

Design, Manufacturing and Testing of Circular Welding Positioner

**Prof. N.B.Totala, Sarang S. Bhutada, Nakul R. Katruwar,
Rachan R. Rai, Ketan N. Dhumke**

¹*Assistant Professor, Department of Mechanical Engineering, MIT Academy of Engineering,
Alandi (D), Pune Maharashtra 412105.)*

^{2,3,4&5} *(Department of Mechanical Engineering, Sinhgad Institute of Technology, Pune
Maharashtra 411041.)*

Abstract:- This paper deals with the construction and working of all components required for welding positioner. With an increase in size and complexity of today's welding requirements, new techniques must be developed so as to ease the operator's burden and ensure uniform and efficient circular welding. In this paper the various components of the circular welding positioner are critically designed, manufactured and tested, along with which a cost and time parameters have been included to aid in the manufacturing of the positioner. The arc torch is fixed to an adjustable clamp, not hand held. It is different from a robot since operator's continuous surveillance and intervention are essential for successful work

Keywords:- Circular welding, CO₂ welding, Welding positioner, Welding gun subassembly, Automation

I. INTRODUCTION

Welding is a process for joining different materials. The large bulk of materials that are welded are metals and their alloys, although the term welding is also applied to the joining of other materials such as thermoplastics. In order to join two or more pieces of metal together by one of the welding processes, the most essential requirement is heat. Pressure may also be employed, but this is not, in many processes essential. The use of welding in today's technology is extensive. It had a phenomenal rise since about 1930, this growth has been faster than the general industrial growth. [1]

Welding-positioner is a special accessory tool or manipulator that helps achieving the required economic results of a welding program. It all depends on the process used, on what is going to be welded, on quantity and quality of what has to be provided, and on whether the Return on Investment (ROI) is going to justify the expense for procuring the tool.

Welding positioner is an advanced implement that helps perform welding. It keeps in place the elements being welded, while providing some relative, progressive, smooth movement between the torch of a fusion welding head and the joint to be welded. The movement is relative, because it does not matter if the arc source or the work is fixed, while the other element moves along simple lines. A welding table, although very useful, has no intrinsic movements available so that it falls short of the above definition. Welding-positioner is a necessary tool for highly productive mechanically assisted manual welding for those different processes that supply filler metal continuously from a spool (GMAW, SAW) or for GTAW with thin sections if filler metal is not required.

A set of uniformly placed good quality tack welds has to be made to bridge the gap and to provide some rigidity against the stresses developed during welding. A Welding-positioner assures enhanced quality and increased productivity. This is the most important gain, because of reduction of downtime, and also as the welding parameters can be selected to provide the maximum weld deposition rate, compatible with acceptable (not excessive) heat input. Arc-on time is equally increased resulting in potential reduction of welding costs.

Jafar Takabi et al. state that the operating temperature plays a key role in the overall performance of a bearing system. Affected by the bearing temperature are many critical parameters, such as the lubricant viscosity, load-carrying capacity, load distribution and power loss. This typically results because of an imbalance between the frictional heat generation inside the bearing and heat dissipation to the surroundings. Consequently, the bearing components undergo excessive thermal expansion resulting in sudden increase in the contact loads. They presented a novel idea for comparing the combination of geometric and elastic accommodations with the nominal clearance wherein the expansion of inner ring and shaft was treated as a de-stabilizing factor and that of the housing as a stabilizing factor [2]

Jun Yong Choi et al suggested that the application of fracture mechanics is being increased gradually to assess the safety of welding crack- containing structures and suggest cracks initiate and propagate in welding joint part due to impact and fatigue load, therefore it is necessary to improve welding performance and fracture resistance of welding part in structure. Their study presents a suitable CO₂ welding process for lap joints, taking into consideration tensile strength and fatigue strength under various welding conditions. [3]

Lelio Della Pietra investigated experimentally the tension variation in a flat belt transmission which is obtained by measuring its deformation with electrical resistance strain gauges as transducers. He also proved that two models of validity showing the strength of weld are equally important which were one addition arc and sliding to presence of shear strain along different sliding angles on driving and driven pulleys. These model gave the force transmitted into the device. [4]

II. DESIGN METHODOLOGY

In our attempt to design a special purpose machine we have adopted a very careful approach, the total design work has been divided into two parts:

- **System design**
- **Mechanical design**

A. System Design

System design mainly concerns with the various physical constraints and ergonomics, space requirements, arrangement of various components on the main frame of machine, no. of controls, position of these controls, ease of maintenance, scope of further improvement, height of m/c from ground etc. In system design we mainly concentrate on the following parameters;

1. System selection based on physical constraints:-

While selecting any m/c it must be checked whether it is going to be used in large scale or small scale industry in our case it is to be used in small scale industry so space is a major constraint. The system is to be very compact. The mechanical design has direct norms with the system design hence the foremost job is to control the physical parameters.

2. Arrangement of various components:-

Keeping into view the space restriction, the components should be laid such that their easy removal or servicing is possible moreover every component should be easily seen and none should be hidden. Every possible space is utilized in component arrangement.

3. Components of system:-

As already stated, system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed and compact. A compact system gives a better look and structure.

4. Chances of failure:-

The losses incurred by owner in case of failure of a component are important criteria of design. Factor of safety while doing the mechanical design is kept high so that there are less chances of failure. Periodic maintenance is required to keep the m/c trouble free.

5. Servicing facility:-

The layout of components should be such that easy servicing is possible especially those components which required frequent servicing can be easily dismantled.

6. Height of m/c from ground:-

For ease and comfort of operator the height of m/c should be properly decided so that he may not get tired during operation also enough clearance should be provided from ground for cleaning purpose.

7. Weight of machine:-

The total weight of m/c depends upon the selection of material components as well as dimension of components. A higher weighted m/c is difficult for transportation and in case of major break down it becomes difficult to repair.

B. Mechanical Design

In Mechanical design the components are categories in two parts.

- **Design parts**
- **Parts to be purchased**

For design parts detail design is done and dimensions thus obtained are compared to next higher dimension which are readily available in market. This simplifies the assembly as well as post production servicing work. The various tolerances on work pieces are specified in the manufacturing drawings. The process charts are prepared and passed on to the manufacturing stage.

The parts are to be purchased directly are specified and selected from standard catalogues and are specified so as to have ease of procurement.

A. DESIGN OF PARTS Motor Selection

Thus selecting a motor of the following specifications

1. Single phase AC motor
2. Commutator motor
3. TEFC construction
4. Power = 1/15 HP = 60 watt
5. Speed= 0-6000 rpm (variable)

Motor torque calculated $T=0.095 \text{ Nm}$

B. Design Of Worm Shaft

Material selection: -Designation: EN 24 [2]

ASME CODE FOR DESIGN OF SHAFT:

$$\tau_{per} = 0.18 \times 800 = 144 \text{ N/mm}^2$$

$$\tau_{per} = 0.30 \times 680 = 204 \text{ N/mm}^2$$

Considering minimum value of the above values,

$$\tau_{per} = 144 \text{ N/mm}^2$$

Shaft is provided with key way, this will reduce its strength. Hence reducing above value of allowable stress by 25%.

$$\tau_{per} = 108 \text{ N/mm}^2$$

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

To calculate worm shaft torque:

Power = Motor is 60 watt power, run at 6000 rpm, connected to worm shaft by belt pulley arrangement with reduction ratio 1:5.

Hence input to worm gear box = 1200 rpm

$$T=0.48 \text{ Nm}$$

C. Design Of Worm Wheel Shaft

Material Selection: - Designation: EN 24[5]

Asme code for design of shaft:

$$\tau_{per} = 0.18 \times 800 = 144 \text{ N/mm}^2$$

$$\tau_{per} = 0.30 \times 680 = 204 \text{ N/mm}^2$$

Considering minimum value of the above values,

$$\tau_{per} = 144 \text{ N/mm}^2$$

Shaft is provided with key way, this will reduce its strength. Hence reducing above value of allowable stress by 25%.

$$\tau_{per} = 108 \text{ N/mm}^2$$

This is the allowable value of shear stress that can be induced in the shaft material for safe operation.

D. Design Of Key

Selecting parallel key from standard data book for given application. Material of key is 55C8 [3]

Table I

| | | |
|-------------------------------|--------------|-----------|
| For Shaft Diameter(mm) | Above | 12 |
| | Up to | 17 |
| Key cross section(mm) | Width (b) | 5 |
| | Height (h) | 5 |

Dimensions (b×h×l):-5×5×24

E. Design Of Worm And Worm Wheel

The pair of worm and worm wheel used in the machine is designated as 1/80/10/1.5. The worm is made of case hardened steel EN24 whereas the worm wheel is made of Phosphor bronze. [6]

As the drive is capable of transmitting 0.1796 kW and we intend to transmit 0.06 kW therefore the drive is safe.

F. Selection Of Bearing

1. Selection of worm shaft bearing:

Deep groove ball bearing is most frequently used bearing. These bearing take the loads in radial as well as axial. Here, calculated shaft diameter “d = 16 mm” which is safe under torsional load but during selection of ball bearing we found that 16 mm bore diameter bearing is not available in standard catalogue of bearing. So we select next standard size of shaft diameter “d = 17 mm” from bearing series 6003ZZ. [6]

Table II

| Brg Basic Design No (SKF) | Bore dia.(d) mm | Outside dia.(D) mm | Width(B) mm | Basic capacity | |
|---------------------------|-----------------|--------------------|-------------|------------------------------|-----------------|
| | | | | Static ‘C _o ’ (N) | Dynamic ‘C’ (N) |
| 6003ZZ | 17 | 35 | 10 | 2850 | 4650 |

2. Selection of worm wheel shaft bearing

Deep groove ball bearing is most frequently used bearing. These bearing take the loads in radial as well as axial. Here, calculated shaft diameter “d = 22 mm” which is safe under torsional load but during selection of ball bearing we found that 22 mm bore dia. bearing is not available in standard catalogue of bearing. So we select next standard size of shaft diameter “d = 25 mm” from bearing series 6005ZZ. [6]

Table III

| Brg Basic Design No (SKF) | Bore dia.(d) mm | Outside dia.(D) mm | Width(B) mm | Basic capacity | |
|---------------------------|-----------------|--------------------|-------------|------------------------------|-----------------|
| | | | | Static ‘C _o ’ (N) | Dynamic ‘C’ (N) |
| 6005ZZ | 25 | 47 | 12 | 7800 | 5200 |

G. Design Of Open Belt Drive

Motor pulley diameter = 20 mm
 Reduction ratio = 5
 Input shaft pulley diameter = 100 mm
 Coefficient of friction = 0.2
 Maximum allowable tension in belt = 200 N
 Center distance = 120 mm
 Arc of contact for smaller pulley (α) = 141° [7]
 Ratio of belt tension = 4.2 [7]
 Width at the base is given by (b₂) = 3.1 mm
 Area of cross section of belt (A) = 18.2
 Mass of belt per meter length = 0.23 kg/m
 Velocity = 4.19 m/sec
 Centrifugal tension (T_c) = 4.034 N
 Tension at tight side (T₁) = 200 - 4.034 = 195.966 N
 Tension on slack side (T₂) = 49 N

H. Design Of Screw For Tilting Mechanism

Material selection: - [6]

Table IV

| Material | | Bearing Pressure, (N/mm ²) | Rubbing Speed |
|----------|-----|--|---------------|
| Screw | Nut | | |
| Steel | C.I | 13-17 | Low Speed |

Calculate load (w) on screw
 W = Weight of work piece + Weight of base plate
 W = 315.1 N
 For core diameter (d) = 8 mm, pitch (p) = 1 mm [2]

Core diameter of screw (d_c) = $d - p = 8 - 1 = 7$ mm
 z = no. of threads in engagement with nut = 12

I. Design Of Spring

Material selection: - [6]

Patented cold drawn steel wire (unalloyed).

$S_{ut} = 1390 \text{ N/mm}^2$

Permissible shear stress = $0.3 \times S_{ut} = 417 \text{ N/mm}^2$

We assume maximum force that can be applied by hand (P) is 70 N. As there are two springs, therefore force on each spring is 35 N.

Assume spring index, $C = 5$ [6]

From required load condition the free length is 60mm.

Table V: Designed Table

| Sr. No | Part Name | Dimension |
|--------|---------------------|-----------------------------------|
| 1. | Motor | 60 W, 0-6000 rpm |
| 2. | Worm Shaft | $\varnothing = 16\text{mm}$ |
| 3. | Worm Wheel Shaft | $\varnothing = 22\text{mm}$ |
| 4. | Key | 5×5×24mm |
| 5. | Bearing | 6003ZZ,6005ZZ |
| 6. | Worm And Worm Wheel | 1/80/10/1.5 |
| 7. | Open Belt Drive | FZ 6×500 |
| 8. | Screw | $\varnothing = 8$, 1 mm pitch |
| 9. | Spring | $d = 1.2$ mm, $L_f = 60\text{mm}$ |

III. MANUFACTURING

Details of manufacturing is given below

A. Machining Parameters[8,9,10]

Table VI: Machining Parameters

| Sr No. | Part Name | Tools | | | Time Required |
|--------|------------------------------|------------------------------|---|-------------------------|---------------|
| | | M/C tools | Cutting Tools | Measurement Instruments | Min |
| 1 | Worm Shaft | Lathe, hobbing | Facing tool, Turning tool, Parting tool, Chamfering Tool, Hob | Vernier Calliper | 201 |
| 2 | Worm Wheel Shaft | Lathe, Milling m/c | Facing tool, Turning tool, End mill | Vernier | 104 |
| 3 | Worm Gear | Lathe, hobbing, Slotting. | Turning tool, Twist drill, Boring tool, Slotting tool, Hob. | Vernier | 124 |
| 4 | Pulley | Lathe | Turning tool, Facing tool, Twist drill, Boring tool, Parting tool, Form tool. | Vernier | 108 |
| 5 | Input Shaft Bearing Housing | Milling, Lathe. | Facing cutter, Twist drill, Boring tool | Vernier | 70 |
| 6 | Output Shaft Bearing housing | Milling, Lathe. | Facing cutter, Twist drill, Boring tool. | Vernier | 76 |
| 7 | Base Plate | Wire cutting, Milling, Lathe | Wire cutter, End Mill, Twist drill | Vernier | 73 |

B. Miscellaneous Cost

Table VII: Miscellaneous Cost

| Operation | Cost(Rs) |
|---------------------|----------|
| Wire Cutting | 50 |
| Sawing | 120 |
| Welding | 250 |
| Total | 420 |

C. Cost Of Purchased Parts

Table VIII: Cost of Purchased Parts

| SR NO. | DESCRIPTION | QTY(No.) | COST(Rs) |
|--------------|------------------------------|----------|----------|
| 1. | Motor | 01 | 1450 |
| 2. | Belt | 01 | 110 |
| 3. | Grub Screw | 15 | 60 |
| 4. | Bearings | 02 | 270 |
| 5. | Electronic Speed Regulator | 01 | 110 |
| 6. | Inching Switch | 01 | 120 |
| 7. | Proximity Sensor | 01 | 450 |
| 8. | Electronic Relay | 01 | 540 |
| 9. | Roller Operated Micro Switch | 01 | 45 |
| Total | | | 3155 |

D. Total Cost

Total cost = Raw Material Cost + Machining Cost + Miscellaneous Cost + Cost of Purchased Parts + Overheads.

Total cost = 4800 + 3560 + 420 + 3155+ 1500

Hence the Total Cost Machine = Rs. 13435/-

IV. CAD REPRESENTATION:

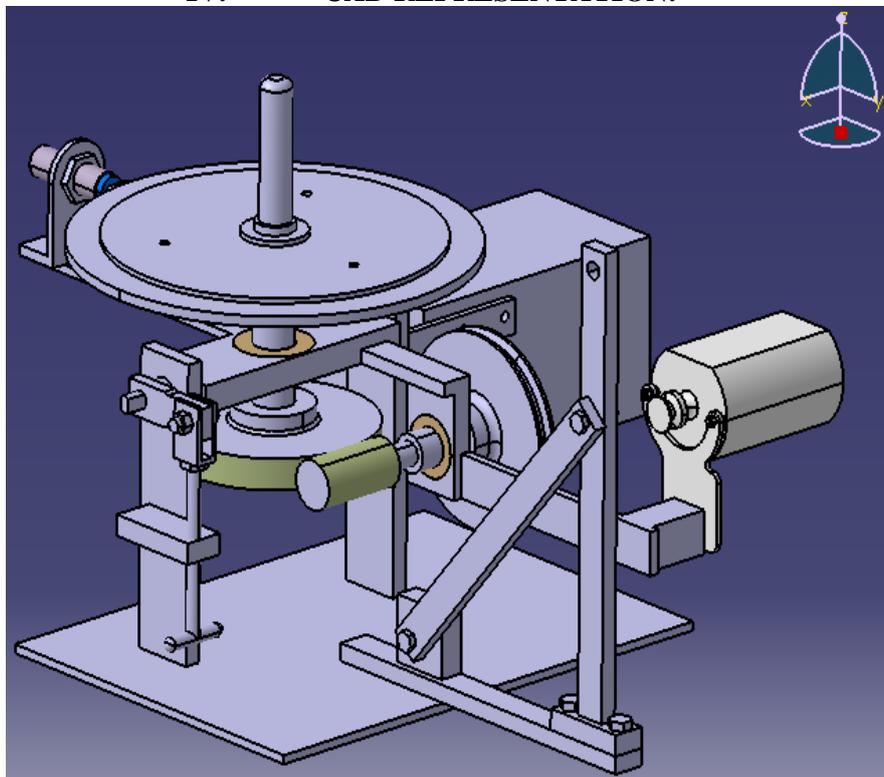


Fig. 1: Assembly of Stand

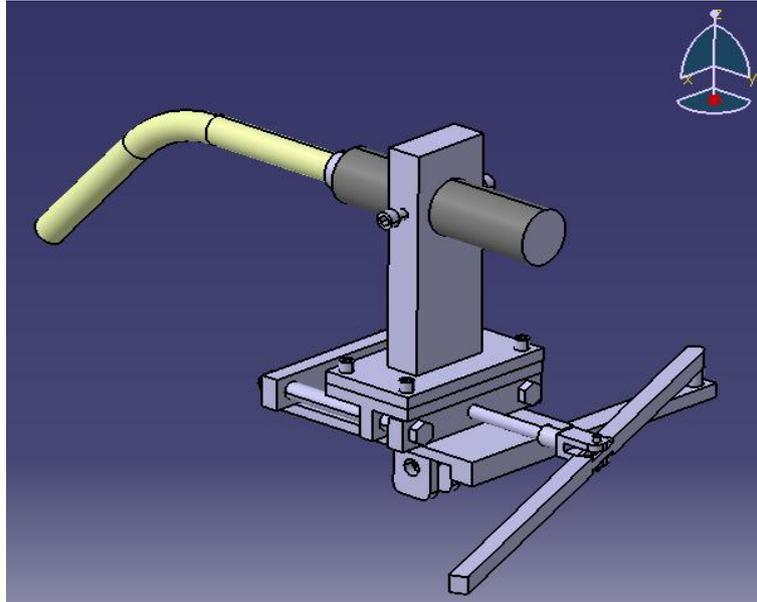


Fig. 2: Subassembly of Gun Holder

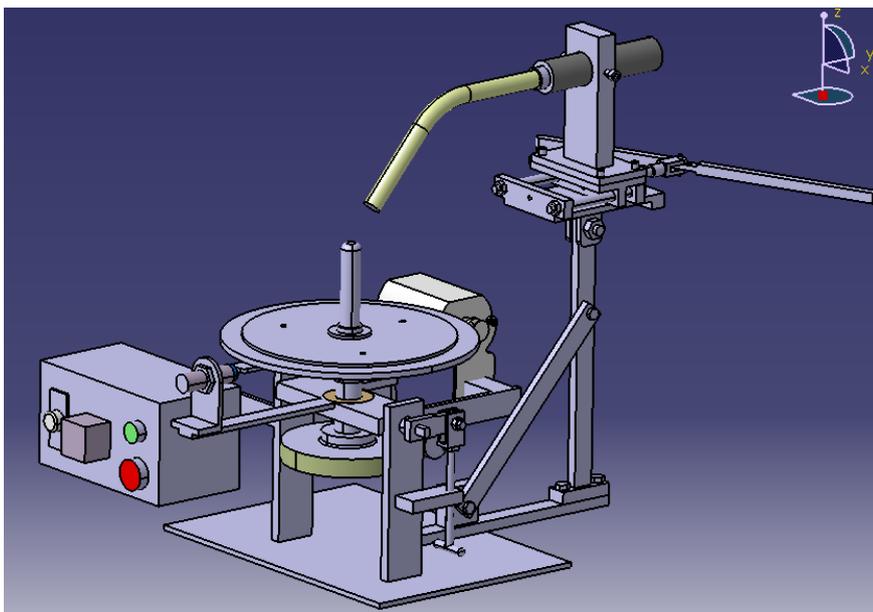


Fig. 3: Welding positioner

V. TESTING

For testing purpose following parameters are considered: [1]

1. *Electrode Size*

For work piece thickness of 2.0 - 4.0 mm, wire diameter 1.0 – 1.2 mm is selected.

2. *Welding Current and Voltage*

For electrode diameter 1.0 – 1.2 mm, current range is 60 – 160 A, voltage range is 16 – 25 V.

3. *Arc Travel Speed*

The speed at which arc moves along the joint is 0.44 m/min.

4. *Results*

Time required for loading and unloading the job = 15 sec

Time required for actual welding process = 15 sec

Total cycle time = 30 sec

Production rate = 120 pieces per hour.

VI. DISCUSSIONS

The designed welding positioner can be used for the following applications.

1. To weld the bush inside fork of a bike.
2. CO₂ welding of circular or staggered welded joints is possible.
3. Welding of pipe and flange can be done.
4. Pressure vessel heads, nozzles and other fittings can be welded.
5. Welding of small circular automobile components for example silencer.

VII. FUTURE SCOPE

1. Currently the welding positioner is used with welding gun which is fed manually and has a spring return mechanism which can be replaced and automated with pneumatic cylinders.
2. The guide bars can be replaced with linear guide ways in order to increase accuracy.
3. The entire positioner can be controlled using Microprocessors to increase automation.

VIII. CONCLUSION

1. A Heavy load capacity of table of about 30 kg is achieved.
2. Adjustable table speed (0 to 15 rpm).
3. Auto stop feature, operation at precise positions (starts and end process).
4. Multiple indexer positions (3), enables to make staggered welded joints.
5. Ease of operation, as table automatically stops as per indexer button position and next operation is started by merely pressing the inching switch.
6. Compact, the entire drive assembly fitted below the table itself, and the controls are placed on the front at ergonomic positions.
7. Weight and easy to operate.
8. Low power consumption (60 watt).
9. Precise and noiseless in operation.
10. Less skilled operator can perform operation.

REFERENCES

- [1]. "Welding Technology", O P Khanna; Dhanapat Rai Publication; 1999.
- [2]. Jafar Takabi, M.M. Khonsari, "Experimental testing and thermal analysis of ball bearings", Tribology International 60 (2013) 93–103.
- [3]. Lelio Della Pietra et al "Tension in flat belt transmission: Experimental investigation", Mechanism and Machine Theory 70 (2013) ,pp 129–156
- [4]. Jun young choi et al., "Effect of current and Voltage on on strength of lap joint with CO₂ welding process key engineering materials", vol. 297-300(2005),pp 2859-2863
- [5]. "P S G Design Data Book"; Published by Kalaikathir Achchagam, 2011.
- [6]. "Design of Machine Elements", V B Bhandari; Tata McGraw Hill Publication; 2009.
- [7]. "Machine Design", R S Khurmi and J K Gupta; S Chand Publication; 2010.
- [8]. "Engineering Mechanism", Erdman and Sandor; Prentice Hall Publication; 2001.
- [9]. "Manufacturing Science", Amitabh Ghosh and Malik; East West Publication; 2011.
- [10]. "Elements of Workshop Technology" Vol 1- Manufacturing Processes, S K Hajra Choudhury and A K Hajra Choudhury; Media Promoters and Publishers Pvt. Ltd.; 1994.