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DESIGN DEVELOPMENT OF WELDING INDEXING FIXTURE WITH AUTO-POSITIONING

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Abstract

Electrical arc welding, or CO2 welding, is typically performed with a handheld tool, which makes achieving a uniform weld challenging and can lead to issues such as blow holes, resulting in poor weld quality and increased welding time. To address these challenges, a multi-axis welding positioner is used, incorporating a proximity sensor to ensure consistent and uniform round welds. This positioner enables both continuous and step-by-step welding, with adjustable angles of 60°, 90°, and 120°, and a variable speed range from 0 to 20 RPM. The system provides a uniform finish at a lower cost and includes a tilt-table that supports job angles from 0° to 45°, improving efficiency and weld quality while saving time and money.

The project focuses on the design, development, and analysis of the multi-axis welding positioner. The design of the components was approached using both theoretical methods and simulations conducted with ANSYS Workbench. The unit was successfully fabricated, and extensive testing was carried out to evaluate its performance in both continuous and discontinuous welding, as well as its ability to handle inclined positions.

This report outlines the design, manufacturing process, and testing of the multi-axis welding positioner.

Keywords: Arc welding, circular welding, uniform weld, staggered weld.

Introduction

In today's age of mass production, there is a growing need to automate manufacturing processes that were traditionally carried out manually. One such process is welding, which can include Electric Arc Welding, CO2 Welding, or TIG Welding. Traditionally, both Electric Arc and CO2 welding are performed manually. In Electric Arc welding, after striking the arc, the electrode is moved along the welding path while maintaining an effective arc gap, which is a similar process in CO2 welding. This movement requires considerable skill, particularly for circular components, where the task becomes even more challenging.

Even when performed by skilled professionals, manual welding requires the workpiece to be rotated around a fixed axis to achieve a consistent profile and homogeneous weld. However, the rotation speed is often inconsistent, which impacts the quality of the weld. This calls for the development of a special device capable of rotating the workpiece at a fixed rate to assist the welding process for circular components, ensuring a better profile and uniform weld quality.

2.1 Background:

Circular welding is generally done manually, but it demands significant skill and time, making the process expensive. Commercial circular welding fixtures are available, as illustrated below:

Figure 1: Commercial Circular Welding Fixture

However, high-cost PLC-controlled devices on the market are not suitable for small batch production due to their size, weight, and high cost. These devices are typically not ideal for small-scale industries.

2.2 Need for the Project:

The Multi-Axis Circular Welding Positioner is a low-cost, simple circuit solution to the manual circular welding process. Manual indexing results in poor quality and takes longer, hence the need for an automated solution.

2.3 Requirements of the Circular Welding Fixture:

The indexing process of the workpiece can be achieved by mounting it on an indexer table, and the following features are required for this process:

1. **Stability**: The table should be stable and capable of carrying heavy loads.
2. **Speed Variability**: The table should operate at different speeds to accommodate various welding processes and electrode sizes.
3. **Auto Stop**: The table should automatically stop after each welding cycle.
4. **Angle Indexing**: The table should be able to index at any given angle in the horizontal plane to support staggered welding.
5. **Inching Facility**: The table should have an inching function to allow for continuation after the first stage of welding, enabling the second stage.

6. **Versatility**: The table should be universal and capable of accommodating various workpiece sizes within given specifications.

2.4 Latest Trends in Industry:

Alignment and positioning equipment are crucial in both research and manufacturing processes. With the growing emphasis on nano-scale engineering, engineers and scientists are focusing on advanced alignment devices for new and emerging applications. Currently, two primary types of state-of-the-art devices are available: fixtures and positioners. Fixtures are devices that define a part's fixed orientation and location using fixed geometry.

a. Drop-Center Gravity Positioner:
The DCG series positioner offers 2-axis motion, continuous rotation, and ±180° tilt from the horizontal table position. This type of positioner can also be made with a third powered axis for elevation if required. The worktable surface can be adjusted to varying distances below the tilt axis, with the swing radius clearances from the table's rotation axis being specified based on application needs. The cantilevered hanger's counterbalancing effect makes it necessary to consult the manufacturer for sizing and capacity requirements, as these can vary greatly depending on the configuration. The load, center of gravity, and swing clearance details will help determine the appropriate model.

Drop-Center Gravity Features:

- AC variable speed drives and motors
- Optional servo drives
- Powered ±180° tilt
- Optional geared elevation models available
- Robotic versions available

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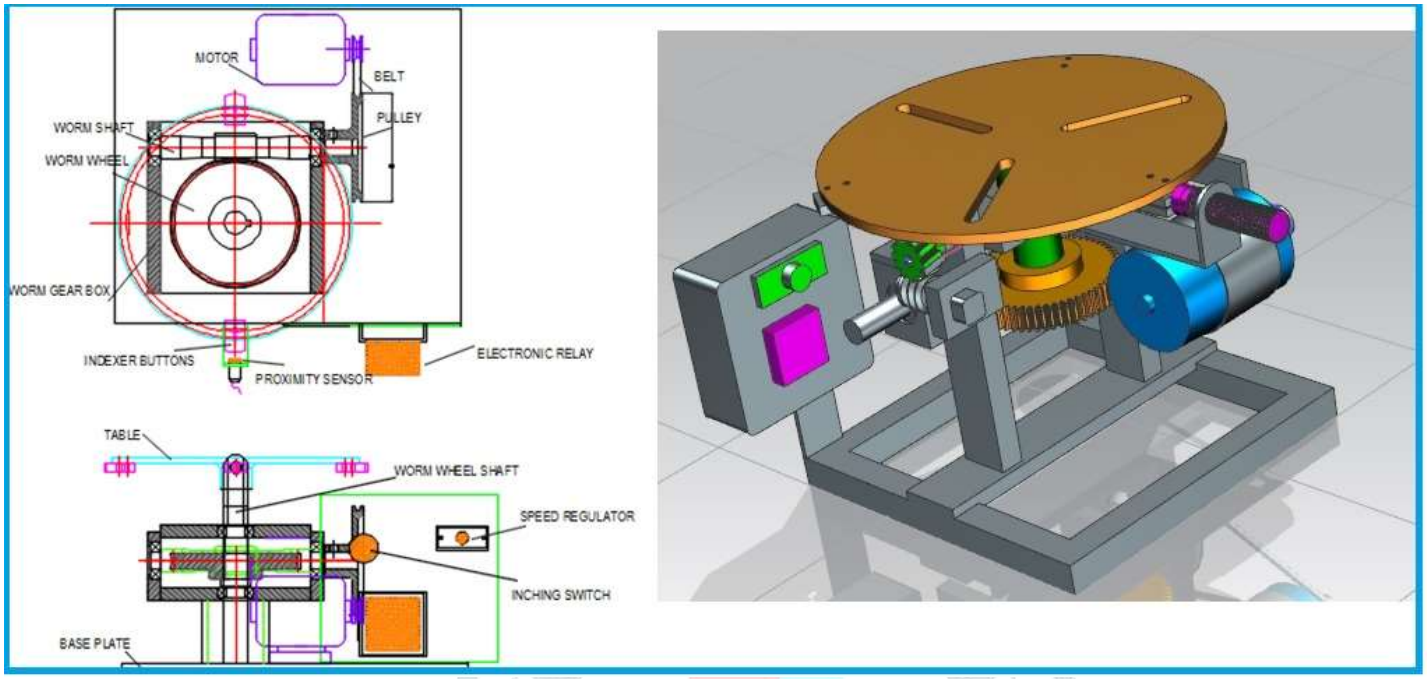
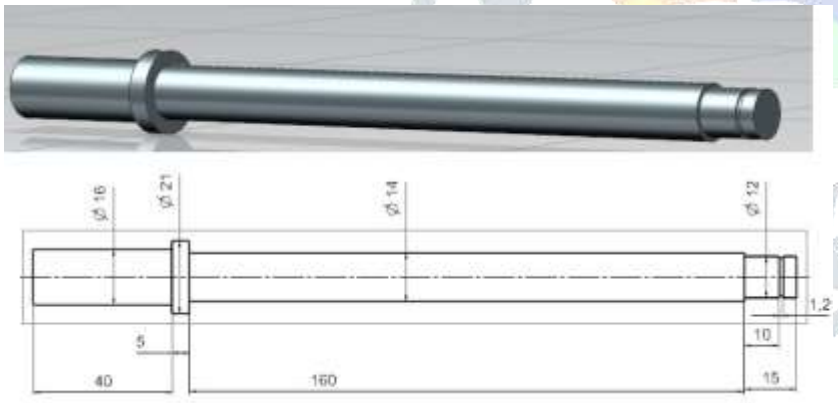
Even when performed by skilled professionals, manual welding requires the workpiece to be rotated around a fixed axis to achieve a consistent profile and homogeneous weld. However, the rotation speed is often inconsistent, which impacts the quality of the weld. This calls for the development of a special device capable of rotating the work-piece at a fixed rate to assist the welding process for circular components, ensuring a better profile and uniform weld quality.

Concept of the Welding Indexing fixture with auto-positioning



Design of Parts of Welding Indexing fixture with auto-positioning

DESIGN OF WORM SHAFT



MATERIAL SELECTION : -Ref :- PSG (1.10 & 1.24)

DESIGNATION	ULTIMATE TENSILE STRENGTH (MPa)	YEILD STRENGTH (MPa)
EN24	800	680

Check for torsional shear failure of shaft

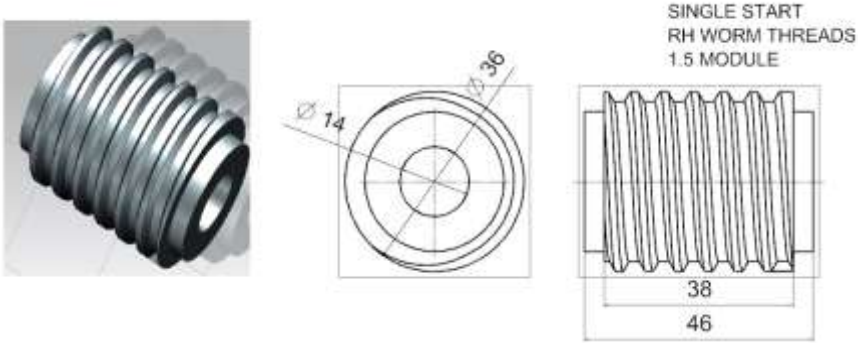
$Te = \frac{\Pi fs\ d^3}{16}$

$fs_{act} = 0.884079496/mm^2$

As; $fs_{act} < fs_{all}$

The worm shaft is safe under torsional load

DESIGN OF WORM



MATERIAL SELECTION : -Ref :- PSG (1.10 & 1.18)

DESIGNATION	ULTIMATE TENSILE STRENGTH (MPa)	YEILD STRENGTH (MPa)
20MnCr1	1000	760

As per ASME code $fs_{allowable}$= 110Mpa

Check for torsional shear failure of shaft

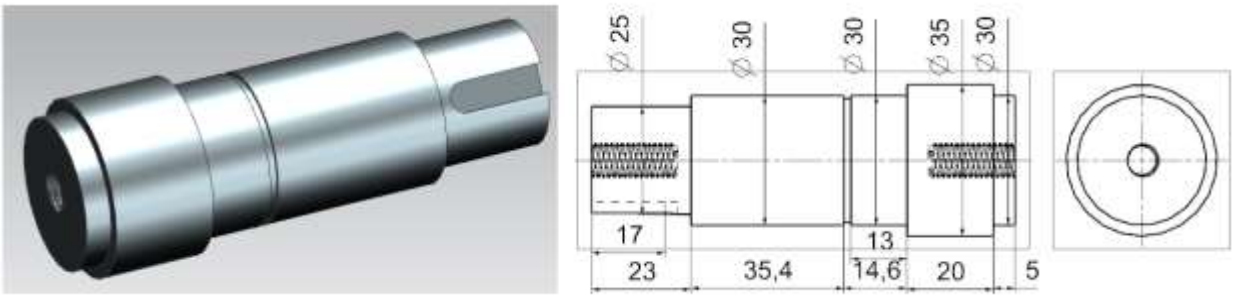
$Td = \Pi/16 \times fs_{act} \times (D^4 - d^4) / D$

fs_{act} = 0.233236 Mpa

As; $fs_{act} < fs_{all}$

The worm is safe under torsional load

DESIGN OF TABLE SHAFT



MATERIAL SELECTION : -Ref :- PSG (1.10 & 1.24)

DESIGNATION	ULTIMATE TENSILE STRENGTH (MPa)	YEILD STRENGTH (MPa)
EN24	800	680

As per ASME code $fs_{allowable}$= 104 Mpa

Check for torsional shear failure of shaft

$$Te = \frac{\Pi fs\, d^3}{16}$$

fs_{act} = 7.78917887 N/mm^2

As; $fs_{act} < fs_{all}$

The table shaft is safe under torsional load

Test and Trial for Performance Evaluation

Automatic -Multi Axis Welding Positioner
Continuous / Staggered Welding (60 , 90 , 120 , 180 Degree)
Auto Stop , Variable Speed
Variable inclination (0 to 45 degree---Self Locking Table

Sr. No	Parameter	Value	Result
01	Maximum load carrying capacity	28 kg	As the maximum load 25 kg> design load 25 kg the designed unit works to optimal design
02	Maximum size of weld	8 mm	At the lowest speed of table the maximum size of weld is 8mm
03	Minimum degree of indexing	60 degree	Thus the device can make 6 staggered welds to a given work-piece
04	Maximum degree of indexing	360 degree	Thus the device can make full 360 degree welds to a given work-piece with auto stop
05	Maximum degree of inclination	48 degree	Thus the table can be indexed to 96 degree total included angle which is greater than the design target of 90 degree.

Results and Discussion

1. Maximum stress induced by theoretical method in parts is found to be well below the permissible value and the parts are found to be safe.
2. As the maximum load 25 kg> design load 25 kg the designed unit works to optimal design
3. At the lowest speed of table the maximum size of weld is 8mm
4. The device can make 6 staggered welds to a given work-piece
5. The device can make full 360 degree welds to a given work-piece with auto stop
6. The table can be indexed to 96 degree total included angle which is greater than the design target of 90 degree

Conclusion

The sizing , design analysis critical components of multi axis welding positioner is successfully done and the dimensions of the components have being determined. Estimation of the maximum stress induced in the components of the welding positioner have being determined by both theoretical method as well as using Ansys Work bench and the results indicate that the maximum stress values are well below the permissible limit hence the parts are safe under given system of loads. As the maximum load 25 kg> design load 25 kg the designed unit works to optimal design. At the lowest speed of table the maximum size of weld is 8mmThe device can make 6 staggered welds to a given work-piece. The device can make full 360 degree welds to a given work-piece with auto stop The table can be indexed to 96 degree total included angle which is greater than the design target of 90 degree The general type of welding fixture that are designed to suit all circular welding operations in the continuous round form

or discontinuous or staggered welding are absent hence there is a need to develop one such fixture which will be universal in operation.

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