Application of CAD in Design of Tack Welding Fixture for Front Chassis of Wheel Loader

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***Abstract*—The main load carrying member of any equipment is the chassis which consists of many sub-components that are joined by welding. To achieve high productivity while at the same time reduce unit cost and achieve interchangeability during assembly, it is important to have suitable setting arrangements during tack welding to improve the work holding of the components. This necessitates the development of fixture which helps in securing the job during tack welding. In this paper a proposal in given on the appropriate fixtures needed during tack welding of front chassis for a wheel loader. The input data are the Engineering drawings and process sheets of front chassis. The output data are the CAD models of the needed fixtures done using Creo Parametric 1.0.**

Keywords—CAD;Welding;Fixture; Creo; Design

I. INTRODUCTION

Design experience has been recognized as a significant source of knowledge in the creative process of design. Fixture design as a key process in manufacturing has traditionally been a human job which time consuming and experience plays an important role in the fixture design quality. Since the 80s of last century, computer aided fixture design has got great progress and has gained more attention. While manufacturing a mechanical part, the process of work holding becomes necessary to reduce manufacturing cycle time. It is often seen that only approximately less than 10% of the overall time required to fabricate a part is spent actually on tack welding of a work piece; the other time is spent primarily on planning for executing part setup, work holding and handling of part which requires highly skilled fitter with vast experience. Recently, industries are finding difficulty to find highly skilled fitter because the number of apprentices is decreasing and it is likely that the situation will worsen in near future. This necessitates that setup and work holding to be efficient to increase the rate of loading and unloading and speed up the manufacturing cycle time. The use of fixtures also eliminates individual marking, positioning and frequent checking before welding, thereby resulting in considerable saving in set-up time. In addition, the usage of fixture saves labour by simplifying locating and clamping tasks and makes possible the replacement of skilled workforce with semi-skilled labour, hence achieves substantial saving in labour cost. Widely used in manufacturing, fixtures have a direct impact upon product manufacturing quality, productivity and cost, so much attention has already been paid to the research of computer aided fixture design and many achievements in this field have been reported.

II. OVERVIEW OF FIXTURE

A. Fixture

A Fixture is a work holding device used in the manufacturing industries. Fixtures are used to securely locate the position or location and to support the work, ensured that all parts produced using the fixture will maintain conformity and interchange ability. Using this fixture improves the economy of production by allowing smooth operation and quick transition from part to part production [1].

B. Fundamental Principle of Fixtures

For a fixture designer, the major portion of design time is spent deciding how to locate the work piece in the fixture. It is known that any free body has a total of twelve degrees of freedom as below:

6 translational degrees of freedom: +X, -X, +Y, -Y, +Z, -Z

And 6 rotational degrees of freedom:

- Clockwise around X axis (CROT-X)
- Anticlockwise around X axis (ACROT-X)
- Clockwise around Y axis (CROT-Y)
- Anticlockwise around Y axis (ACROT-Y)
- Clockwise around Z axis (CROT-Z)
- Anticlockwise around Z axis (ACROT-Z)

It is necessary to fix all the 12 degrees of freedom as shown in Fig 1., except the three transitional degrees of freedom (-X, -Y and -Z) in order to locate the work piece in the fixture. So, 9 degrees of freedom of the work piece need to be fixed. This is done by using the 3-2-1 method [2] as shown below:

- Rest the work piece on three non-collinear points of the bottom surface (XY), so that +Z, CROT-X, ACROT-X, CROT-Y and ACROT-Y degrees of freedom are constrained.

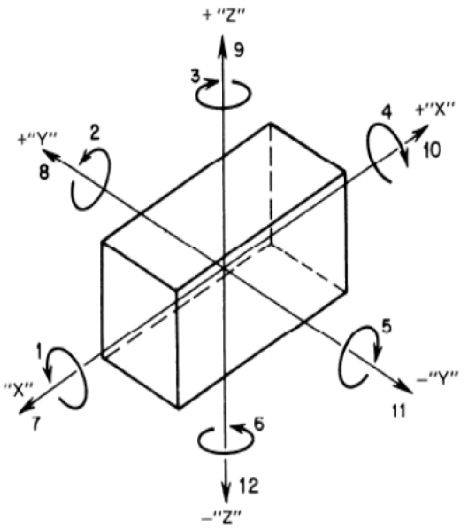

Fig. 1. Degrees of freedom for a free body

- Now, rest the work piece at two points of side surface (XZ), so that +Y and ACROT-Z degrees of freedom are constrained.
- Now, rest the work piece at one point of the adjacent surface (YZ), so that +X and CROT-Z degrees of freedom are constrained.

C. *Essential Features of Fixtures*

Fixtures having some essential features that has to be incorporated into it in the design stage. They are

- Reduction of Idle Time - The design of jigs or fixtures should be such that the process of loading and unloading the components takes the minimum possible time and enables on easy location and clamping should be such that idle time is reduced to minimum.
- Replaceable parts or standardization - The locating and supporting surfaces, as far as possible should be replaceable that is not permanently fastened. When worn out, new ones may replace them. Moreover, they should be standardized so that their interchangeable manufacture is possible.
- Position of clamps - The clamps should be so positioned that clamping occurs directly above the points supporting the work piece so as to avoid distortion and springing of work, which otherwise will result in an inaccurate work. Moreover, the clamps should be strong enough to resist bending under clamping pressure.
- Fool Proof - The fixture should be made fool proof as far as possible so that even a semi skilled worker can manufacture the component without any mistakes.
- Safety and usability - The design of fixture should be such that it should not constitute any danger to the operator. The locaters and clamps should be visible so that they can be conveniently used by the operator.
- Economic soundness - The equipment to be used should be economically sound, i.e., the cost of its designing and manufacturing should be in proportion to the quantity and price of the producer.

D. *Design Guidelines for Welding Fixtures*

A few design guidelines applicable to welding fixtures are given below [3].

- Welding spatter should not be allowed to fall on the threaded parts of the clamping elements and the parts near the welding area should not to be threaded.
- As far possible, the fixture should be designed that all welding in one setting.
- Clamps should be kept clear of welding zone or be shielded.
- The removal of work piece from the fixture should be as easiest as possible after welding.
- Location & clamping should not make the welding zone inaccessible.
- Care should be taken to check that the joined work piece do not get locked in the fixture after welding.

III. FIXTURE DESIGN METHODOLOGY

The fixture design starts with realization of knowledge of the part geometry, welding process and fixture resources. The main sources of information are the engineering drawings and process sheets. From engineering drawings all the necessary dimensions and tolerances that has to be controlled in the final component is obtained. These are called manual check points that have to be verified before tack welding. Process sheet gives the sequence of operation that has to be performed to get the desired component.

A. *Component Details*

As a part of initial stage, component geometry is discussed here. The component 3d model is as shown below in Fig. 2. The component is Front Chassis, made up of Structural Steel material, weighing about 1300 kg.

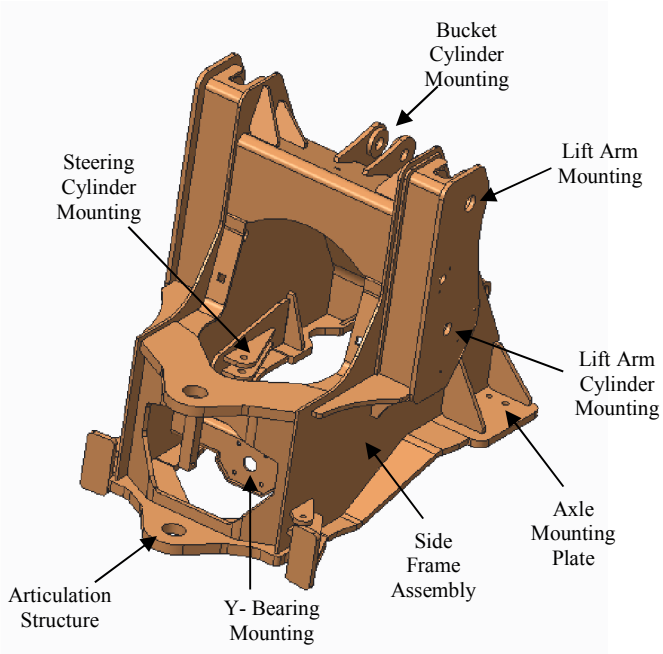

Fig. 2. Front Chassis of Wheel Loader

B. Identification of Need

The need for developing the fixture was identified by observing the process of setup and discussing with operator. The following are some of the need identified apart from the basic need of fixtures. They are

- All the manual check point to be eliminated, if possible.
- External aids should be minimized.
- Clamping & locating arrangements should be as simple as possible.
- If possible all components should be welded in single stage.
- Arrangements for placing components inside the chassis should be made as easy as possible.

C. Fixture Concept

In any product design process, the initial step is to create conceptual drawings so that the idea of the product could be better understood. Below Fig. 3 shows the concept drawing of fixture. The concept drawing helps to identify the position of locaters, supports and clamps. It also helps to identify different alternative position of locaters, supports and clamps.

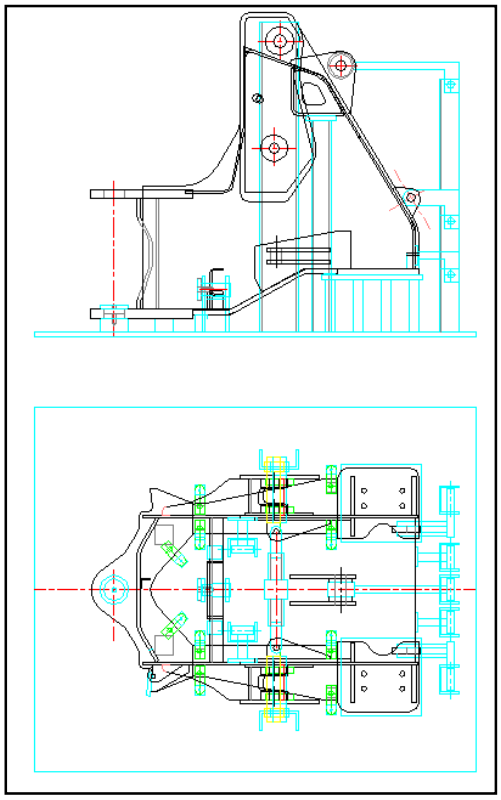

Fig. 3. Fixture Concept with Front and Projected Top Views

D. Detail Design of Fixture

During tack welding, the position of component is a key aspect, and fixtures are the elements responsible to satisfy this general goal. Usually, a fixture solution is made of one or several physical elements, as a whole the designed fixture solution must satisfy the entire functional requirements and the associated constraints. Locating, clamping, and supporting, can be considered the functional requirements of fixtures. In terms of constraints, there are many factors to be considered, mainly dealing with shape and dimensions of the part, tolerances, sequence of operations, cost, etc. Considering this, the circular locaters are used locating the centre of articulation structure and a pin with screw is used to clamp it as shown in Fig. 4. The Side frame assembly is located using circular locators as shown in Fig. 5 and screw clamps with swing arrangement are used for clamping them. The Bucket cylinder mounting oriels are located using circular locator and a pin with screw arrangement is used to clamp them. The rear Axle mounting plate is located using circular locator with bolt and nut for clamping as shown in Fig. 6. The entire fixture is modeled using the software Creo Parametric 1.0.

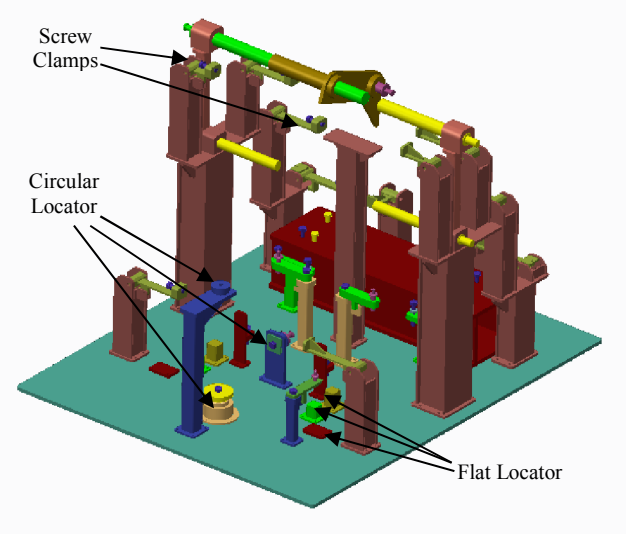

Fig. 4. Fixture for Front Chassiss

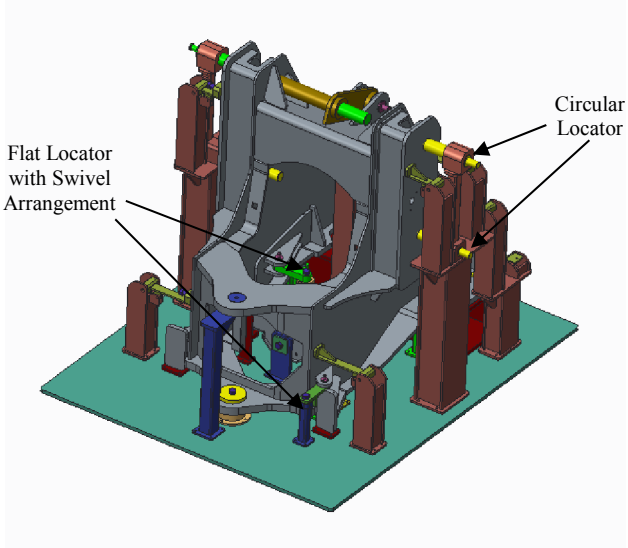

Fig. 5. Fixture with Front Chassis Assembled – View -1

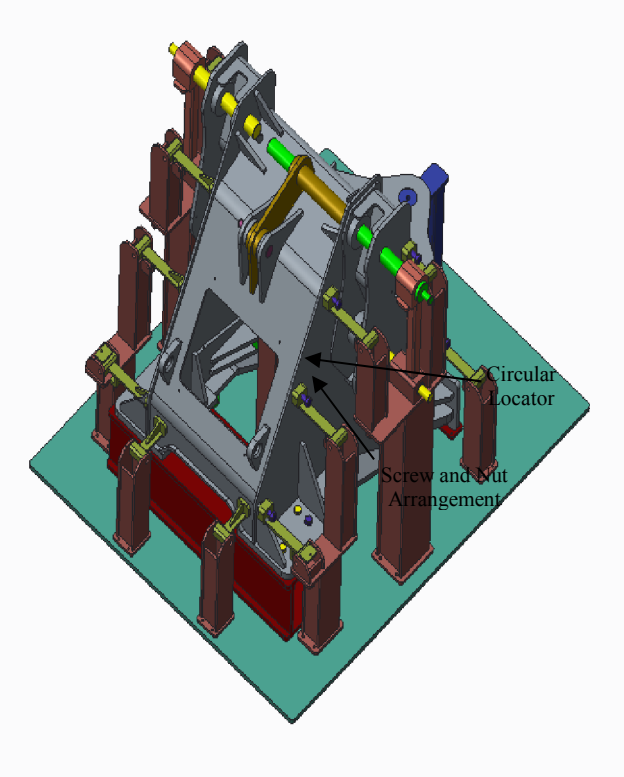

Fig. 6. Fixture with Front Chassis Assembled - View -2

IV. CONCLUSION

In this work, a tack welding fixture is designed using Creo Parametic 1.0 for front chassis of a wheel loader. The application of CAD techniques in designing fixture helps to analyse the different possibility of locating, supporting and clamping arrangements. Compared with the traditional design method, it can improve the design efficiency 3-4 times more. Due to the simple arrangement of clamps and locaters, the level of skill required to assemble and operate these fixtures are very low, making it more and more economically viable apart from reducing the cycle time required to fabricate the components. Currently, most of reported research has been mainly focused on machining fixture, and the applications of computer aided fixture design technology are still very limited in the welding sector.

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