Quality Information Flow Of Welding Process In Auto Manufacturing

Maw Maw Htay, Guo Shunsheng, Asa Romeo Asa

Abstract: The automobile is one of the most complex consumer products in world market today. Manufacturing a vehicle is one of the highest tech operations in the manufacturing sector. Much of the technology and concept employed in vehicle manufacturing constantly change to meet growing demand for rapidly changing technology, higher quality, and improved safety, reduced emission, fierce competition and improved energy efficiency in new vehicles. Due to these growing global demands, quality information is an important measure in quality decision-making, quality control, quality plan and it directly affects the quality of product, therefore quality information is an important resource. Welding process is common in manufacturing industry especially for car component assembling. In this study the authors discussed the basic theory of the welding process and the quality information flow in auto manufacturing processes. The internal and external inspection flow of the welding workshop and the specific information flow of the welding process were also discussed.

Index Terms: Quality management, Inspection process, Welding process, Auto manufacturing, Welding theory

1 Introduction

Welding is a manufacturing process for joining different materials. Unlike other processes, such as casting, forming, machining, etc., which are employed to produce a single component, joining processes are used to assemble different parts to yield the desired complex configuration [16]. Auto manufacturing processes include four main processes which are stamping, welding, painting and assembling. For all processes, quality is the main role in these production processes. No matter how low the cost is the products with poor quality gets negative customer attention. In this context, quality plays an essential role in every manufacturing process right through to their final marketing. In this paper the authors presents an overview of auto manufacturing process, fundamental theory of welding method and the quality information of the welding processes. Welding process is common in manufacturing industry especially for car component assembly production. The automotive manufacturing process activities can be analyzed on two levels: the manufacturing system and the process levels. The manufacturing system view is typically investigated from three different perspectives: the production line (the structural aspect) which covers the machinery, the material handling equipment, the labor resources and its allocations to the different activities. The transformational aspects include the functional part of the manufacturing system that is the conversation of the raw material into finished or semi-finished products [11]. The transformational activities include all the stamping, welding, machining and painting efforts within the plants.

- Maw Maw Htay is currently pursuing doctoral degree program in Industrial engineering in Wuhan University of Technology, China, PH-+8613720263612. E-mail: maw041@gmail.com
- Guo Shunsheng is a Professor in School of Mechanical and Electronic Engineering in Wuhan University of Technology, China, PH-+8613307126816. E-mail: guoshunsheng@263.net
- Asa Romeo Asa is currently pursuing doctoral degree program in School of Management in Wuhan University of Technology, China, PH-+8615071474543. E-mail: romeoassa@gmail.com

2 Overview of the Vehicle Manufacturing Process

The manufacturing process of the vehicles usually follows a standard process: stamping, welding, painting, making the engine, assembly and inspections [4]. Stamping is a forming process performed on sheet metal by a series of stamping stations. The stamping process is used to produce mass quantities of finished products. The steel sheet is cut according to the size of the part and is bent and cut in a stamping machine [7].Welding is the process of permanently joining two or more metal parts, by melting both materials. The molten materials quickly cool, and the two metals are permanently bonded. There are about 100 different types of welding, Arc welding is the most common type. Standard arc welding involves two large metal alligator clips that carry a strong electrical current. One clip is attached to any part of the workpiece being welded. The second clip is connected to a thin welding rod. When the rod touches the workpiece, a powerful electrical circuit is created. The massive heat created by the electrical current causes both the workpiece and the steel core of the rod to melt together, cooling quickly to form a solid bond [8]. During welding, the flux that surrounds the rod's core vaporizes, forming an inert gas that serves to protect the weld from atmospheric elements that might weaken it. Welding speed is important because variations in speed can change the amount of flux applied, weakening the weld, or weakening the surrounding metal by increasing heat exposure. Spot welding and seam welding are also two very popular methods used for sheet metal parts [17]. Spot welding is a process in which contacting metal surfaces are joined by the heat obtained from resistance to electric current flow. Seam welding is a process that produces a weld at the faying surfaces of two similar metals [15].The painting processes start after the body of vehicle is assembled. The purpose of this processes are to give more attractive appearance to the vehicles and to provide the layer of protection against corrosion and weathering. Car painting is a complex combination of different layers of base coat, color and protective finishing coat. The setup for the painting process requires the optimal adjustment of a variety of different parameters such as humidity, temperature and the consistence of the lacquer itself. The paints and coatings industry is made up of many different types of operations, ranging from large-volume original equipment manufacturers that run highly automated, closely monitored systems to custom shops performing a range of contract work with

manually operated equipment [9]. After painting process, it needs to consider making engine parts. These parts are then used to assemble the engine and suspension. Assembling is the manufacturing process (sometimes called progressive assembly) in which parts (usually interchangeable parts) are added to a product in sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods [3]. The parts are attached according to the customer's orders. In the inspections process, these are made on the brakes, windshield wipers, engine components and parts and other supply systems.

3 FUNDAMENTAL WELDING THEORY

The welded connections are solid, non-detachable connections based on the principle of local melting of connected parts using heat or pressure. The joining of components may be achieved technically using two methods:

-Fusion welding (arc, flame, plasma, laser and thermite) This weld is a result of local melting of the material of connected parts, and usually also filler metal, without pressure.

-Pressure welding (resistance, induction, ultrasonic, friction and explosion) After melting in, the components join in the contact spot using mechanical pressure or impacts. An optimum result of the welding process should be a weld with mechanical properties similar as far as possible to the properties of the basic material. According to their function, can divide welds into:

-Force welds - load-bearing welds used to transfer external load

-Tack welds - welds providing only compactness of the whole (with no or negligible external load)

-Caulk welds - welds providing staunchness of connected parts (vessels, pipelines, etc.)

This program is designed for the calculation of statically loaded welded connections of machinery structures manufactured, for working temperatures ranging from -20 to 150°C. The program enables to perform geometrical design and strength checks of force connections with the most common types of fusion welds and connections with spot resistance welds [14]. The calculation does not consider the sudden formation of fragile fractures, change in material properties due to temperature, impact of own tensions or concentration of stress in the weld. An accurate theoretical solution to force and strength conditions is an extremely complicated problem for welded connections, even for welds with simple shapes. That is why common technical calculations are based on a range of conventions and simplified premises. In view of the strength checks, welded parts are usually considered a single compact part with a dangerous spot (section) in the welded area. On the grounds that there is an even distribution of stress in the active weld section, only theoretical rated stress in the specified section is specified for the respective load, regardless of the technological workmanship of the weld or potential internal tension [10]. For connections with multiple welds, an even load on individual welds is assumed. The strength checks of the connection are performed by simple comparison of the calculated rated stress with the permissible stress in the weld. Permissible weld stress "S_{wA}" is usually specified from the value of the yield strength of the basic material "R_e" based on the required safety.

$$S_w \le S_{wA} \qquad S_{wA} \approx \frac{R_e}{FS}$$

When selecting the safety coefficient "FS", it is necessary to consider the specific factors of welded connections in addition to the general principles used to specify the safety coefficients. The required safety degree should respect all the facts that were not considered in the calculation of rated stresses (technological workmanship of weld, weld quality, internal tension, weld homogeneity, shape and finish of weld surface, weld reinforcement, ignites and penetrations, etc.). The direction of stress and the anisotropic properties of material in the weld must also be considered. Different weld material properties in the vertical and horizontal direction result in differing values of the safety coefficient depending on the type, workmanship and load type of the welded connection [2]. The rated stress specification in the load-bearing section of the fillet weld is an extraordinarily complicated task due to the combined load. Therefore, a simplified method is used in the calculation for handling fillet welds that reclines the load-bearing weld section into the plane of connection of the parts. Depending on the respective load, the individual stress components are specified in such reclined section, in the direction normal to the weld (⊥) and in the direction parallel to the weld (‖) (see Fig.1). This convention also includes an assumption that all components specified like that will actually have a character of the shear stress. The calculated rated stresses must not exceed the values of permissible material stress in shear. This method represents a general method of handling welded connections and is based on the most frequent calculation methods for welded connections of machinery equipment .Depending on the respective type, workmanship and load of the welded connection, this method calculates the respective theoretical rated stress in the load-bearing weld section (normal, shear, or equivalent) in the first step. The strength checks of the weld are then performed by simple comparison of the calculated stress to the yield strength of the basic material. With respect to the type of calculated stress, we can describe the conditions of the load-bearing capacity of the weld using the following relations:

$$S_w \le \sigma_A \le \frac{R_e}{FSy} \qquad \sigma_\perp \le \sigma_A \le \frac{R_e}{FSy'}$$

$$\tau_\perp \le \tau_A \le \frac{R_e}{FSy''} \qquad \tau_\parallel \le \tau_A \le \frac{R_e}{FSy'''}$$

The required safety of the weld stress is then the ratio between the value of the yield strength of the basic material and the value of the maximum admissible stress of the specific weld. This method is disadvantageous due to the rather complicated procedure in specifying the suitable safety rate minimum value. In addition to the common (qualitative) criteria, specific factors of the specific welded connection (type, workmanship and the way of connection load) must be considered when choosing the required safety. The required

safety for the yield strength "FSy" is then defined as the product of two safety coefficients FSy = FS1 * FS2. FS1 depends on the direction of the acting stress and the anisotropic properties of the material in the examined weld spot, its value should also consider the technological weld parameters. With respect to the type, workmanship and the way of connection load, it is chosen from the range 1 to 2.

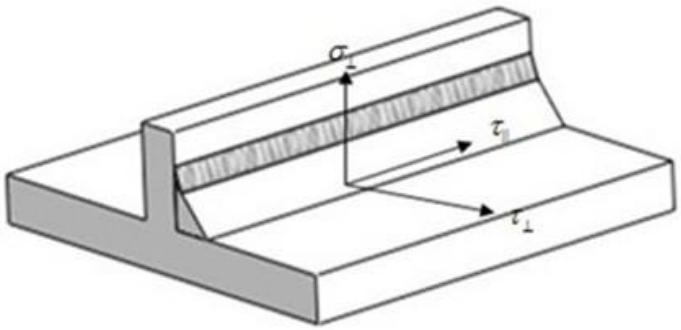

Fig.1 Illustration of Strength in Welding

FS2 considers qualitative parameters. With respect to the accuracy and value of input information, connection importance, production quality, operating conditions and calculation accuracy, it is usually chosen from 1.1 to 2.

4 Welding Procedure for Auto Manufacturing

The production process in the weld shop starts by manufacturing of subgroups – smaller car body units, such as doors, parts of the floor or the roof. The ratio of automation in production of subgroups is approximately 50%. Completion of large units and the final car body are provided by fully automated line working within one tenth of a millimeter precision [1]. A car body may contain more than 3000 welds from floor to roof, on motor compartment, seat rails and doors. All these welds are numbered in construction plans and the results of the ultrasonic examinations have to be linked to these individual positions and numbers [13]. This produces a basis for quality assurance for all joints in the components of the car body. At first, the robots weld the front and rear parts of the floor into one. The completed floor then moves to a totally revolutionary type of a production line the so-called global body line, where other parts are welded to the chassis sides, dashboard and roof [5]. The weld shop contains over 200 robots of various types. 2220 welds are made on the car during the welding process, using spot and arc welding in protective atmosphere. When including welds made at suppliers on smaller parts, one car has a total of 3300 welds. When the car body is completed and adjusted, it passes to the main welding line, where robots perform strong welds, strengthening the whole car body [12]. This step is followed by installation of minor body parts and installation of doors and the hood. The car body is then taken to individual quality inspection and then to the paint shop.

5 The Model of Information Flow Quality of Welding Workshop

In the production of the body of white car, metal forming of steel plate will be welded into a complete body which is the most important part of the vehicle. Established a specific quality of internal and external information flow model welding workflow, on the base of understanding of specific workflow of welding workshop, and the existing quality control approach, and make a classification through the quality information of welding workshop. Working as the second link of the four big craft workshop ,the welding workshop are closely linked with suppliers, stamping plant, paint shop, assembly shop, the quality department, manufacturing department, and technical center, and each department has a different interaction [6]. The specific information flow in the welding workshop is shown in Fig.2.The welding workshop will check the incoming before welding production. If the parts supplying outside are found failure, the workshop will return material to the supplier. If the suspicious materials are found in the parts supplying outside, it will inform the SQE to handle through consultations. As the downstream of stamping workshop, the information exchange between welding workshop and stamping workshop are particularly frequent. The quality of stamping has a direct impact on the quality of welding of the body so in this process, stamping plant feed-forward information is very important. Similarly, the welding workshop should provide the feed-forward information for the paint workshop, and assembly workshop. Defects in quality painting and assembly found in the production process that involves the body shop will be promptly notified to the welding workshop to take corrective measures. Quality department set a SIP confirming station in the last section of the welding workshop, to check the white car which will be storage and find the quality defects, will determine the area of responsibility rework rectification. The quality of test results will be shared with the workshop. The welding workshop will promptly notify the equipment problems found in the production process to carry out maintenance and manufacturing department on a regular basis the body shop equipment, inspection, maintenance and equipment repair information, timely feedback with the welding workshop. The information exchange between the welding workshop and the technology center is very frequent, and technology center provides mainly information for the welding workshop, which includes processes information. But the fight fixture models matching guidance check with the operating specifications and other information is not very comprehensive, but needs to be improved.

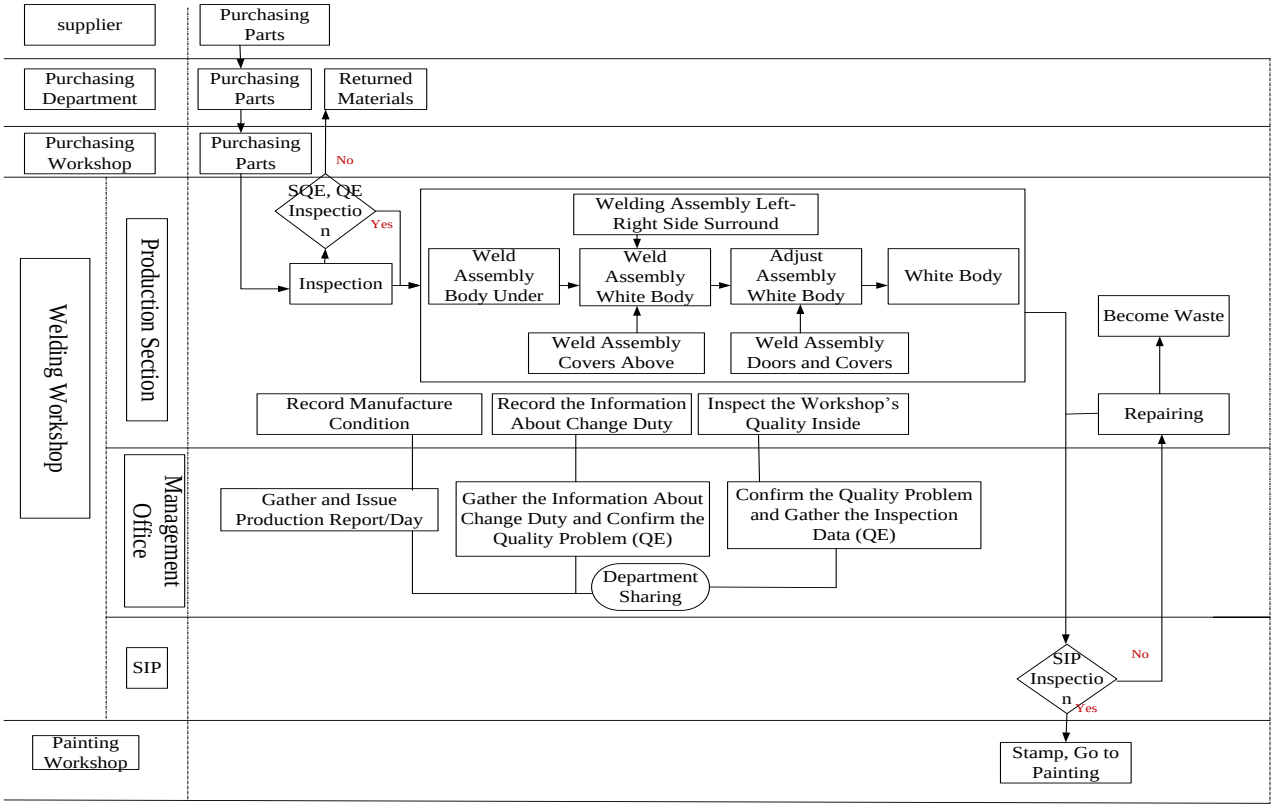

Fig.2 Specific Information Flow in the Welding Workshop

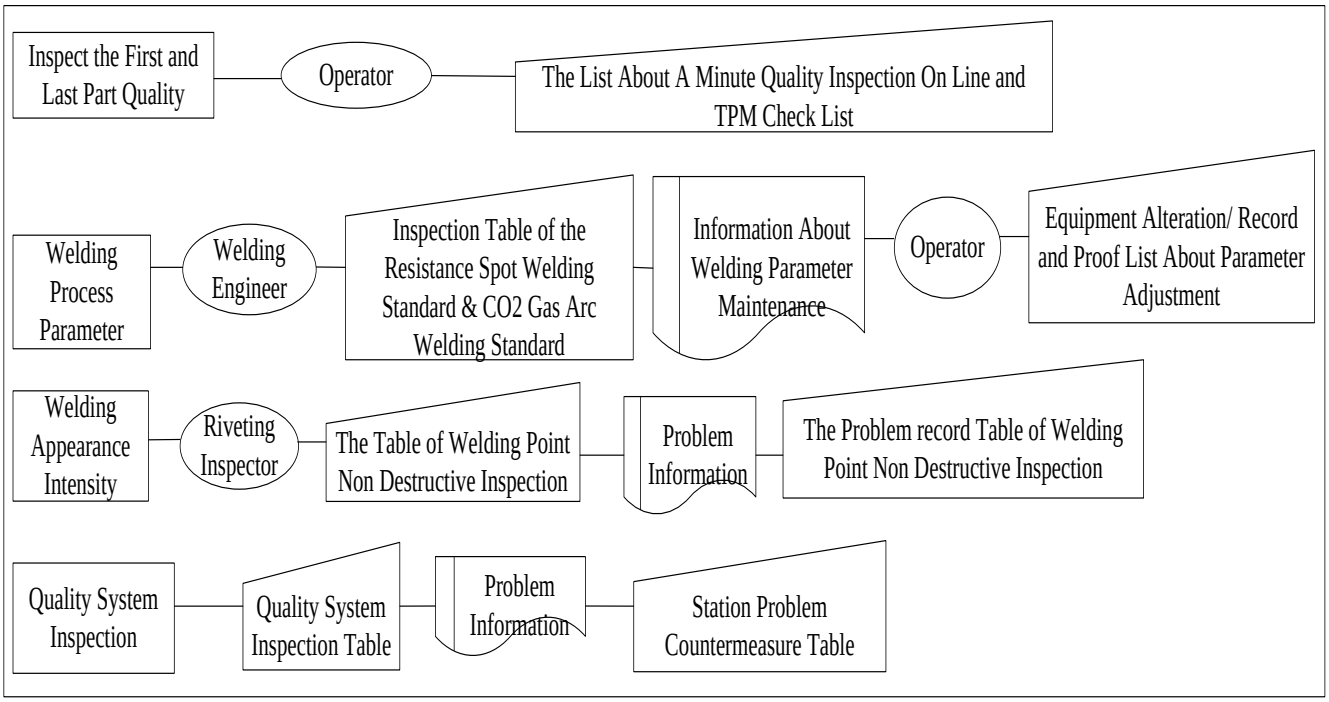

Fig.3 Internal Inspection Process in the Welding Workshop

6 INFORMATION CLASSIFICATIONS IN WELDING WORKSHOP

In the information classification in welding workshop, generally there have two inspection processes. These are internal inspection process and external inspection process. The operation of the internal inspection process in the welding process is shown in Fig.3. The operator of various processes production line should do a minute check for the first and last parts and pass minute check information. Operators of production line process check the workshop equipment per shift, fill out the TPM checklist, and pass the TPM check information. Welding engineer check the welding parameters, fill the results in "resistance spot welding specifications checklist and CO2 gas shielded welding specifications checklist", resistance spot welding specification checks table, and pass welding parameters to maintain information. The riveting inspectors check the strength of solder joints of non-destructive examination against welding appearance, fill the results in "the solder joint non- destructive checklist", and pass the solder joint non-destructive inspection information. The quality problems which are checked by workshop SIP Station, the GCA review related to the welding workshop problem, CMM problem, AUDIT reviewing problem and car body problem found by other workshop will feedback to the corresponding section of the workshop in the form of quality information card or PCR, transmit quality problem information and PCR information as shown in Fig. 4.

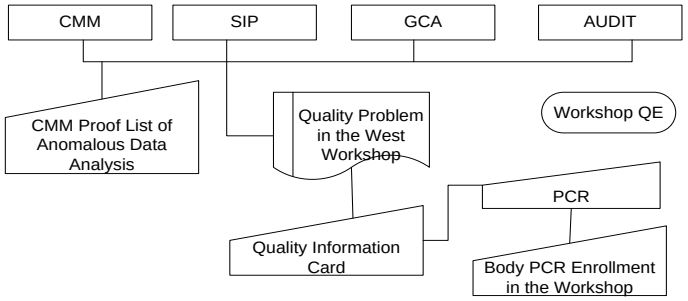

Fig.4 External Inspection Process in the Welding Workshop

Manufacturing engineers, quality engineers, statistic and analyze workshop quality objectives operation to forming day/week/month of journal sheet, transfer workshop operation state quality information is shown in Fig. 5.

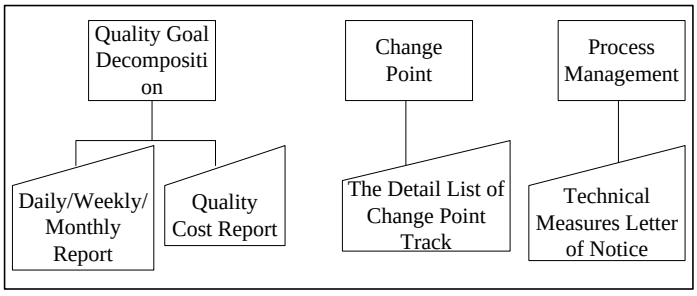

Fig. 5 Transfer Workshop Operation in the Welding Workshop

Team leader and engineers put the change point together, and feedback for region chief of a section, according to change some the content of changing point and change the classified standards of changing point to make related measures, and feedback team leader and employees, and put the related content to visual board of changing point in workshop. When a control cycle end, the chief of a section determine whether the changing point can be closed, the point can be closed exiting visual wall in workshop, the chief of a section responsible clear the related content, that can't be closed, open another control cycle. When solving GCA and FTQ problems, such as the corresponding technical measures needed to increase, team leader and engineers will distribute measures under the technical measures advice .The chief of a section receives the notice issued by the engineer technical measures, staff training, and supervise the implementation of the measures.

7 CONCLUSIONS

For an auto manufacturing enterprise, the manufacturing process quality information management is an important link of the quality control in the process. It is an important role for the timely discovery in the process of manufacturing defects and deviation; ensure the process quality control effectively. The quality of manufacturing engineering refers to the manufacturing process quality, it points to the design requirements, through the production process manufacturing and actually reached physical quality, is the realization of the design quality. The operation of the research as a whole process requires the close cooperation of various departments. Secure sharing of information can make the relevant departments to obtain the required information in the shortest time, under the premise of doing the work of the department. The information provided in this research will greatly improve the quality of corporate governance in all aspects and product quality, accelerate the development of enterprises, and enhance the competitiveness of enterprises. This also may inspire local and overseas students interested in learning quality information management in manufacturing engineering.

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