Chapter 42
Analysing the Effect of Fixture on Manual Welding Application

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Abstract The industries are moving towards automation to stay competitive in a competitive world with accurate and fast production. Welding is the most convenient method of joining two materials and is used in various industries. However, the disadvantage of welding is that it is more challenging to achieve the desired surface finish for a specific job. Large-scale factories will use advanced welding techniques such as automated laser welding and electron beam welding to improve the precision of the welding process. However, manual welding methods are also used in small-scale industries. The welded pieces have a poor surface finish and low quality. The precision of the surface finish of the welded circular component was measured in this study, which required both translation and longitudinal motion welding. As a result of the findings, we created a fixture to improve surface finish and production volume. The design constraints must be flexible, thermally resistant, and not increase the welding time. Owing to the setup time of part on fixtures, the increase in welding time results in decreased production volume. So, using the 3–2-1 theory, we established fixture design functions that reduced the total time of a component by 25.39%.

Keywords Manual production technique · Welding · Poor surface finish · Fixture · Production rate

Introduction

Welding is the most widely used way of joining two pieces all over the world. According to Zhao et al., the dynamic voltage can be used to test the accuracy of welding. [1]. The computational welding mechanics monitor the weld distortions on large beams and structures [2]. Penttila et al. used laser triangulation measurement to assess the welding accuracy. It shows the weld geometrical analysis and weld bead consistency [3]. Buffa et al. developed a fixture for friction stir welded titanium alloys, investigated mechanical and metallurgical properties, and emphasised the

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challenges of fixture [4]. Jigar D et al. designed a fixture for welding an exhaust impeller and analysed it in ANSYS bench work. He selected the welding parameters like current, voltage, welding wire, welding speed, gas mixture [5]. Welding is the most economical and efficient way to join metals permanently. It is the only way of joining two or more pieces of metal to make them act as a single piece. Welding is vital to our economy [6]. So, the finishing needs to be more accurate and precise. But without new techniques, it is not feasible. We attempted to improve the surface finish of the manual weld component in small-scale applications in this paper. The supply of fixtures is a fantastic choice for this. However, for the best fixture design, the above considerations must be prioritised. The degree of freedom, thermal resistivity, heat transfer, height, and shape are all considerations that are taken into account.

Mounting Bracket Applications on Automobiles

Mounting brackets are firm holders of the parts on dynamic vehicles. The correct positioning of the brackets on the vehicle resists the vibration and helps to perform better [7]. The mounting brackets usually undergo a high amount of stress and a dynamic imbalance that needs to be resisted. They identified that durability and fatigue strength are the main parameters to be calculated to control both uninterrupted stress and fluctuating vibrations [8]. Tushar P. Kamble et al. optimised the engine mounting bracket design shown in Fig. 42.1, which firms the engine without fluctuations or vibrations. This study focussed on modelling the mounting bracket in CREO with added subparts, as shown in Fig. 42.2. They analysed the mounting bracket performance with three different materials [9].

Fig. 42.1 Engine mounting bracket [10]

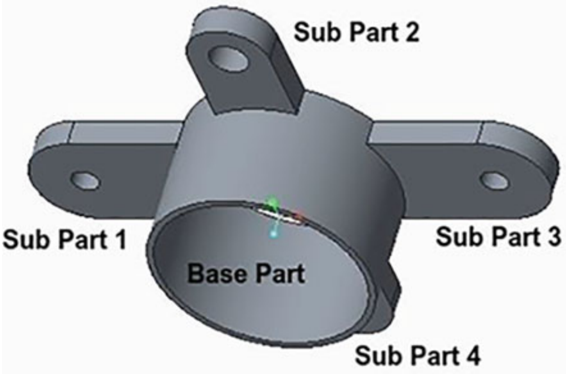

Fig. 42.2 Circular mounting bracket for automobile subparts

Results and Discussion

Manufacturing of Mounting Bracket

To ensure the process, a circular mounting bracket was used to hold the part on automobile applications, as shown in Fig. 42.2. The metal inert gas welding (MIG) is used for welding the sub-assembly mounting bracket. Yang et al. [11] investigated the microstructure properties of hybrid laser-MIG welding, as shown in Figs. 42.3 and 42.4. They measured the microstructure of the weld bead under various magnetic fields. The characteristics of the arc zone are analysed, however, the severe splash and overlaps are identified at the edges. So even on the automated hybrid welding process, the weldment is seemed to be weak and splashed over edges. Assuming that welding parameters taken into account are known and optimal [12]. The welding parameters are welding current, voltage, fillet, gas flow, wire-speed, shield gas is taken into consideration. The fixture design factors are the degree of freedom on the universe, thermal resistivity of material used for the fixture, the amount of heat transfer, shape, and size of the fixture going to be used. J. Zhu et al. [13] investigated the residual stress and angular methodologies due to welding on the weldment part. They identified that thermoelastic plastic and inherent strain are the huge influential parameters on welding. They also considered the effect of different shapes of impacts on the weldment material regarding its geometrical changes [14].

So, weld on four places for producing the part shown in Fig. 42.5. The shape and locating factors of parameters are described without a fixture designed for a part as follows. Figure 42.6 depicts cleanly about time consumption without a fixture. The value is taken for an average individual worker performance with 50 iterations exhibits that the average lead time for producing the part will be 7.1 min. In contrast, a shift can yield an average of 67 parts.

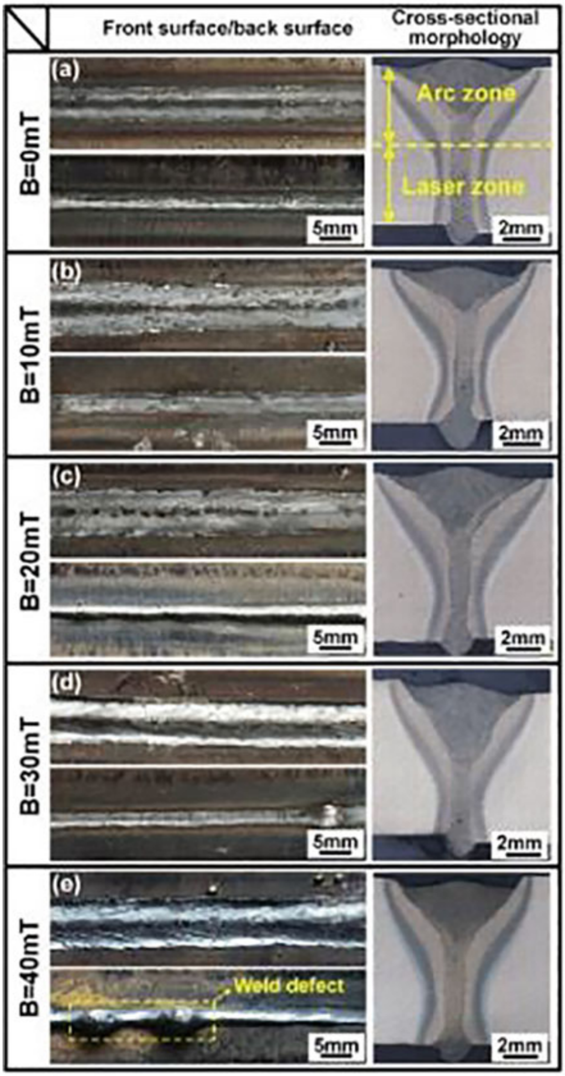

Fig. 42.3 Cross-section of hybrid weldment (MIG + laser) [11]

Design of Fixture for Holding the Sub-assembly Bracket

The earlier researchers formulated whilst designing fixture. To develop the dynamic interactions with tool and workpiece on machining to load the fixture, which affects the quality of the workpiece [15]. A. A. Karad et al. designed a fixture for holding the fuel tank mounting bracket. The deformation of all individual parts is calculated, and the results are presented [16]. Zeshan Ahmad et al. identified a new methodology for accurate functioning of the fixture. They placed the control on the degree

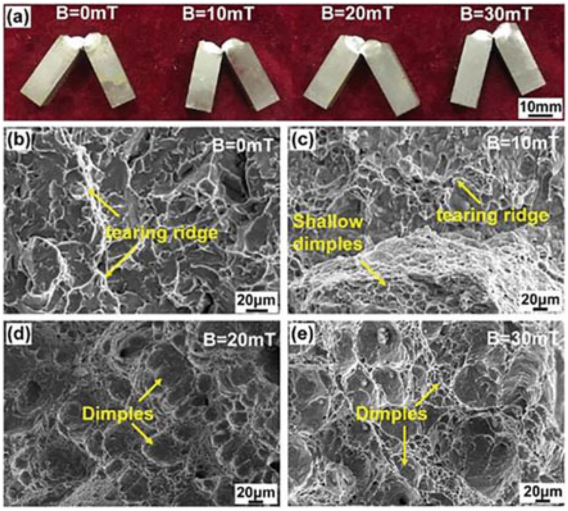

Fig. 42.4 Fracture samples in weld bead zone on different depth ratio [11]

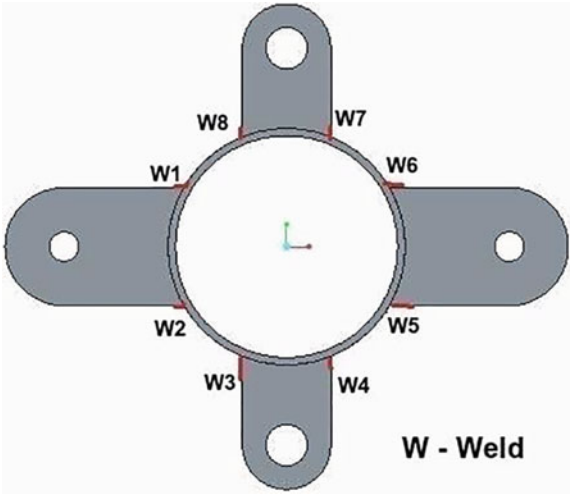

Fig. 42.5 Welding of sub-assembly mounting bracket

of freedom and the three axial control required for proper positioning of the fixture. They proposed that the stiffness energy needs to be identified to understand the stability of the fixture [17]. Salone et al. validated three different methodologies for electromagnets, grub screws, and pneumatic cylinders. Amongst them, the pneumatic cylinders proved to be the vital methodology [18]. The part shown in Fig. 42.1 is a sub-assembly mounting bracket used in cars for proper holding of components like electronic devices. The primary purpose of holding the object to resist its vibration and provide support for welding. But setup time, locking time, and unlocking time

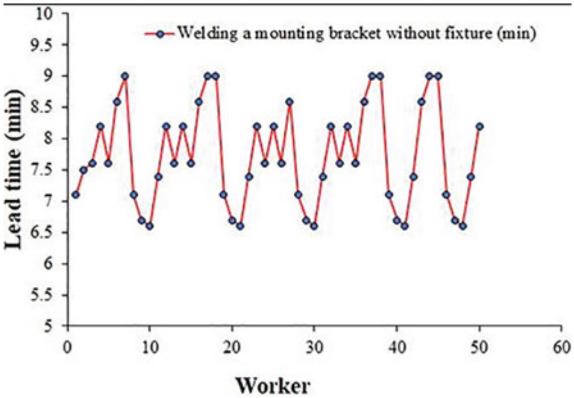

Fig. 42.6 Production of the mounting bracket without a fixture

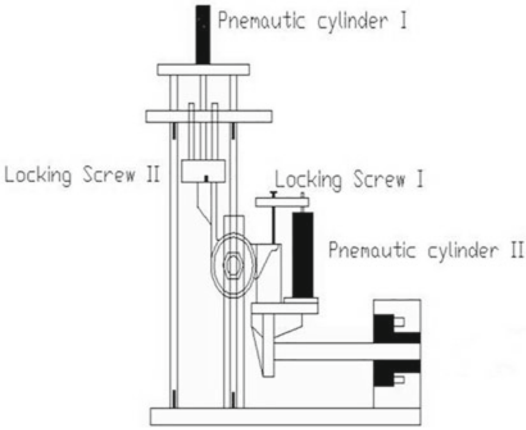

Fig. 42.7 Fixture with circular component

should be very minimal as possible. In the accounting of all these constraints, formulated fixture, as shown in Fig. 42.7. The locking screw is threaded and does not have any hold for locking the part. So, the hole could be easily mounted in the locking screw and the time required for locking and releasing the clamp is eliminated.

Instead of locking all the points in the part component, we optimally designed the locking fixtures in the 3-2-1 principle. This provided greater control over time as the degree of freedom is reduced by 50% with only locking x-axis linear movement ($X+$, $X-$) and translational movement at the y-axis ($Y+$, $Y-$).

Material Selection and Design for the Fixture

As the heat transfer is going to taking place, the theoretical validation is performed. The input temperature can be derived from the heat conduction equation. As a result, a

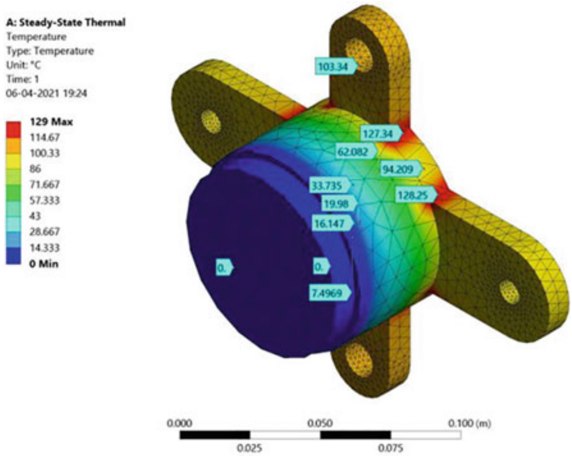

Fig. 42.8 Heat transfer in the fixture on welding the sub-assembly mounting bracket

temperature around 130 °C is identified as the operating temperature. As the temperature is high, a low-thermal conductivity material is preferred for functioning. Stainless steel is identified as the material for the fixture as it needs to resist the heat moving outside. The material selected for the fixture to hold the sub-assembly bracket is stainless steel. The heat transfer rate in fixtures due to welding is shown in Fig. 42.8.

The main factor behind the selection of stainless steel as fixture material because less in weight, good corrosion resistance, but the essential property is it should be thermal resist heat transfer due to conduction. The stainless-steel fixture is loaded thermally. Due to its heat transfer, the properties of the fixture will vary. The temperature distribution will be different at each node concerning time. The main factor behind the selection of stainless steel as fixture material because less in weight, good corrosion resistance, but the essential property is it should be thermal resist heat transfer due to conduction. The stainless-steel fixture is loaded thermally. Due to its heat transfer, the properties of the fixture will vary. The temperature distribution will be different at each node concerning time is illustrated in Fig. 42.8. The performance of mounting bracket welding before holding on to the fixture is already indicated in Fig. 42.7. The average lead time is around 7.1 min, and the production rate is approximately 67 pieces per shift. Once the fixture is introduced, the lead time is increased with a load of fixture setup time, loading, and unloading time. The results are mentioned in Fig. 42.9. But the overall time is decreased with idle time reduction on welding sequentially the weld 1 to 8 positions. As the fixture holds the component, the worker can weld the multiple edges sequentially without having idle time for holding the grip. Though the cost of the pneumatic cylinder is added to the manual welding operation, the main reason for getting into this setup is it increases the production rate.

In contrast, the same could be a massive benefit for any small-scale sector. The efficient improvement of the worker is calculated with various iterations, and results are plotted in Fig. 42.10. The minimum progress we achieved 20%, and as maximum,

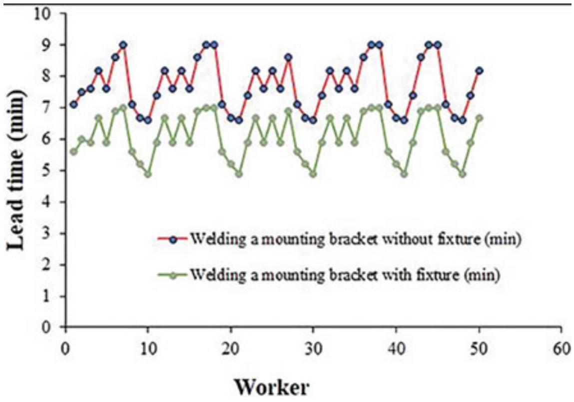

Fig. 42.9 Comparative performance of welding mounting bracket with and without a fixture

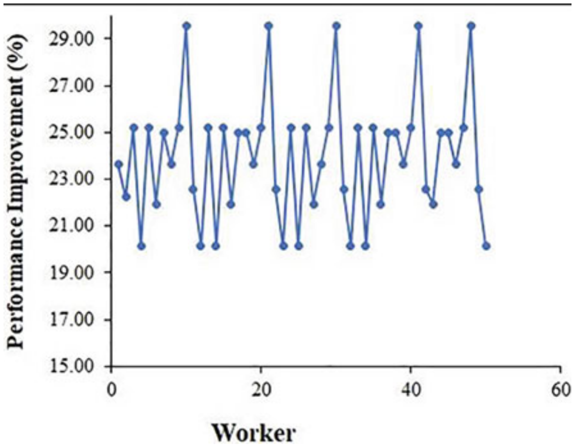

Fig. 42.10 Performance improvement of workers after inclusion of fixture

we got 30% improvement from the worker. As an average improvement, we got 25.39% from the worker.

Conclusion

This study focuses on small-scale industries that still conduct welding by hand. The significant investment is limited by using simple pneumatic cylinders, which is offset by unsustainable demand. The accuracy of the weld improved as a result of the proper locating of the part piece.

1. The optimal 3-2-1 principle reduces the locating time, loading time, and unloading time.

2. Since they can be conveniently placed on thread sections, the location of parts for welding and maintaining the edge has been minimised.
3. The average lead time for welding apart before the addition of a fixture was 7.1 min per piece. With the fixture addition, we reduced the lead time to 5.5 min per piece, which is a 25.39% improvement over the original.
4. When the process of holding the hot material, the efficiency of worker and protection was improved.
5. The output of 50 workers is compared with and without the use of a fixture. The quality of the work has increased by at least 20–30%.

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