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Design and Thermal Stress Analysis of Welding Fixture of a Brake Pedal

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***Abstract*—** Fixtures, the component or assembly that holds a part undergoing machining, must be designed to fit the shape of that part and the type of machining being done. The parts to be welded are placed in proper position in fixture and tightened. Welding fixture holds and supports the work piece, prevents distortion in work piece during welding process and withstands high welding stresses. Design of welding fixture involves several parts which broadly include body, locating elements, clamping element and positioning elements. Welding fixture may be modular or permanent fixture, modular fixture is just like permanent fixture with some key changes like it has specially designed tooling plate, block with standard grid pattern and modular elements with great flexibility to arrange them with high accuracy. Brake pedal assembly is to be welded on fixture using MIG welding process. The relative arrangement of different elements on base plate of fixture is vital part of design. The welding fixture will serve in reducing production time, maintain consistent quality, maximize efficiency, and reduce operator error and makes possible mass production of similar parts in very less time.

Keywords: *welding fixture, flexibility, brake pedal assembly*

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I. INTRODUCTION

Fixtures- the device that locates and holds the work piece during its machining process. Fixture design has large impact on the product quality manufacturing lead time and the cost.

The obvious place for fixture is the mass production, where large quantity output offers simple opportunities for recovery of the necessary investment. However, the advantage in use of fixtures are so great and so varied that these devices have also naturally found their way into production of parts in limited quantity as well as into manufacturing processes outside of machine shop, and even outside of machine cutting industries.

It is a special tool use for locating and firmly holding a workpiece in the proper position during the manufacturing operation.as a general rule, it is provided with devices for supporting and clamping the workpiece. It is fixed to the machine bed by clamping in such a position that the work is in correct relation to the machine tool elements. These are the devices which accelerate the production particularly with 100% interchanging parts.

II. BASIC ELEMENTS OF WELDING FIXTURE

Locators: A locator is usually a fixed component of a fixture. It is used to establish and maintain the position of a part in the fixture by constraining the movement of the part.

Clamps: The main purpose of clamping is to securely hold the work piece against the locators throughout the work cycle.

Fixture body: Fixture body, or tool body, is the major structural element of the fixture. It maintains the relationship between the fixtures elements namely locator, clamps, supports and the machine tool on which the work is to be processed.

Supports: A support is a fixed or adjustable element of a Fixture. When severe part displacement is expected under the action of imposed clamping and processing. [3]

III. DESIGN CONSIDERATIONS

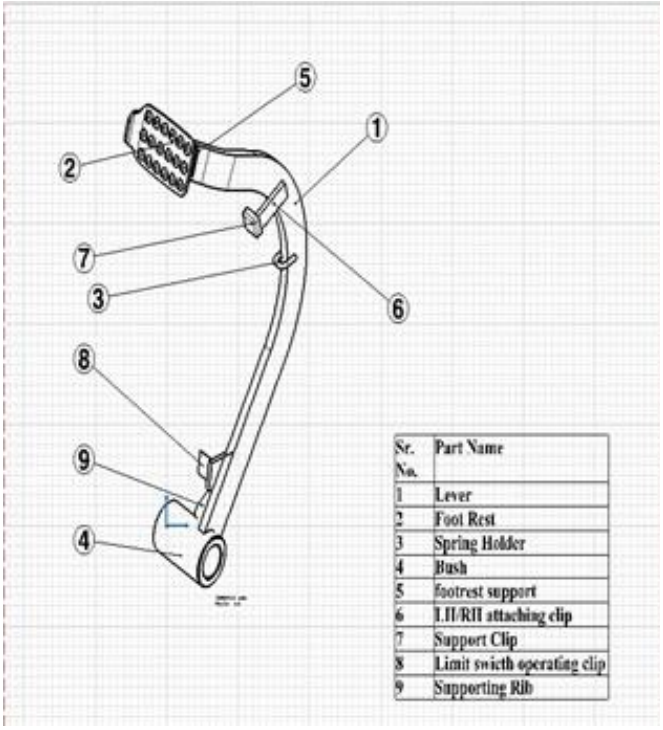
- Expansion of the heated work piece and resulting distortion should not affect proper location, clamping, loading and unloading. There should be adequate clearance between the work piece and locators to permit expansion, contraction and distortion of the work piece without jamming the fixture. Handles

subjected to heating should be made of insulating materials such as wood.

- Welding spatter should not be allowed to fall on the threaded parts of the clamping elements. The parts near the welding area should not to be threaded.
- Spatter grooves must be provided below the line of welding to prevent the work piece from getting welded to the base plate.
- Care should be taken to check that the joined work piece do not get locked in the fixture after welding.
- For work piece requiring welding from a number of sides, a provision for easy tilting or rotating the fixture should be made to ease welding from the various sides.
- To protect the weld from the atmosphere, the purging facility can be designed. [1]

IV. INTRODUCTION TO BRAKE PEDAL

We have designed the welding fixture of the brake pedal of the tractor. Before this we should have some basic information of the brake pedal like its parts, of which material it is to be made, etc. It consists of 9 parts viz. lever, footrest, spring holder, bush, footrest support, LH/RH attaching clip, support clip, limit switch operating clip and supporting rib. All the parts are made of MS.



Sr. No.	Part Name
1	Lever
2	Foot Rest
3	Spring Holder
4	Bush
5	footrest support
6	LH/RH attaching clip
7	Support Clip
8	Limit swicth operating clip
9	Supporting Rib

Figure 1: Brake Pedal and its parts

V. DESIGN METHODOLOGY

The design of the welding fixture for brake pedal is carried out as per the flow chart given in fig2. In this flow chart, the initial step starts with the material information, machine specifications, geometric dimensions and tolerances required to be achieved on the component, and different parts of the head end sub-assembly and their cad drawings which are modeled using the software CATIAV5R21. Before the design of the welding fixture the fixture requirements have to be considered.

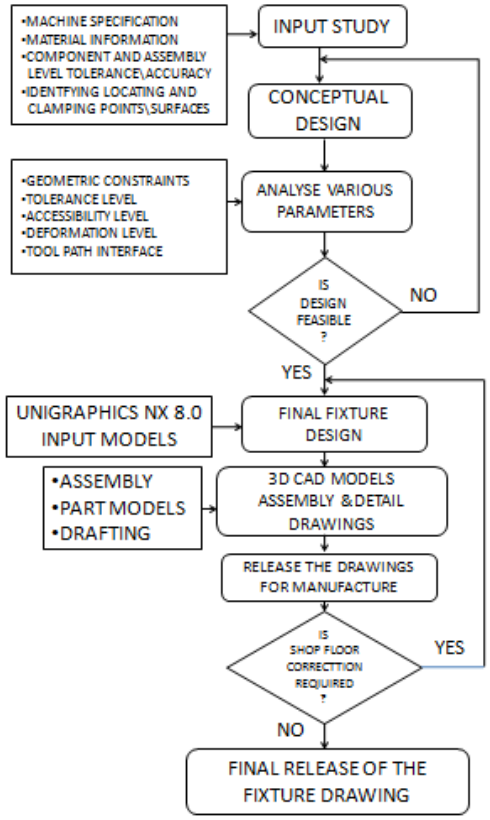


Figure 2: Flow Chart to design the fixture. [1]

Some of the requirements are stated below:
Generic requirement: Abstract sub-requirement examples.

- Physical: The fixture must be physically capable of accommodating the work piece geometry and weight. The fixture must allow access to the work piece features to be machined.
- Tolerance: The fixture locating tolerance should be sufficient to satisfy part design tolerances.
- Constraining: The fixture shall ensure work piece stability (i.e., ensure that work piece force and moment equilibrium are maintained). The fixture shall ensure that the fixture/work piece stiffness is sufficient to prevent deformation from occurring that could result in design tolerances not being achieved.
- Affordability: The fixture cost shall not exceed desired levels. The fixture assembly/disassembly times shall not exceed desired levels. The fixture operation time shall not exceed desired levels.
- Collision prevention: The fixture shall not cause tool path– fixture collisions to occur. The fixture shall cause work piece–fixture collisions to occur (other

than at the designated locating and clamping positions).The fixture shall not cause fixture–fixture collisions to occur (other than at the designated fixture component connection points).

- Usability: The fixture weight shall not exceed desired levels. The fixture shall not cause surface damage at the work piece/fixture interface. The fixture shall provide tool guidance to designated work piece features. The fixture shall ensure error-proofing (i.e., the fixture should prevent incorrect insertion of the work piece into the fixture). The fixture shall facilitate chip shedding (i.e., the fixture should provide a means for allowing machined chips to flow away from the work piece and fixture).[2]

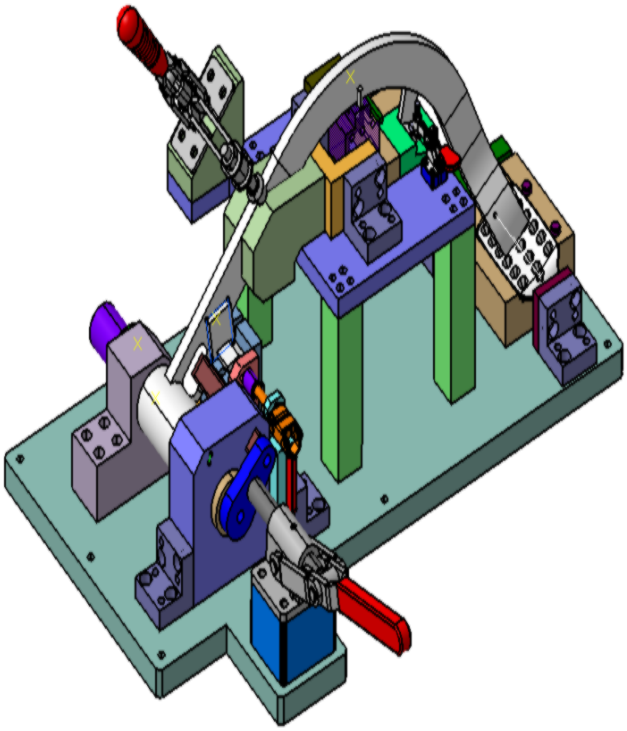


Figure 3: Welding Fixture with brake pedal mounted

VI. THERMAL STRESS ANALYSIS

After designing next step is to do the thermal stress analysis of the welding fixture and also of the brake pedal. Thermal stress analysis is important because as per the law of conduction heat is transferred throughout the body of the fixture and also the brake pedal. To know up to how much extent heat flows across the body, thermal analysis is done using the software ANSYS 14.0.

Thermal analysis helps in calculating the thermal stresses which are to be generated while welding of the fixture. Also it helps in determining whether the fixture material will withstand the thermal stresses which will be generated on the fixture and brake pedal. This heat flow along the body of the fixture depends on the welding temperature. Considering MIG welding process which has the maximum temperature of around 3200°C using CO_2 gas.

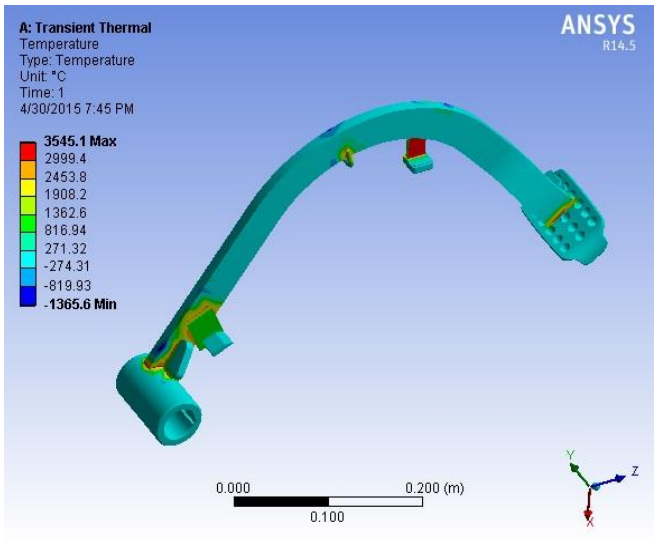


Figure. No. 4 Thermal stress analysis of Brake Pedal

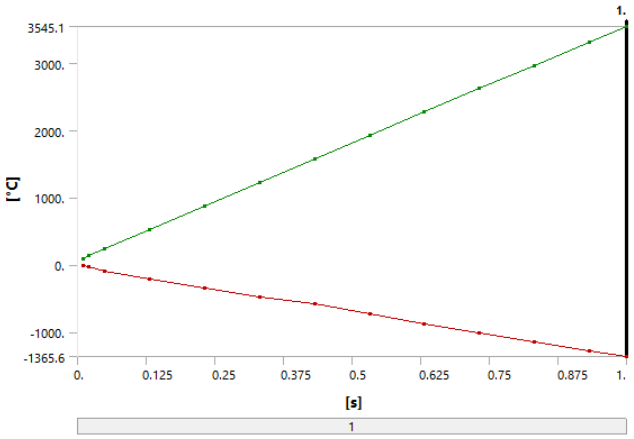


Figure No. 5 Temperature Vs. Time Variation (Max and Min Temp.)

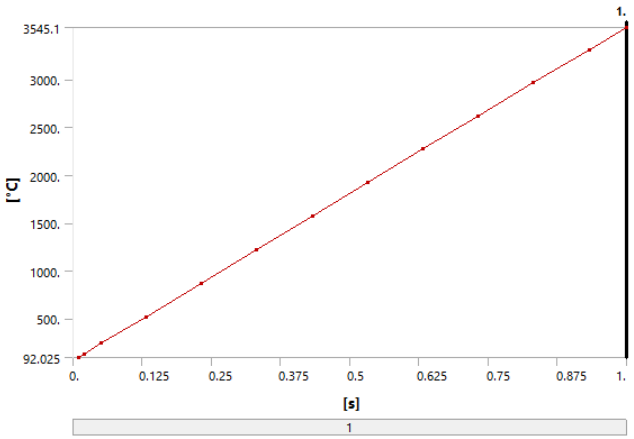


Figure 6 Global Maximum Temperature Variation

Time [s]	Maximum [°C]
1.00E-02	92.025
2.00E-02	132.07
5.00E-02	239.38
0.13201	520.43
0.23201	865.37
0.33201	1219.5
0.43201	1571.7
0.53201	1922.1
0.63201	2271
0.73201	2618.6
0.83201	2965.1
0.93201	3310.6
1	3545.1

Table 1: Temperature variation with time

Density	7850 kg m^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	434 J kg^-1 C^-1
Thermal Conductivity	60.5 W m^-1 C^-1
Resistivity	1.7e-007 ohm m

Table 2: Material Properties

CONCLUSION

An attempt was made to design, analyze and optimize the welding fixture of the brake pedal of a tractor by using ANSYS Workbench 14.5. From results of the thermal analysis we observed that the thermal stresses are distributed around the welding points. Also the graph shows the temperature variation with respect to time.

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"No matter what accomplishment you achieve, somebody helps you."

-Althea Gibson

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