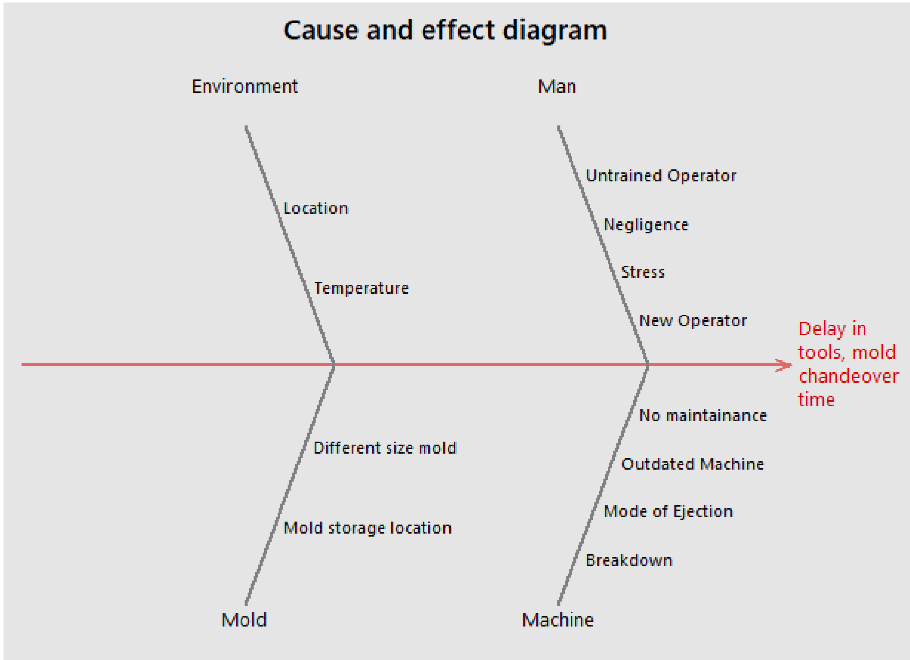


Figure 5: Cause and Effect Diagram

Data Collection

Data is collected of the existing changeover activities for further examination, this data is collected for 5 weeks of one shift the method used is of simple watch and for each different activity this data is collected. Below is the data collected for further analysis.

From figure 6 show the data collected for changeover of head tool, plate, pin, mold and final connection in total 50 count of data is collected and closely examined in further steps of DMAIC which will show where exactly the problem is occurred. For further analysis in measure phase after identifying the actual steps and process and also collecting the data the next step is this data is entered in pareto chart to analyze out of the collected data which factor causes maximum percentage of rejection.

Sr No change over	Different Activities time				
	Head Tool	Mold	Pinch Plate	Spreader Pin	Final Connection
1	45	33	15	8	7
2	40	31	14	8	7
3	39	38	8	6	7
4	38	33	7	8	8
5	56	32	7	7	6
6	44	35	7	8	9
7	43	37	10	4	8
8	52	47	14	6	6
9	40	33	10	6	7
10	55	30	12	5	8
11	42	36	11	7	7

12	**44**	**31**	**10**	**8**	**7**
13	**50**	**33**	**8**	**7**	**8**
14	**48**	**40**	**10**	**8**	**7**
15	**58**	**29**	**9**	**6**	**7**
16	**44**	**32**	**11**	**4**	**7**
17	**42**	**32**	**10**	**9**	**7**
18	**39**	**31**	**9**	**8**	**9**
19	**34**	**34**	**10**	**6**	**7**
20	**49**	**33**	**10**	**7**	**6**
21	**43**	**29**	**9**	**9**	**6**
22	**44**	**32**	**7**	**5**	**7**
23	**39**	**30**	**7**	**10**	**7**
24	**44**	**31**	**9**	**9**	**9**
25	**50**	**38**	**9**	**5**	**6**
26	**44**	**29**	**9**	**6**	**5**
27	**42**	**33**	**7**	**6**	**7**
28	**54**	**38**	**14**	**7**	**5**
29	**36**	**32**	**10**	**6**	**5**
30	**48**	**22**	**11**	**5**	**9**
31	**33**	**30**	**12**	**6**	**7**
32	**37**	**27**	**13**	**5**	**7**
33	**52**	**31**	**13**	**4**	**8**
34	**33**	**34**	**10**	**7**	**7**
35	**39**	**36**	**11**	**5**	**6**
36	**40**	**33**	**12**	**8**	**6**
37	**42**	**27**	**11**	**7**	**7**
38	**59**	**32**	**11**	**6**	**9**
39	**38**	**41**	**10**	**9**	**6**
40	**40**	**32**	**12**	**7**	**6**
41	**44**	**33**	**12**	**6**	**7**
42	**43**	**36**	**10**	**5**	**8**
43	**50**	**37**	**10**	**4**	**7**
44	**39**	**32**	**9**	**5**	**7**
45	**55**	**32**	**9**	**6**	**8**
46	**37**	**27**	**7**	**9**	**9**
47	**44**	**30**	**7**	**9**	**9**
48	**43**	**33**	**9**	**8**	**8**
49	**49**	**36**	**9**	**7**	**7**
50	**30**	**29**	**10**	**9**	**7**

Figure 6: Changeover Time

Pareto Chart

Pareto chart which is also know as 80-20 rule is nothing but 80% problems are caused due to 20% of the problems from over all system, by this chart it gives clear idea which factor could me a maximum defect causing factor out of the all reasons mentioned to cause a defect. In this project Pareto chart is use to identify which reason would cause maximum delay in changeover as it will be very easy to identify and focus on the only factor which will have improvement in changeover and maximum capacity of manufacturing of tank will increase.

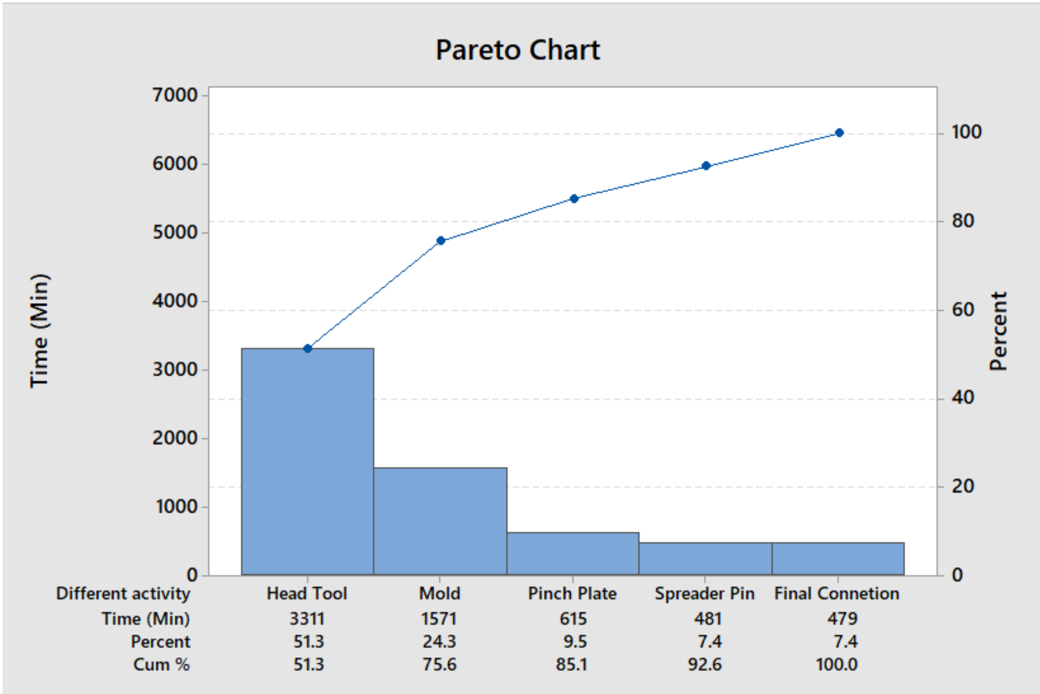


Figure 7: Pareto Chart

From the above figure 7 it shows which are the factors causes maximum defects and they are the factors for maximum defect cause in the overall process. From the graph it is clear that head tool changeover process has maximum percentage of defect with 51.3% delay in this tool changeover process causes more time delay in overall process. The next major factor identified from the graph which will cause defect is mold process it has 24.3% in the chart which shows blow molding process has consumed more time due to more time taken for mold changeover. From the chart it clearly shows that process of pin, plate and final connection does not cause major delay in process as they cause less defects in the process of changeover.

5.3 Analyze

Once the measurement phase has set the further measures, the information is then gathered and analyzed. At this point, it is possible to decide whether the question is reasonable or whether it is a random occurrence that does not have a particular reason that will be rectified. The information that has been gathered will be used as a basic point to analyze against measures after the work has been completed to determine the success of this program. In this phase all the data which is gathered is examined properly buy using run chart, process capability analysis, ANOVA and many more tools to see where exactly the problem is and helps to identify the real area of improvement. In order to identify the area of improvement all the data is put in run chart to identify where exactly the problem is going and how we can improve the process. In order to identify the area of improvement run charts are created for every activity and with that common cause of variation is found in which factors which are more out of the limit are taken into consideration for the improvement.

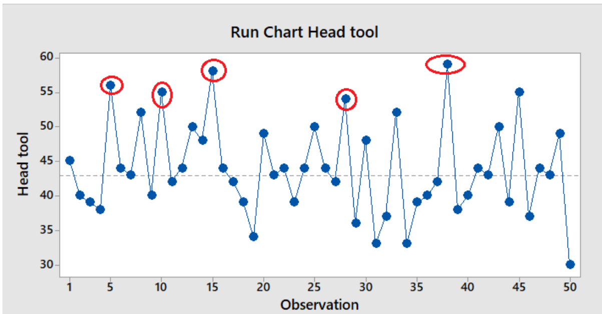


Figure 8: Run Chart Head Tool

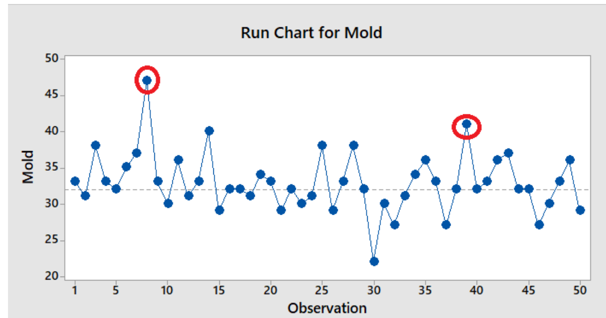


Figure 9: Run Chart Mold

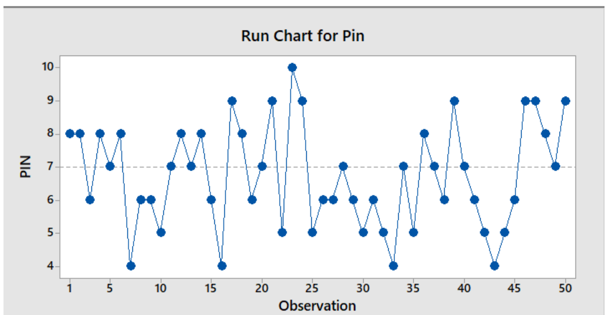


Figure 10: Run Chart Pin

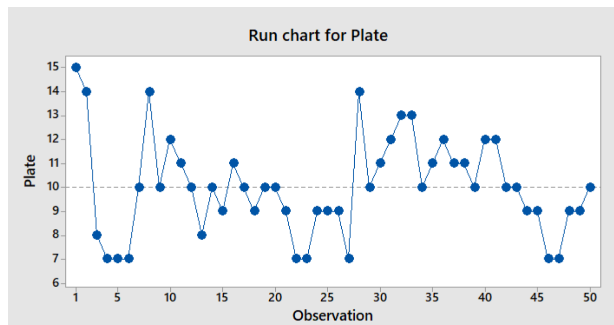


Figure 11: Run Chart Plate

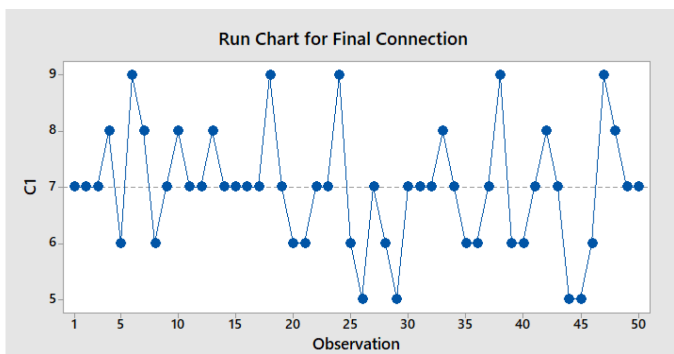


Figure 12: Run Chart Final Connection

Figure 8 is the run chart for head tool here basically the data which is collected of time for changeover is entered in run char to see how is the pattern of the data is it within the limits or it falls out of the limit. The upper specification and lower specification limit is 28 min and 50 min for head tool, it clear shows from the run char that at some instant the data is going out of the limit, it shows that sometime the head tool changeover time taken is 55 min up to 60 min which falls out of the desired limit. The next run chart which is of mold here it shows clearly that at many instants the data is out of the limit, the desired limit here is 18 minutes to 38 minutes but at some instants it takes 47 minutes and also 40 minutes for the changeover of mold. In case of other process of changeover for pin, plate and final connection it clear shows from the run chart that all the data is within the required limit. For further analysis on the data collected for each process capability analysis is done through which CP and CPK which gives the estimation of the current state and also helps to determine the future state of the process for improvement.

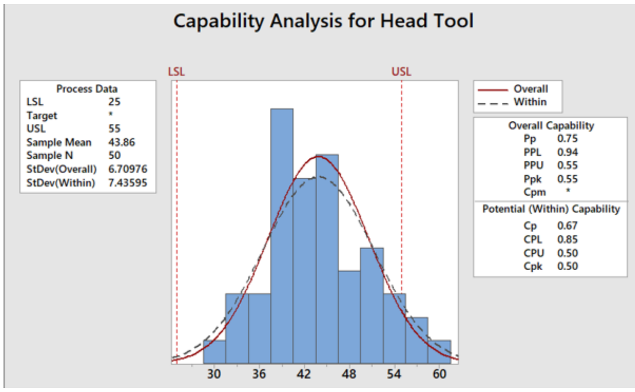


Figure 13: Capability Analysis of Head Tool

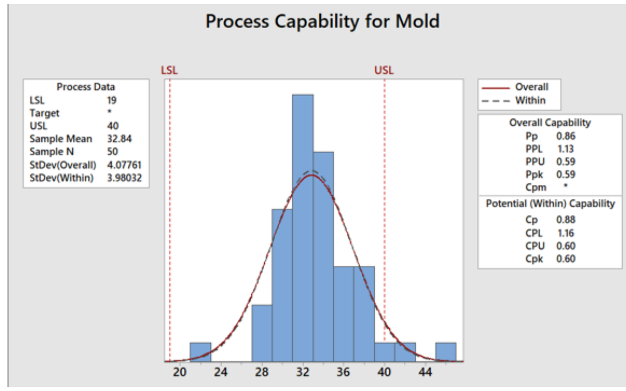


Figure 14: Process Capability of Mold

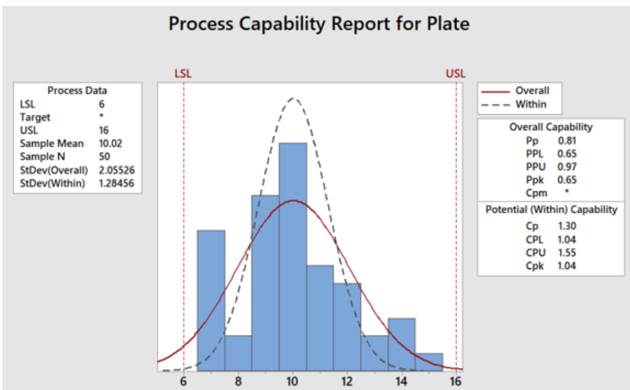


Figure 15: Capability Analysis of Plate

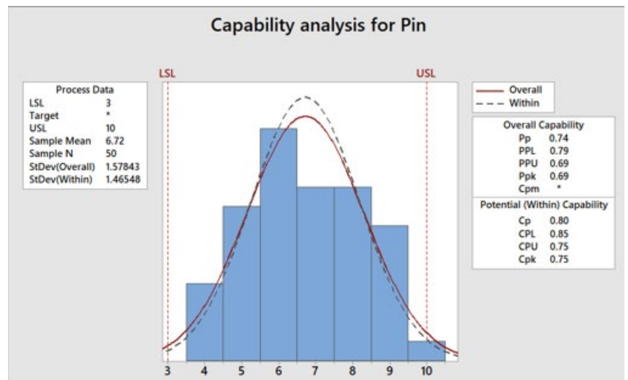


Figure 16: Capability Analysis of Pin

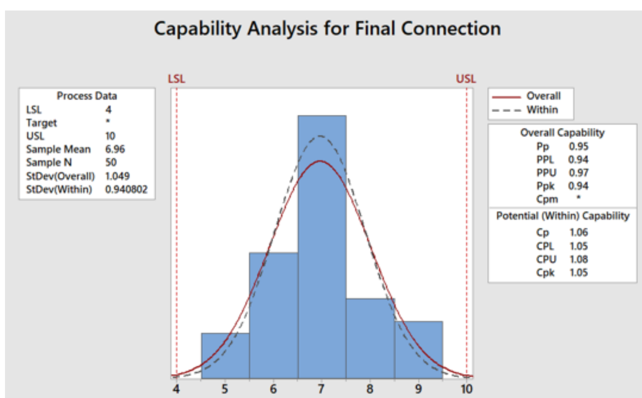


Figure 17: Capability Analysis of Final Connection

From the figure 13 it clearly shows that the CP and CPK value for tool is less that 1 from which it is proved that tool changeover time has a major problem and which causes maximum defects and more time delay in the process of the changeover. Even for the mold the CP and CPK very is less than 1 which show major defects are caused due to mold. If we look at figure 15, 16 and 17 from the process capability analysis we can see that process of changeover of plate, pin and final connection are within the limits and it is clear that the analysis that this changeover does not take lot of time for the changeover and does not cause delay in overall process. Therefore, from run chart and process capability analysis for improving the process mold and head tool are take into consideration for the improvement which will definitely reduce the problem in the production of tanks.

5.4 Improve

The Improve phase works in alliance with the Analyze phase, wherein the defect causes previously recognized in the analyses phase is worked on and rectified in the improve phase. This procedure involves brainstorming potential solutions, testing selected solution and evaluating the result of the implemented solution. Many different techniques are used to find the solution for the problem from which problem can be solved in a proper way. In this particular project head tool, and mold are taken into consideration for the improvement, after review the work strategy with the changeover team for improvement in head tool it was identified that developing a tool chart for all tools near to the work station will eliminate the extra time required to perform the changeover operation

Figure 18: Tool Kit

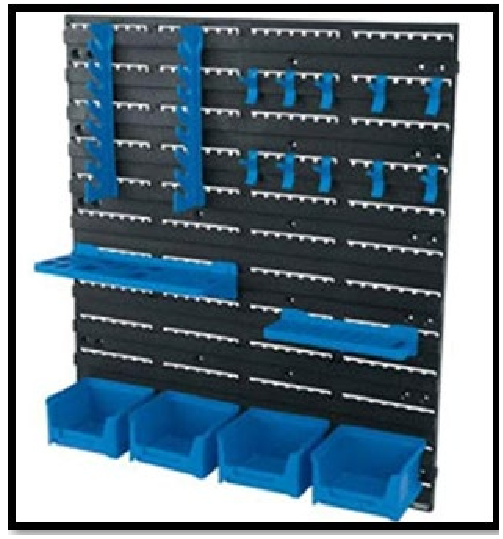


Figure 19: Tool Kit

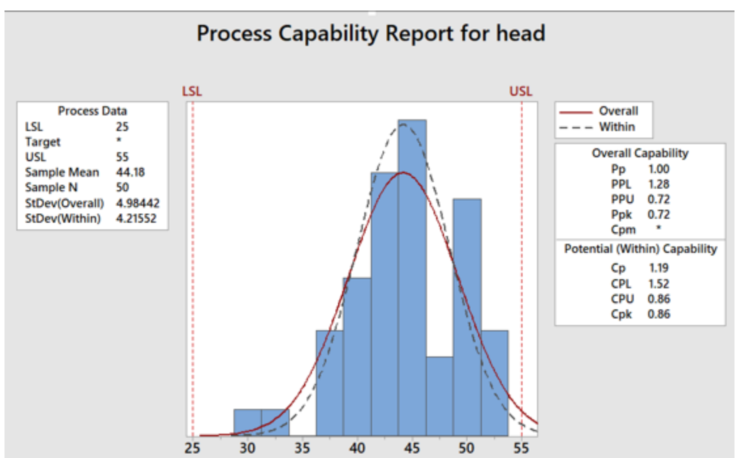


Figure 20: Process Capability Report improved for Head

The above figure 18 and figure 19 are the improvement made for the head tool where tool charts where developed so that now it be very easy for them to keep to tools at one place so that traveling time which was initially very high now it got reduced and automatically the tool changeover time got decreased. From the figure 20 it clearly shows CP and CPK value is now above 1 therefore the possibility of error is now decreased and it clearly shows that there is a process improvement.

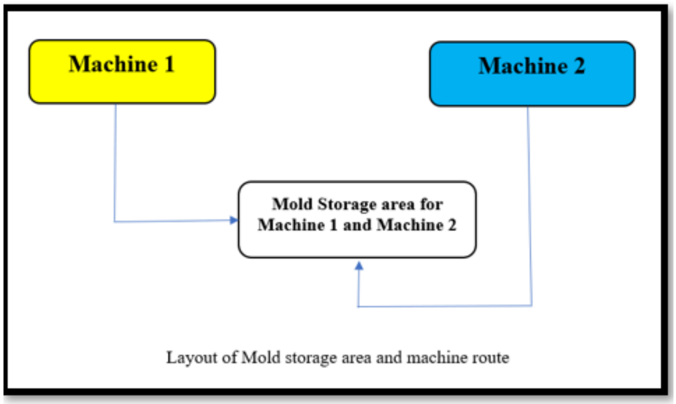


Figure 21: Mold Storage Area Before

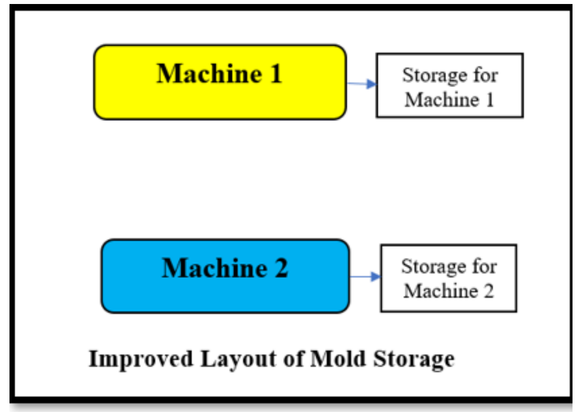


Figure 22: Mold Storage area After

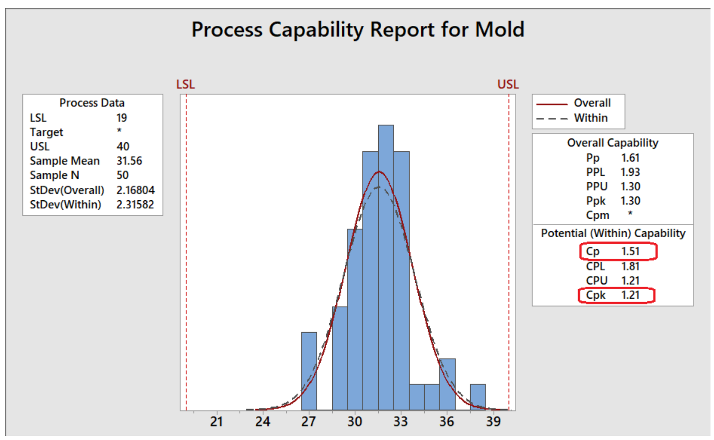


Figure 23: Process Capability report Improved Mold

In figure 21 this was the previous layout of the mold storage area where all the mold which are required to be changed are kept in this area and when every changeover takes place it was required to be picked up from this storage. Initially the storage area for all the mold was same for both the machines, Machine 1 and Machine 2 the storage area was at one place, for improvement this storage area was divided into proper area now besides each machine individual storage area for mold was designed and implemented. This really helped to improve the changeover time of mold as the extra time which was wasted initially now it decreased. From figure 23 we can clearly see CP and CPK value has got increased which is more than 1.

5.5 Control

The main focus of this phase is to examine the changes which we have implemented is being followed and maintained inside the system. This is really the most important phase of six sigma because from this phase it is made sure that the new system which we have implemented is being properly followed and is satisfying for many years, therefore it provides guaranty of improvement in the system for longer period of time. There are many tools used inside the control phase to examine the situation of the present improved system and they are SPC tool i.e. statistical process control where different charts like x bar chart, p chart and many more are used to examine the overall process in the system. In this project to have assurance that the whole improve system has the desired output capability analysis of the sample data of total time required for changeover is examined.

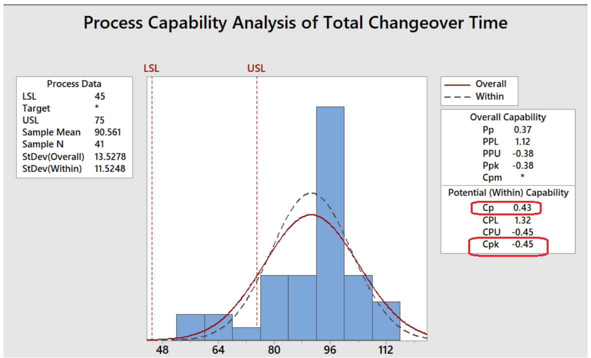


Figure 24: Time Changeover Before

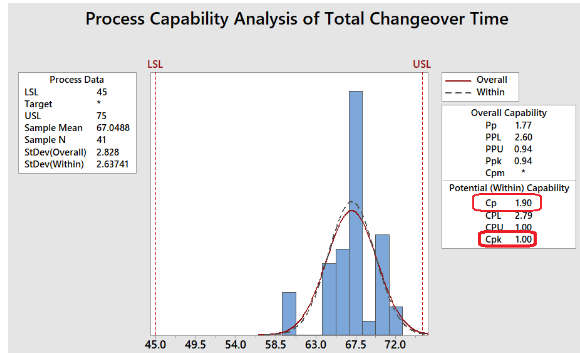


Figure 25: Total time Changeover After

From the figure 24 we can see that the CP value initially was less than 1 therefore it shows that system is capable enough to do changeover of tools, molds in less time, but in figure 25 we can see that now after implementing six sigma tools it is now sure that process of changeover has become robust as we can see that it is going to sigma level of 1.2 which is really a good notion for the improvement of the system. To check whether the data obtained has a confidence interval we check it in excel with 95% confidence interval and from figure 26 it is clear that the observed data can produce same result for maximum time in a large scale.

Confidence Interval In Excel		
Data	**Description**	**Result**
0.05	Significance level	
2.81	Standard deviation of the total change over time	
41	Sample Size	
Formulae	Description	
Confidence(Alpha,S.D,size)	Confidence interval for total change over time. In other words confidence Interval for the sample side mean is 67.04 ± 0.8631	0.8631

Figure 26: Confidence Interval in Excel

6. Conclusion

By implementing the six sigma DMAIC tools it became very easy to identify the real problem in this plastic manufacturing industry which really helped to increase the overall tool, mold and die changeover efficiency than previous by 50%. Initially on an average all the process of changeover from tool, mold, pin, plate and final connector it used to take on an average 95 min but now after implementing the six sigma tools it helped to remove this time consuming process of changeover now new time for the changeover for head tool, mold, plate, pin and final connector came to on an average of 70 min which is really a good improvement. By use of six sigma tools the real problem causing factors where found in analyze phase which made it very clear that head tool changeover took a lot of time delay which may have been caused by new worker or tools are not in the required place as which resulted in the delay and more time for the changeover of tool. The other problem identified in analyze phase was mold changeover also took lot of time as the location of the mold storage area was far off from the machine which resulted in time delay in changeover operation of mold. In improve phase the location of mold storage was changed from the previous in which the new one was now very next to the machines, therefore now it became very easy for the operator to pick the required mold to be change in less time which helped to decrease the overall changeover time just by simply modifying the location of mold storage area. In this project SMED single minute exchange of die concept is used in which it is made sure that all the changeover of the parts takes place in just one minute or must not exceed 10 minutes.

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8. Biographies

Kaustubh Kale is a Master's student in Lawrence technological University perusing Master of Science in Industrial engineering. He graduated from Savatribai Phule Pune University in India in the year 2015 having major in Mechanical engineering. He has green belt certification completed in the year 2017 and has an experience in manufacturing industry in AIM Engineers and also worked in KSH logistics as an industrial engineer intern worked in warehouse inbound & outbound process improvement.