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Interpretation and Implementation of Some Aspects of Welding Process and Fixture for Increasing SPR in Manufacturing Industry A Case Study

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Abstract: The MIG welding parameters are the most important factors affecting the quality, productivity and cost of welding. This paper presents the influence of welding parameters like welding current, welding voltage, Gas flow rate, wire feed rate, etc. on weld strength, design and fabrication of MIG welding fixtures. The objective of this thesis is to develop welding fixtures that able to clamp workpiece and reduce the rejection ratio in production. Clamping design and common welding jigs material was studied in order to design and generate concept for the MIG welding jigs. Solid Works was used to design or draw the final concept of the MIG welding jigs. On the other hand, screw clamp was used to design clamping system for the welding jigs. The welding jigs were design in such an order that it able to adjust the gap between workpiece and give out the gap measurement so that the time taken for the welding research can be reduced. Methods and process involve in accomplish this is the machining process by using conventional milling machine, cutting process by using the vertical bend saw, joining process by using screwing, welding process and filing process.

Keywords: MIG welding, optimization, Welding distortion, Welding fixture, Weld sequence, Welding speed.

1. Welding Processes

1.1 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 part in such close tolerances 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.

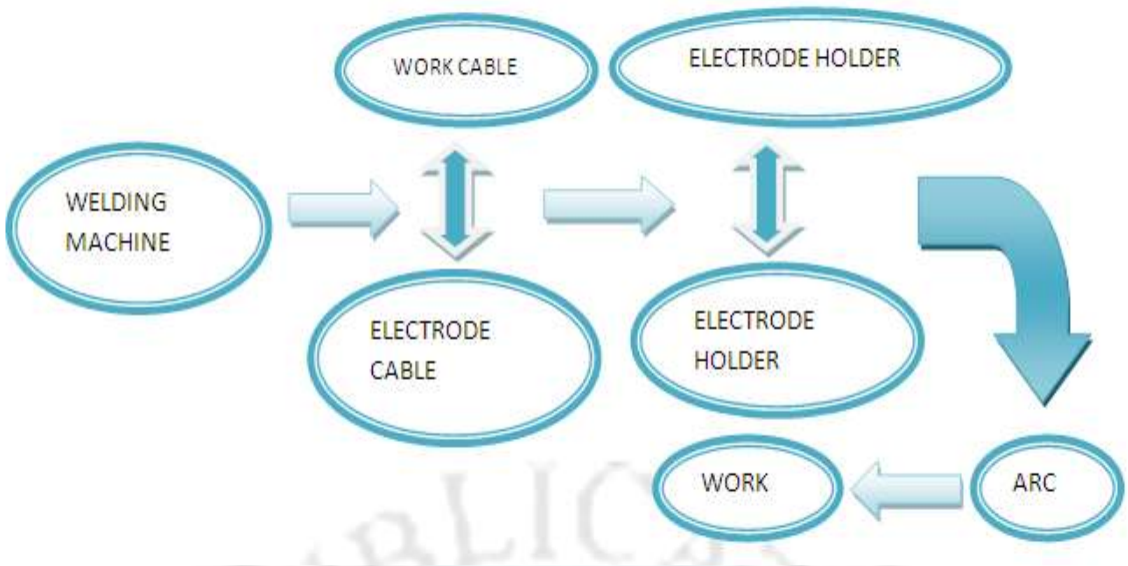

Fig: 1.1 the weld shop basically involves five operations

1.2.1Classification of Welding Processes –There are about 35 different welding and brazing processes and several soldering methods in use by industry today. There are various ways of classifying the welding and allied processes. For example, they may be classified on the basis of :

- Source of heat, i.e., flame, arc, etc.
- Type of interaction i.e. liquid/liquid (fusion welding) or solid/solid (solid state welding).

Here we use only Metal inert gas welding (MIG).

1.2.2 MIG Welding

Metal inert gas welding (MIG) was also known as gas metal arc welding (GMAW) or metal active gas welding (MAGW). MIG welding process is a semi- automatic process that used consumable wire electrode and shielding gas. The wire electrode was continuously and automatically fed through the welding gun. The wire electrode diameters used in this welding process is around 0.8 to 6.5 mm and it is depend on the thickness of the part to be joined. Gases that normally used as shielding gases can be inert gases such as helium and argon or active gases such as carbon dioxide. Gases used during the welding process depend on the type of metal to be weld where inert gases for aluminium alloys and stainless steels but carbon dioxide for low and medium carbon steels. Shielding gases function to eliminate slag covering on the welded part. As MIG welding save more time compare to Shielded metal arc welding (SMAW), it is widely used in factories. MIG welding operate by creating a short circuit between the wire electrode (anode) and the metal being weld (cathode). This short circuit will produce enough heat energy to melt the metal and allow them to join together. The schematic diagram and the picture of traditional MIG welding can be seen as following;

1.2.2 .1 Working Principles of GMAW

The gas shield around it does not ionized, which prevents weld against atmospheric co contamination and surface oxidation. Some torch has water cooling systems.MIG welding is also called Gas Metal Arc Welding. The filler metal is transmitted from electrode to joint by different methods. It is dependent on the current passing through the electrode and voltage. GMAW / MIG welding applications: MIG may be operated in semiautomatic, machine, or automatic modes. All commercially important applicable metals such as carbon steel, high-strength, low-alloy steel, and stainless steel, aluminium, copper, titanium, and nickel alloys can be welded in all positions with this process by choosing the appropriate shielding gas, electrode, and welding variables. MIG welding Effecting parameters: Weld quality and weld deposition rate both are influenced very much by the various welding parameters and joint geometry. Essentially a welded joint can be produced by various combinations of welding parameters as well as joint geometries. These parameters are the process variables which control the weld deposition rate and weld quality. The weld bead geometry, depth of penetration and overall weld quality depends on the following operating variables.

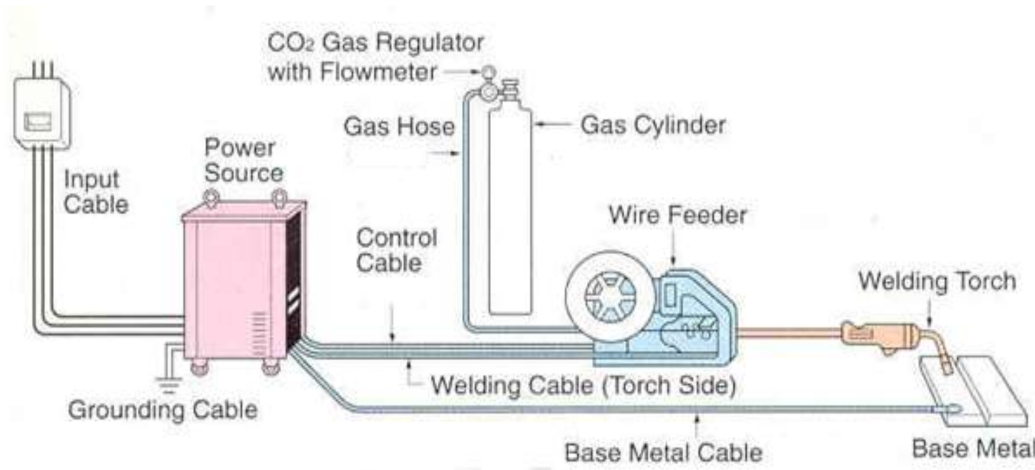

Fig: 1.2 Metal inert gas welding (MIG)

• Electrode size, Welding current, Arc voltage
• Arc travel speed, welding position
• Gas Flow rate, Shielding Gas composition
• Electrode extension (length of stick out)

1.2.3 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.

1.2.4 The Welding Process
The simplest and most understandable definition for welding can be given as a process used to join metals by the application of heat. However, and more completely, The American Welding Society (AWS) definition for a welding process is "a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone and with or without the use of filler material". Today, in our ever vibrant and constantly changing industrial environment, more than fifty processes, used in different applications, are available commercially to join metals. Welding gives a high joint efficiency with comparison to riveted or bolted joints, due to the nature of the weld joint itself and the strength it provides.

1.2.5 WELD SHOP
In the WELD SHOP, all type of sheet metal parts are manufactured for automobile manufacturers. Before any finished assembly, a number of subassembly is done for main assembly & the Some fit & function testing being done. Although weld shop is under control of number of qualified & experienced quality professionals, but still due to some reason various quality faults arise in weld shop which reduce SPR & Capacity in weld shop. The reasons are:

- Man
- Machine
- Method
- Machine

We have tries to solve the faults in the weld assembly by applying modern techniques like:

- Process validation
- Pokayoka In Welding Jig & fixtures
- Brainstorming
- Pareto Chart
- Ishikawa Diagram
- SPC Cp , Cpk study

1.2.4 .1 Welding Defects
Welding defects are excessive conditions, outside the acceptance limits, which risks to compromise the stability or the functionality of the welded structure. They are also called reject able discontinuities. This means that the same type of discontinuity of a lesser degree, might be considered harmless and acceptable. There is a difference between discontinuities and welding defects. A discontinuity is an objective lack of material, an interruption in the physical consistence of a part. Examples are cracks, seams, laps, porosity or inclusions. It may or may not be considered a defect depending if it its presence endangers or not the integrity, the usefulness and the serviceability of the structure

1.2.5Advantages and Disadvantages

1.2.5.1Advantages of Welding–

- A good weld is as strong as the base metal.
- General welding equipment is not very costly.
- Portable weldingequipment's are available.
- Welding permits considerable freedom in design.
- A large number of metals/alloys both similar and dissimilar can be joined by welding
- Welding can join workpieces through spots, as continuous pressure tight seams, end to end and in a number of other configurations.
- Welding can be mechanized.

1.2.5.2 Disadvantages of Welding –

- Welding gives out harmful radiations (light) fumes arid spatter.
- Welding results in residual stresses and distortion of the work pieces.
- Jigs and fixtures are generally required to hold and position the parts to be welded.
- Edge preparation of the workpieces is generally required before welding them.
- A skilled welder is a must to produce a good welding job.
- Welding heat produces metallurgical changes. The structure of the welded joint is not same as that of the parent metal.
- A welded joint for many reasons, needs stress relief heat treatment.

1.3 Weld Distortion

1.3.1 Weld Distortion and Residual Stresses
To be able to develop a tool to predict weld distortion, it is important to understand how different types of distortion are caused in welded fabrications and what effect they will have on the finished part. Distortion is always a perennial problem resulting from most industrial metal working processes, which employs a concentrated nature of heat source. However, our focus in this report shall be concentrated primarily on welding distortions, and not of those from other heating processes. Such a phenomenon can be explained by considering a weld bead depositing along the longitudinal axis of a plate with infinite width. The heated zone tries to expand but is restrained by the surrounding colder material, causing this zone to yield in compression. During the cooling cycle, the colder material prevents the contraction of this region, causing tensile stresses to be developed. This tensile stress around the weld with simultaneous generation of compressive stresses shall result in distortion if they exceed certain levels.

1.3.2 Types of Weld Distortion
Distortion in welded fabrications is caused by three fundamental dimensional changes, which are:

- Transverse shrinkage perpendicular to the weld line.
- Longitudinal shrinkage parallel to the weld line.
- Angular distortion (and bowing, buckling and twisting) **-** rotation around the weld line.

1.3.3 Factors Affecting Distortion
In welding process, there are numerous differing and interacting factors. When this combines with the several parameters involved in the process itself, it is not hard to realise the enormous possible combinations and outcomes. The factors affecting distortion can be summarised and described as per the follow sections: The inherent stresses in the material to be welded are important in the final distortion outcome. Stresses in a material usually originate from a mechanical cause, usually the manufacturing process, for example from cold forming, rolling, shearing/guillotining, and others. These give the material its required shape but create internal residual stresses. The general view that can be gathered from research states

that the greater the shape change, the greater the residual stresses become. During the welding process, extra stresses are created, as previously described which either result in increase or reversely decrease of these inherent stresses that already existed.

1.4 Welding Jigs

Jig is a device used to clamp workpiece in a specific location so that the mechanical process is properly guided. Jigs are independent devices which fastened to the machine table (K Venkataraman, 2005). Jigs are designed in such order that it able to load and unload workpiece easily. Thus, we can said that welding jigs are devices that mounted on the welding table so that it can guide the welding gun and produce a straight perfect welding bead. Same with other jigs, welding jigs require gripping devices to hold the workpiece in place during welding process through clamping devices. K Venkataraman (2005) has stated that there are various methods to clamp such as threaded fastener, cam clamps, „V" type sliding clamps, pneumatic clamps, hydraulic clamps, and more. P.H. Joshi (2003) has stated that a clamping system should be strong enough to withstand the forces during operation without damaging the workpiece surface.

1.4.1 Definitions of Jigs, Fixtures and Tooling

A Jig is defined as a manufacturing aid that either holds a part or is itself located on the part and is fitted with devices to guide a cutting tool ensuring the correct location of the machining path relative to the part . As the main subject of this thesis is 'Jig less Assembly', there needs to be a definition of what a 'Jig' is to understand what Jig less Assembly would mean. Jigs are often mentioned in the same phrase as 'Jigs, Fixtures and Tooling'; consequently definitions are required for Fixtures and Tooling, also. A Jig is a workpiece locating and holding device which positions and guides or controls a cutting tool. A Fixture is a workpiece locating and holding device used with machine tools, inspection, welding and assembly; it does not control the position of the tool or instrument which is being used. Elements of the Jig or Fixture must also be present which Support the work and elements, called locators, which Position the work. Once located and positioned, the work is clamped so that it will not move off the supports or locators

1.4.1 .1 Principle of Clamping

There are several things should be considered when designing a clamping system for the welding jig. The things to be considered are the position of the clamping, the strength of the clamping, productivity, operator fatigue, and workpiece variation. First of all, the clamping system of the welding jig must be designed so that it will not obstruct the path of the welding gun as well as the path of loading and unloading of the workpiece. In term of strength, the clamping device should be able to withstand the forces developed during the operation which is welding operation. The force in welding operation mainly is the distortion of the workpiece due to thermal stress. However, the clamping forces should not damage the workpiece.

1.5 POKA-YOKE: An Emerging Research Area

In manufacturing industries, Poka-Yoke has become an important approach in order to produce quality products. Poke-yoke is a method that uses sensor or other devices for catching errors that may pass by operators or assemblers. Poka-yoke have effects two key elements of ZDQ:

- Identifying the defect immediately (Point of Origin Inspection)
- Quick Feedback for Corrective Action.

Poka-Yoke is a very important tool by which rejection in operation of a system may be eliminated. Various Poka-Yoke techniques may be applied to reduce or eliminate rejection and error in manufacturing process. By the application of this tool, errors are removed in production system before they produce rejection using sensors and other quality improving instruments. Poka-Yoke allows process to run smoothly as they are fail-safe solution. It is the concentration on removing the causes of defects that is important. The inspection process is a backstop.The possibility of implementing of the Poka-Yoke as a factor of improving operation in the process of the modernizations of the companies.

1.6 Statical Quality Control

A Quality control system performs inspection, testing and analysis to conclude whether the quality of each product is as per laid quality standard or not. It's called ''Statistical Quality Control'' when statistical techniques are employed to control quality orto solve quality control problem.SQC makes inspection more reliable and at the same time less costly. It controls the quality levels of the outgoing products. SQC should be viewed as a kit of tools which may influence related to the function of specification, production or inspection. Controlling the quality of products so as to maintain it at a given level is a major problem in production. Production has been trying to use some men, machine and raw materials in the hope of turning out of uniform quality. But neither men nor machine are infallible and cause of irregularity often creep in inadvertently. As a result, rejection in finished materials are rarely eliminated and inspection and screening because necessary for varied extents depending on the nature of the products.

1.6.2 Principles of Statistical Quality Control:

The principles that govern the control of quality in manufacturing are:

- Control of quality increases output of saleable goods, decreases costs of production and distribution, and makes economic mass production possible.
- The quality of manufactured goods is variable with an upward trend under conditions of competitive manufacturing.
- The conformance of finished product to its design specifications and standards should be accomplished by avoiding the making of non-conforming materials rather than by storing the good from the bad after manufacturing is completed.
- Variability exists in every repetitive operation, statistical methods enable management to determine what the expected or chance variability of the process is, and thus isolates the excessive variations due to an assignable cause from those due to chance. These may then be studied for the cause and corrective steps taken.
- Wherever like products are turned out in quantity, statistical quality control techniques are applicable.
- A state of statistical quality control, in which an operation produces articles that remain consistently within their range of chance variation, so that no assignable or findable cause is present, is not usually found where statistical control techniques have not been used.

1.6.3 Objectives

To solve the problems using various quality tools.Identifying the problem—Which problem should I address? If there are several, how do I choose the most important one?
Describing the problem—How do I accurately and completely describe the problem?
Analyzing 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 do I make sure the solutions are implemented correctly and effectively?
Monitoring/evaluating the solution--How did the solutions work? What needs to be changed?

1.7 Some Statistical Tools of Quality

Some statistical tools of quality is a designation given to a fixed set of graphical techniques identified as being most helpful in troubleshooting issues related to quality. They are called basic because they are suitable for people with little formal training in statistics and because they can be used to solve the vast majority of quality-related issues.
The some tools are:

- Stratification (alternately, flow chart or run chart)
- Histogram
- Cause-and-effect diagram (also known as the "fishbone" or Ishikawa diagram)
- Pareto chart
- Control chart.
- Brainstorming
- Control chart
- Time-Motion Study

Some of these tools in this paper which given below:

2. 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 thousands 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. However if, during heating, an element was deformed plastically, then, after cooling, it tends to change dimensions proportionally to the amount of the plastic deformation. All the elements now have different size and cannot be reassembled into a solid body without some changes in their stress and deformation state. As a result, residual stresses and deformation form in the body.

In general, the non-uniformity of the temperature distribution during welding of a real structure causes a complex three-axial stress. In other words, all elements in the structure expand differently in all three directions. But, in most cases some components of the stress are negligible, and it is possible to consider 2D or even 1D stressed states. 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. The model consists of one central rod and two limiting rods, joined with each other by the rigid plates, and each of the rods have the same initial length. The central rod is exposed to a high temperature simulating the zone close to the weld. The limiting rods are kept at a constant temperature, representing the rest of the joining plates.

The changes in gas metal arc welding parameters are influenced the effect of the microstructure of weld metal. Pawankumar, Dr.B.K.Roy was worked carried out on plate welds AISI 304 & Low Carbon Steel plates using gas metal arc welding (GMAW) process. Taguchi method is used to formulate the experimental design. Design of experiments using orthogonal array is employed to develop the elements. The input process variables considered here include welding current, welding voltage & gas flow rate. A total no of 9 experimental runs were conducted using an L9 orthogonal array and the ideal combination of controllable factor levels was determined for the hardness to calculate the signal-to-noise ratio. After collecting the data signal-to-noise (S/N) ratios were calculated and used in order to obtain optimum levels for every input parameter. The Nominal-the- better quality characteristic is considered in the hardness prediction. The Taguchi method is adopted to solve this problem. Subsequently, using analysis of variance the significant coefficients for each input parameter on tensile strength & Hardness (WZ & HAZ) were determined and validated.Sukhomay Pal, Santosh K. Malviya, SurjyaK. Pal and Arun K. Samantaray studied optimization of quality characteristics parameters in a pulsed metal inert gas welding process using grey-based Taguchi method. K.Y. Benyounis and A.G. Olabi[2] The optimization methods used in this study are appropriate for modelling, control and optimizing the different welding process.

A. Kumar and S. Sundarrajan[3] Taguchi method was applied to optimize the pulsed TIG welding process parameters of AA 5456 Aluminium alloy welds for increasing the mechanical properties. P. SrinivasaRao, O. P. Gupta, S. S. N. Murty and A. B. KoteswaraRao[4] studied the effect of process parameters and mathematical model for the prediction of bead geometry in pulsed GMA welding. Ching-Been Yang & Chyn-Shu Deng and Hsiu-Lu Chiang proposes a progressive Taguchi neural network model, which combines the Taguchi method with the artificial neural network to construct a prediction model for a CO2 laser cutting effect of each welding parameter on the weld bead geometry, and then sets out to determine the optimal process parameters using the Taguchi method to determine the parameters. S.C. Juang and Y.S. Tarng studied the process parameter selection for optimizing the weld pool geometry in the tungsten inert gas welding of stainless steel. Jig is a device used to clamp work piece in a specific location so that the mechanical process is properly guided. Jigs are independent devices which fastened to the machine table (K Venkataraman, 2005[31]). Jigs are designed in such order that it able to load and unload work piece easily. Thus, we can said that welding jigs are devices that mounted on the welding table so that it can guide the welding gun and produce a straight perfect welding bead. Same with other jigs, welding jigs require gripping devices to hold the work piece in place during welding process through clamping devices. Kitchen ham, B. (2004)[30] has stated that there are various methods to clamp such as threaded fastener, cam clamps, „V" type sliding clamps, pneumatic clamps, hydraulic clamps, and more. Bothe, D. R. (1990)[7]. has stated that a clamping system should be strong enough to withstand the forces during operation without damaging the workpiece surface.

Weller E., (1995)[15], are, in most cases, not applicable to short-run SPC which assumes small production volume of the monitored product. In chemical or continuous process industries, various products or grades of the same product are manufactured in lots or batches and production of the same product continues, although intermittently, followed by batches of other products or grades and so forth. Thus, adequate historical data from past successful batches are usually available for calibrating the in-control behaviour of the quality/product variables which are usually measured once at the end of each batch run and the process variables which are monitored during each batch run.Dr. Walter Shewhart 1980[2] introduced the notion of statistical process control (SPC), and in particular control charts, as a means of monitoring industrial processes and controlling the quality of manufactured products. These and other statistical tools have proven useful in many industries.On the other hand, special causes include, amongst others, machine failure, tool wear, defective material and operator error, which are preventable or at least correctable or controllable Gardiner J.S., Montgomery D.C., (1987[3],,. The primary objective of SPC is to help detect the presence of these extraneous sources of variability so that timely corrective actions can be taken. In this manner, it is hoped that the production process will be capable of meeting given product specifications consistently and economically. Once the common-cause or inherent variability has been quantified, control charts can be used to determine when and whether or not special causes affecting the process under consideration are present aulk M.C., (2001)[25],.

Managers of sheltered work centres can also of ordinary companies, can realize about the great potential of Poka-Yoke as an easy means of flexibility and accessibility (Miralles C, HoltR, Marin-Garcia A, Canor-Daros L) [32]. The aim of Poka-Yoke method is to eliminate human errors in manufacturing process and management as a result of mental and physical human imperfection. The main idea of this method is preventer cause, which may result in errors and use relativity cheap control system for determiners compliance of the product with the model (Dudek-Burlikowksa M., Szewieczek D) [4].

(Ketola J., Roberts K.2001) [39]. The method poke-yoke is based on convenience that it is not acceptable to produce even very small quality of defective products (Ishikawa K.,) [41]. 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) [37]. The name Poka-Yoke, Shiegeo Shingo established in 1963, it is translated as “resistance to errors” (avoid yoker errors resulting from in attention (Poka).

3. Interpretation and Implementation of this study

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, fixtures required were dealt for critical study. The sample product considered for the proposed work was is the welding fixture which is 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 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 components main stand assy. 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 in 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.

3.1 Need for Present Work& its Scope in Indian Context

Similarly use of process control techniques like CP, CPK and standardized deviations in one time 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. Lastly fixtures are manufactured to improve the accuracy of the main stand that is built. There is no use if we build a very accurate fixture but do not build an accurate component. This can happen because of in accuracy in other manufacturing processes like sheet metal part manufacturing. These same principles can be applied to each and every manufacturing process in future to achieve better and more efficient process.

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.

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