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# Reducing Rejection Ratio in Indian Manufacturing Industry by Controlling Welding Processes with CPK

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## ABSTRACT

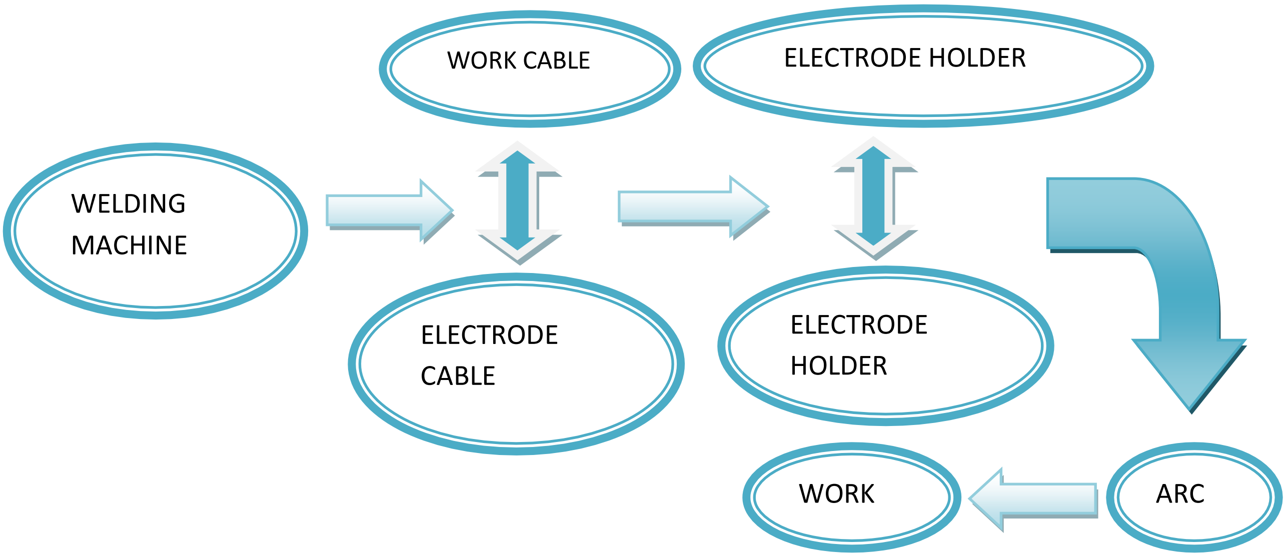
**In current scenario of economic globalization liberalization keen competition and increasing customer awareness quality is a buzzword for survival and growth of any organization whether in manufacturing or production sector. World class organizations have to make major changes in their business performance and customer orientation as a result of ever changing global market conditions. The present era has seen that quality has moved from a shop floor control technique to a strategy where it the driving force for the whole business encircling the gamut of an organization activity. In the past the Indian industries used the method of hit and trial to solve any problem, though it gave results in many cases but generally it was a stop gap arrangement and later on ended up as been permanently followed. This not only led to poor performance but also decreased productivity and lead to unnecessary work. In the light of the above mentioned facts problem solving techniques gain an increased importance in context of Indian industries.**

## INTRODUCTION

As we know, there are a numbers of fabricated parts weld by the welder according to their working condition such as the machine design and the work to be weld. Thus, it is unavoidable that machining at multipoint after welding is very difficult and not possible to maintain in position tolerance. So we have to create our own MIG welding jigs according to the specification of the MIG welding machine in the welding research lab. Thus a study on the manufacturing of welded parts was made by review the lot of trails, by changing jig designs and the information on how the welded parts should machine after welding and from what it should be manufactured.

Welding is a process for joining different materials. The large bulk of materials that are welded are metals and their alloys, although the term welding is also applied to the joining of other materials such as thermoplastics. Welding joins different metals/alloys with the help of a number of processes in which heat is supplied either electrically or by means of a gas torch. In order to join two or more pieces of metal together by one of the welding processes, the most essential requirement is Heat. Pressure may also be employed, but this is not, in many processes essential. The use of welding in today's technology is extensive. It had a phenomenal rise since about 1930; this growth has been faster than the general industrial growth.

Many common everyday use items, e.g., automobile cars, aircrafts, ships, electronic equipment, machinery, household appliances, etc., depend upon welding for their economical construction. Welding, in engineering, is any process in which two or more pieces of metal are joined together by the application of heat, pressure, or a combination of both. Most of the processes may be grouped into two main categories: pressure welding, in which the weld is achieved by pressure; and heat welding, in which the weld is achieved by heat. Heat welding is the most common welding process used today. Brazing and soldering are other means of joining metals.




**Problem Statement**

Welding jig is important in reducing the effect of defect such as thermal stress in welding part. In the welding research lab, most of the sheet metal that been weld deflected. This will trouble the lecturer research on welding. This is mostly due to the improper welding jig that unable to clamp the sheet metals. Thus, a proper welding jig should be produced as soon as in order to overcome this problem and help to increase the accuracy of the research been made. The present jig also cannot clamp work pieces with different thickness.

**Causes for Rejection and How to Avoid Welding-Defects-**

Avoidance of Welding-defects starts with correct design and preparation. This may look as an obvious statement but somehow it is a more frequent than desired situation. There is no point in trying to correct by welding for misalignment or for improper set up of the work piece. There is no gain in time, really, only an increased probability of producing welding-defects and of spending time and resources in trying to repair the welded item.

Also the use of recommended tools and fixtures should be implemented with no excuses admitted for temporary unavailability. The required means, in good operational condition, should be used with the correct parameters, according to the approved procedure. If the welding procedure is incapable of ensuring defect free implementation, then it should be improved upon.

The welder or the machine operator should be proficient in the process selected and all physical accessories assigned should be ready for use. Among them, aspirators of fumes, fan to circulate air, screens to protect other workers nearby, etc. If electrodes need be dried, so they should be. Cleaning of fixtures and work piece should be performed before setting up. A last touch up may be repeated just before welding.

## LITERATURE REVIEW

The welding process causes a highly non-uniform heating of the parts being joined. Areas close to the weld arc are heated up to several thousand degrees Celsius, and then cooled down, the heat being conducted to the bulk of the body. The local heating and subsequent cooling induces volumetric changes producing temporary and residual stresses and deformation. If, during heating, the elements of the weld were stressed elastically, then, after cooling, the body will return to its initial stress-free condition. A simple model, first presented by Hillier, F.S. (1969)[1].that can help to understand the process of 1D -stress foundation, is presented in , which assists in understanding how weld stresses develop.

Chandresh N. Patel used full factorial method for Design of Experiment for optimization work. By use of the experimental data optimal process parameter combination was achieved by grey relational analysis (GRA) optimization technique. In this work, input parameters for MIG welding were welding current, wire diameter and wire feed rate and the output parameter is hardness.

Jigs are often mentioned in the same phrase as 'Jigs, Fixtures and Tooling'; consequently definitions are required for Fixtures and Tooling, also. One definition of Jigs and Fixtures is (Pollack, 1976). A Jig is a work piece locating and holding device which positions and guides or controls a cutting tool. There are several types of clamp that usually used such as the screw clamps, pivoted clamps, hinged clamps, swinging clamps, quick action clamps, multiple clamps, power clamps and non-conventional clamps (P.H. Joshi, 2003). These three clamps are as shown below; this definition has been refined to the following and includes a definition of Jig less Assembly, which will be used as the standard throughout this work (Burley and Corbett, 1998). Within the airframe manufacturing industry, it is generally accepted that approximately 10% of the overall manufacturing costs of each airframe can be attributed to manufacture and maintenance of assembly jigs, fixtures and other ‘special to type’ tooling (Burley et al., 1999). For civil aircraft, the costs are split into Non Recurring Cost (NRC), ‘initial investment’, and Recurring Cost (RC).

Tooling costs are principally part of NRC and for Airbus aircraft the part of NRC dedicated to tooling represents more than a third (ECATA, 1995). The limitations of measuring the wing within the assembly jig results in measurement being delayed until it is located in the final stage when it is structurally complete, making it very expensive and impracticable to correct any defects highlighted by measurement of the wing. (Lewis, 1993). Jigs are independent devices which fastened to the machine table (K Venkataraman, 2005). Kitchen ham, B. (2004) has stated that there are various methods to clamp such as threaded fastener, cam clamps, and “V” type sliding clamps, pneumatic clamps, hydraulic clamps, and more. Bothe, D. R. (1990) [6] has stated that a clamping system should be strong enough to withstand the forces during operation without damaging the work piece surface.

Recently, a review of the literature on the use of SPC in batch production has been presented by Florac W.A., Carleton A.D., (1999)[9], Much of their article is devoted to a particular aspect of short-run SPC, namely, the use of data transformation techniques. Whilst the focus is on univalent processes, wherever appropriate consideration is also given to the multivariate environment for which little has appeared in the literature Dudek-Burlikowksa M., Szewieczek D, 1988[8].

The set of calibration data is reasonably large, there is often no assurance that the resulting estimated control limits will behave essentially like the known limits (Quesenberry1993). Using a simplified economic model Ghost, Reynolds and Hui (1981) showed that ARL is the most important measure associated with the RL distribution that determines the effectiveness of a control procedure. They also noted that other measures may be of interest for some applications. Queensberry (1995d) demonstrated that for comparison of various competing procedures, if RL distributions are known to be geometric before and after a shift in the process parameters, ARL is an appropriate performance criterion because the run length distribution fiction, at any fixed value k is a strictly monotonic fiction of ARL irrespective of shift size. These mechanisms can be electric, mechanic, procedures, human or of any other kind able to prevent the inappropriate achieving of a process stage.(Paun A., Sergiu D., Vladut V., Gagenu P) [43].

Poke-Yoke method was introduced by Shigeo Shingo in 1961, when this was one of engineers Toyota Motor Corporation. This method in other word is to prevent defect & error originating in the mistake (Chakraborty, A. and Chuan, T.K.) [38]. In the year 50 Shingeo Singo being an advocate of statistical process control system in Japanese companies realize that such a solution would never improve the manufacturing process. (Ketola J., Roberts K.2009). The method poke-yoke is based on convenience that it is not acceptable to produce even very small quality of defective products (Ishikawa K.,) [42]. For the companies, production of products in 100% without any defect is not only challenge, but necessity for companies.(Feng, Q. and Manuel, C.M) [32]. The name Poke-Yoke, Shiegeo Shingo established in 1963, it is translated as “resistance to errors” (avoid yoker errors resulting from in attention (Poke).

The indices were Cp, Cpk, k, Cpu, and Cpl have been described as original PCIs by Sullivan and Letters who had observed the usage of these indices at Japanese manufacturing facilities.These indices can provide useful numerical measures for determining a capable process and are appropriate tools in order to measure the capability of process with the comparison of inherent variability of a process with the specification requirements of the product (Kane[5]; Bissell [10]). Tsai and Chen (Tsai and Chen [29]) had a survey about making a decision to evaluate a process capability index Cp with fuzzy numbers. Their methodology was using a-cuts method in order to find the embership function of the fuzzy p C□ . Suppose that Xi is an observation consisted of triangular fuzzy numbers. Parchami, Mashinchi *et al*. (Parchami, Mashinchi *et al*. [34]) in another study introduced a consistent confidence interval for fuzzy capability index Cp. In this study, they assumed fuzzy specification limits and because of using fuzzy specification limits, they usedCp, which is also fuzzy. Introduced a new method to measure the process capability index Cpm with fuzzy data. Since the exact membership function of fuzzy Cpm is really complicated, they used the approximate membership function (Kao and Liu[17]) with a-cuts methods of the fuzzy observation. Their methodology is similar to the methodology of

Tsai and Chen [29], but for different index Cpm. Recently these fuzzy indices have been used in real projects, for example Kaya and Kahraman (Kaya and Kahraman [31]) developed fuzzy robust process capability indices for risk assessment of air pollution. All studies are based on fuzzy data. When the specification data is fuzzy, the process capability indices will be fuzzy.

## CASE STUDY

This study is based on weld shop. How to increase productivity with batter quality in weld shop? It is possible by improving quality of finished product & by process validation. It also increases SPR and capacity of line which one itself a great achievement from point of process standardization. By process standardization there are basically two benefits one is cost saving and other is rejection control. This project will be beneficial for the two wheelers industries as it will make easy to provide required quantity on time. This part was made in a way that it is easy to use and reliable to the user without limiting the user need. Quality & process improvement is initiative for increasing Capacity, its need to create a supportive environment for this initiative. Some method to start increasing Capacity are by solving existing problems with improving welding process & welding Jigs & Fixtures and by increase Cp & Cpk Values for batter results. To begin the process improvement for the first time, think about a small but important problem that is likely to be resolved with some thought and work. Moving in this direction of problem solving there are six steps one has to follow:

- Identifying the problem—which problem should be addressed? If there are several, how to choose the most important one?
- Describing the problem — how to accurately and completely describe the problem?
- Analysing the problem—what are the different causes of the problem, and which causes are most important to solve right away?
- Planning the solutions—what are the different alternative solutions for solving the problem?
- Implementing the solutions—how to make sure the solutions are implemented correctly and effectively?
- Monitoring/evaluating the solutions—how did the solutions work? What needs to be changed?

**AP Precision Auto Private Limited Histories**

Since 2001 Precision Engg. Works had started to manufactured first tooling. Then we had continually manufactured the different type of tooling during the 10 years period, under the able leadership of Mr. Suresh Chand (Managing Director) & Mr. Ashok Kumar. (Technical Director), a qualified engineer having good knowledge and specialization of tooling and sheet metal components.

Today Precision Engg. Works, regarded as one of the leading manufacturers, supplier of sheet metal components including tools, dies, jigs, fixtures and more. These find application in varied engineering industries. We have setup a well equipped standard room to control

## METHODOLOGY

A study was done on a data of straight pass ratio, internal rejection & internal rework for the period of July'15 to March'16 on main stand weld assembly line.

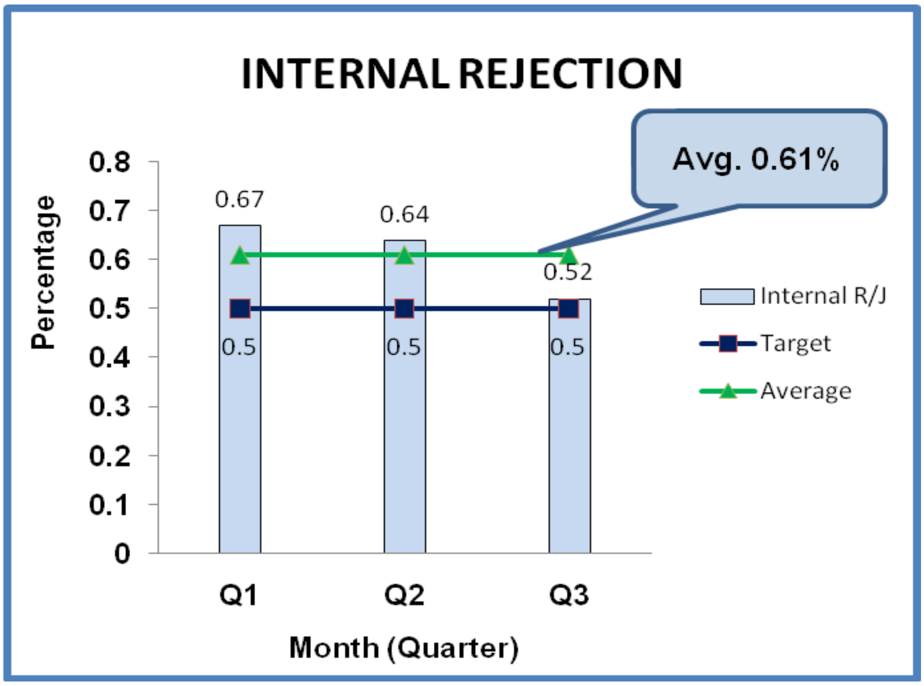



**Fig No.2: Quarterly Internal Rejection Ratio Chart**

A study was done on a data of straight pass ratio, internal rejection for the period of July'15 to March'16 on main stand weld assembly line.

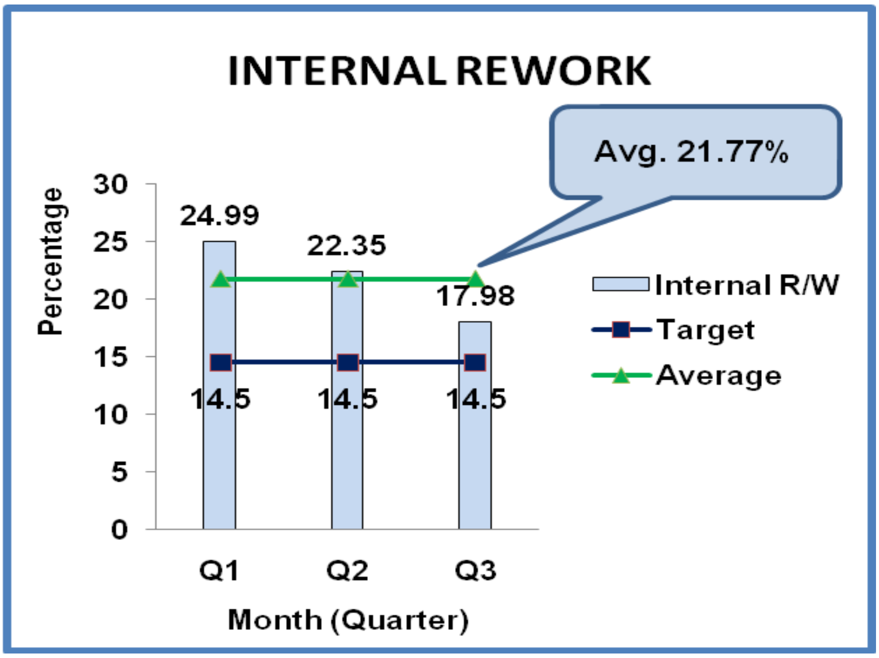
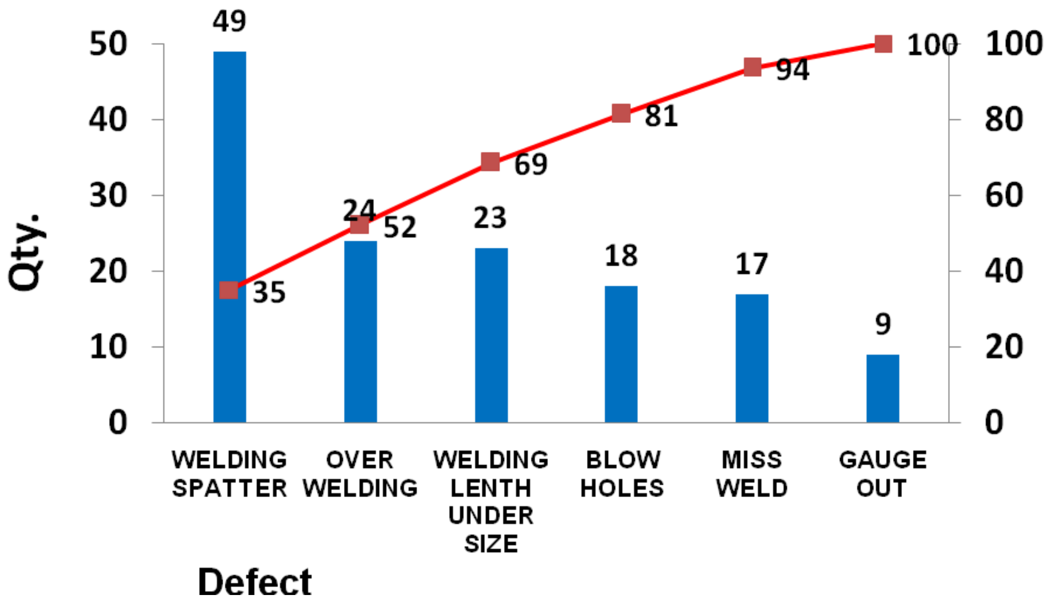



**Fig No. 3: Quarterly Internal Rework**

A study was done on a data of straight pass ratio, internal rework for the period of July'15 to March'16 on main stand weld assembly line.




Rejection due to welding defects for the period of July'15 to March'16 on main stand weld assembly line.According to the collected data, it was analysed that one of the major defect for internal rejection and internal rework was poor welding quality & parts fitment in receiving gauge.

**Description of Problem**

- Line rejection & rework due to welding defects.
- Dim NG due to no controlling point in welding fixture.

Now the most important is to control the quality of the welded product. For improving quality or controlling NG dimension we deciding first study statically process control on the bases of this result we decide which dimensions have Cp/Cpk value less than 1.33. After this we decide what type of action taken and on which stage.

SPC:-Statistical process control study did for few selected dimension Dim8.5, Pivot ID 16.8, Dim 281, Dim 11.3. For statistical process control study we required data of 100 parts. Here we use snap shots of Cp & Cpk data sheets & welding process validation shee

DATE :- 25-Mar-16

| APPROVED | CHECKED | PREPARED |
|---|---|---|
| | | |

**STATISTICAL PROCESS CONTROL STUDY**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PART NAME: | STAND COMP MAIN | QUALITY CHARACTERISTICS | Dim | INSTRUMENT NAME: | HG | MACHINE NAME | | SUPPLIER NAME OR MACHINING SECTION NAME | |
| PART No. : | 50500-K30A-9000 | STANDARD | Dim 8.5±0.5 | OPERATION: | | LEAST COUNT | 0.01 | DOCUMENT CONTROL NO. : | |

DATA COLLECTION: -

| DATE OF MEASUREMENT | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 23.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 | 24.03.2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEASUREMENT TIME | 8:00AM | 10:AM | 11:00AM | 1:00PM | 1:00PM | 3:00PM | 3:00PM | 5:00PM | 5:00PM | 7:00PM | 8:00AM | 10:AM | 11:00AM | 1:00PM | 1:00PM | 3:00PM | 3:00PM | 5:00PM | 5:00PM | 7:00PM |
| GROUP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| MEASURED VALUE X1 | 8.59 | 8.75 | 8.69 | 8.46 | 8.52 | 8.56 | 8.48 | 8.61 | 8.59 | 8.75 | 8.53 | 8.43 | 8.71 | 8.43 | 8.44 | 8.52 | 8.73 | 8.57 | 8.43 | 8.65 |
| X2 | 8.48 | 8.60 | 8.50 | 8.41 | 8.51 | 8.68 | 8.56 | 8.53 | 8.54 | 8.68 | 8.58 | 8.58 | 8.61 | 8.76 | 8.51 | 8.56 | 8.64 | 8.55 | 8.65 | 8.59 |
| X3 | 8.65 | 8.56 | 8.63 | 8.64 | 8.51 | 8.47 | 8.61 | 8.76 | 8.55 | 8.65 | 8.47 | 8.52 | 8.58 | 8.70 | 8.70 | 8.42 | 8.67 | 8.57 | 8.52 | 8.43 |
| X4 | 8.58 | 8.76 | 8.48 | 8.60 | 8.48 | 8.70 | 8.62 | 8.54 | 8.45 | 8.46 | 8.41 | 8.58 | 8.47 | 8.40 | 8.48 | 8.59 | 8.41 | 8.52 | 8.75 | 8.76 |
| X5 | 8.68 | 8.51 | 8.51 | 8.70 | 8.72 | 8.58 | 8.48 | 8.50 | 8.42 | 8.71 | 8.63 | 8.63 | 8.49 | 8.48 | 8.61 | 8.49 | 8.76 | 8.64 | 8.59 | 8.42 |

| SAMPLING RATIO | | | | | |
|---|---|---|---|---|---|
| ALL DIMENSIONS ARE IN MM | | UP TO 6 SAMPLES 'D3' VALUE = 0 | | | |
| | | SAMPLE | $d_2$ | $A_2$ | $D_4$ |
| USL | 9.0000 | 1 | 1.123 | 2.560 | 3.270 |
| | | 2 | 1.128 | 1.880 | 3.270 |
| LSL | 8.0000 | 3 | 1.693 | 1.020 | 2.570 |
| | | 4 | 2.059 | 0.800 | 2.280 |
| | | 5 | 2.326 | 0.590 | 2.110 |

After it was determined that the above defects occurs most regularly, a detailed study was done to find out the causes and possible counter measure to avoid this defect so as to increase capacity or to decrease the rejections & Internal rework at the same time maintaining the production targets as well.

**Why Why Analysis for welding**

| S.No | Process | Rework Qty | Rework % | Description of problem | Why 1 | Why 2 | Why 3 | C'measure |
|---|---|---|---|---|---|---|---|---|
| 1 | welding | 37 | 33 | Welding Spatter | $CO_2$ gas was used | $CO_2$ gas running in all over plant | $CO_2$ gas implemented from day one | Ar + $CO_2$ gas mixture used for mig welding |
| 2 | | 24 | 22 | Over Welding | Limit sample was not display | Limit sample was not freeze | Operator was not aware about this problem | Training to be provided and limit sample display in line. |
| 3 | | 22 | 20 | Welding Length under Size | | | | |

With this table help we can formulate the causes for rejection during the welding processes and take some corrective actions regarding the problem

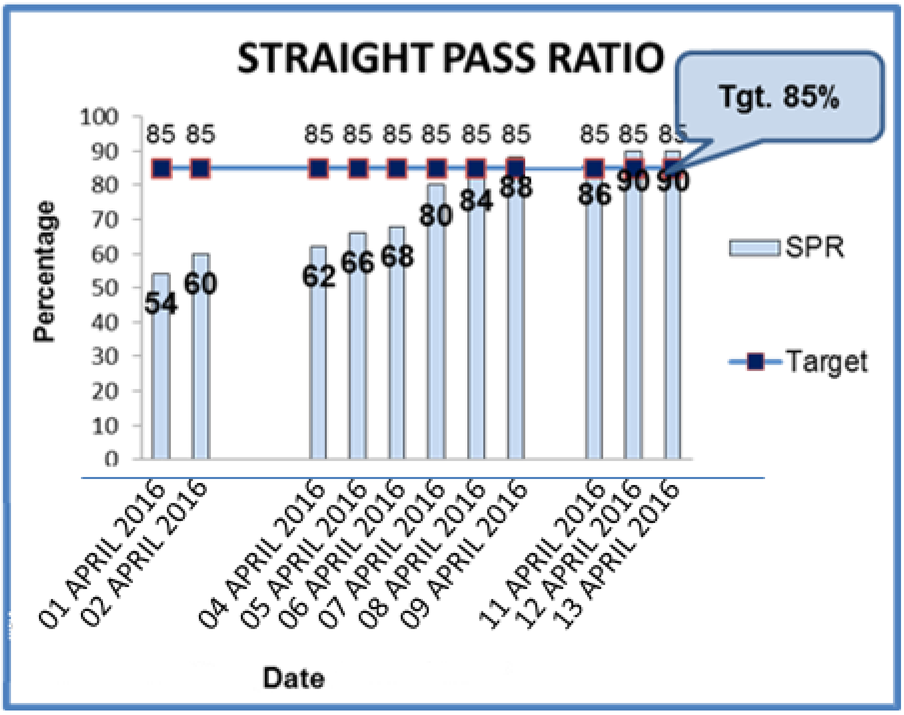
**Few Important Points for Process Validation**

| Process name | Expected Nature of Defects. (Control Points) | Control Available | Remarks |
|---|---|---|---|
| Receiving Inspection | Raw material NG | 1. Material test certificte of Supplier.<br>2. Third Party Material Testing as per plan | Part checked as per MTC / Lab Test Report |
| | BOP part fitment NG. | 1 Part check as per sampling plan (IS:2500).<br>2. Part check as per IQS. | Part check as per IQS Sampling plan IS:2500 |
| Welding Process | Welding defects. (Weld miss, Blow hole, Spatter, Weld over etc.) | 1. Process parameters verification through process inspection check sheet<br>2. On job training to welders.<br>3. Welding defect check at Q-Gate 100% | Defect monitoring counter provided at Q-Gate |
| | Fitment NG | 1. Welding fixture and gauge validation plan.<br>2. 100% parts qualify in receiving gauge. | FOA Inspection Report. |
| Powder Coating Process | Paint Defects | 1. All powder coating process parameters monitoring as per Control Plan<br>2. Calibration of instruments (Temp. meter, DFT Meter, Voltometer), As per calibration plan.<br>3. Timely preventive maintenance of paint shop. | Q-Gate process parameter check sheet. |

Key Points Are Observed Regarding Our Problem And We Are Able To Take Some Corrective Actions.

## RESULT

After some correction in welding process or in welding fixtures again we study SPC for those particular dimensions. We are surprise to find batter results as we expected. Our target to increase SPR up to 85% but we got success to increase it up to 90%. Internal rejection on line is zero and internal rework after applying all countermeasures internal rework also reduced up to 10%. One more benefit after increasing SPR Capacity of line also increased. Now only one shift used for complete daily production target.




This is the required data sheet from 1april 2016 to 13 april 2016 or straight pass ratioand we achieved our target valve in the month of april 2016.

## CONCLUSIONS

The time spent in reworks and efforts spent in identifying rejections affects adversely on quality of main stand, its cost and hence the reputation of the product manufacturer. The competitiveness of auto industry today has forced every company to re-look at its processes involved in controlling accuracy of fabricated products and reduces the variability of products. The present work was an effort to have a look at the existing quality level of the main stand and weld line and then implement the corrective measures for the non-conformities of main stand. Welding Process & welding Fixture, its use and requirements of its quality was studied in depth during the investigation of the present work. For controlling the accuracy of the main stand assembly validate process & validate fixtures are required. The sample product considered for the proposed work are the welding fixtures which are used to weld individual sheet metal components of main stand to arrive at final main stand assembly. Welding process & welding fixture and its component have been studied critically in the present work. Any defect in the welding assembly fixture affects adversely on the vehicles assembly and hence it is very important to get fixtures and its components exactly confirming to design specifications. A survey was carried out in the present study for identifying the Cpk value of some critical dimensions and important product characteristics of the elements of main stand. The various improvements have been done in welding process & in welding fixtures to reduce rejection in main stand assembly.

The work for increasing straight pass ratio and to reduce rejection in main stand were comprising of use of SPC tools namely histograms and control charts for reducing rejection & rework of main stand.. These techniques mainly involved the use of graphs and chart stop in point the variability in different ways. By using the characteristics like magnitude of variability, time-wise trend of variability and the main causes of variability can be determined and reduced to the minimum possible level. For improving the quality of components the elements of welding Fixture was inspected. The current level of quality of components was then understood in the present study. Inspected data regarding elements of main stand on basis of quality was next tabulated. The roadmap for the improvement was then decided to arrive series of actions namely what is our target? What is the quality of component at present? Where is the quality of main stand going wrong? How much the quality of main stand is going wrong? How to improve further? When and how to implement the suggested improvement? Each of these questions will further involve series of answers that generate many actions which is a subset of an action plan to be implemented for improvement for the quality of main stand.

Average percentage rejection was found reduced from0 .61 % to about 0 %. Hence it leads to reduction in rework on shop floor to the minimum which further reduced significantly the cost of production. The manufacturing companies hence therefore get benefited in terms of increasing profits. Finally, the manufacturing time of production of main stand was also then observed and reduced significantly for reducing rejection in components assembly fixture. The main objectives of the project were finally met out and the further suggestion for improvements have been proposed for arriving subsequent modifications or future changes in the process of continuous improvement involved in quality oriented manufacturing of welded components.

## FUTURE SCOPE OF WORK

Similarly use of process control techniques like CP, CPK and standardized deviations in a onetime manufacturing activity (tool room) kind of items (which is the case in unit level manufacturing) is always difficult. This is due to changing nature of environment with respect to time. In such kind of items as every item is unique there are no standardized machines and process. Still there is a great scope of work that could be done in this field for increasing SPR & reducing rework.

Lastly there was more scope in future for reducing reworks and reducing fatlike to operator. More work can we done after studying other hidden factors for increasing SPR and stable complete weld shop by zero PPM.

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