Design of Multi-Axis Welding Positioner with Auto Indexing

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Abstract - This paper describe the welding Positioner with auto indexing which is very important for mass production industries related with circular welding. As it depends upon the skill of worker to move electrode along the welding line. This special device can rotate the job at fixed rate to assist the welding process for circular components and ensure good profile and homogenous welding. This model has applications in small cylinder welding, compressors, and bottle filling plants etc. Automated welding Positioner machine for circular weld is totally satisfying the requirements. For this system Worm and worm wheel, Cummutator motor, Belt drive, Proximity sensor, Ball bearing, Electronic relay, Inching switch, inputs are required.

Keywords – Ball Bearing, Indexing ,Welding, Worm Wheel, Welding Positioner.

I. INTRODUCTION

In the present age of mass production it is often required to automate the manufacturing process that was conventionally done manually. The process of joining in many applications is welding. The welding may be of Electric arc welding, Co2 Welding, or TIG welding. The process of Electric arc welding or Co2 welding is normally done manually. In electric arc welding after striking the arc the electrode is moved in the direction of welding maintaining an effective arc gap, similar type of process is done in Co2 welding.

Moving the electrode along the welding line is a skill full work and especially for circular components become much more difficult. Manual operation though done by an expert works man will require the work piece to be rotated about a fixed axis for good profile and homogeneous welding. Normally this process is done manually but the rate of rotation is not ensured, hence the quality of weld is affected. Hence the need of a special device which can rotate the job at a fixed rate to assist the welding process for circular components and ensure good profile and homogeneous welding.

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld.

II. PROBLEM DEFINITION

In CO2 welding or sometimes electric arc welding the need often arises for welding of circular shape components, where the welding is carried out on the entire periphery or a partial arc length of the job. The electrode is thus moved along this circular path in the conventional method .But movement of the electrode is much more difficult and it is much easier to index the job.

2.1 ACTUAL SOLUTION

Fig.1

III. DESIGN METHODOLOGY:

3.1 SPECIFICATIONS OF WELDING POSITIONER:

Maximum capacity table in the flat position	30Kg
Maximum capacity table at 90 degrees	15 kg
Maximum rotation torque	65 lb-inches
Rotation centroid max capacity	12mm
Rotation centroid min capacity	4mm
Tilting centroid at max capacity	25 mm
Table tilt degrees	0 to 45
Rotation speed	1 to 20 rpm
Table diameter	250 mm
Tee slots	3at 120 degrees
Table height in the flat position	240mm
Weight approximate	20 kg

Table: - 1

PART LIST		
Part No.	Part Name	Material
1	Worm	C.I.
2	Worm Wheel	C.I.
3	Table	Structural grade steel
4	Pulley	M.S.
5	Frame	M.S.
6	Table Shaft	High grade alloy steel

Table-2

3.2 MOTOR SELECTION

Thus selecting a motor of the following specifications
Single phase AC motor
Commutator motor
TEFC construction
Power = 1/15hp=60 watt
Speed= 0-6000 rpm (variable)
Motor is a Single phase AC motor, Power 60 watt; Speed is continuously variable from 0 to 6000 rpm. The speed of motor is variated by means of an electronic speed variator. Motor is a commutator motor i.e., the current to motor is supplied to motor by means of carbon brushes. The power input to motor is varied by changing the current supply to these brushes by the electronic speed variator; thereby the speed also changes. Motor is bolted to the motor base plate welded to the base frame of the indexer table-

Motor Torque

$$P = \frac{2 \Pi N T}{60}$$

$$T = \frac{60 \times 60}{2 \Pi \times 6000}$$

$$T = 0.095 \text{ N-m}$$

Power is transmitted from the motor shaft to the input shaft of drive by means of an open belt drive,
Motor pulley diameter = 20 mm
I/P shaft pulley diameter = 110 mm
Reduction ratio = 5
I/P shaft speed = 6000/5 = 1200 rpm
Torque at I/P shaft = 5 x 0.095 = 0.475 Nm

3.3 DESIGN OF OPEN BELT DRIVE

Motor pulley diameter = 20 mm
IP _ shaft pulley diameter = 110 mm
Reduction ratio = 5
Coefficient of friction = 0.23
Maximum allowable tension in belt = 200 N
Center distance = 120
 = 180 – sin-1 (D-d)/2C

□ = 180 – sin-1 (110-20)/2x200
□ = 1360
□ = 2.37c
Now,
eμ□/sin (θ/2) = e0.2 x 2.37sin (40/2) = 4
Width (b2) at base is given by
b2 = 6-2(4 tan 20) = 3.1
Area of cross section of belt = ½{6 + 3.1}x 4
A = 18.2 mm2
Now mass of belt /m length = 0.23 kg/m
V = ΠDN/(60 x 1000) = 4.188m/sec
Tc = m V2
Tc = 4.034 N
T1 = Maximum tension in belt – Tc
T1= 195.966 = 196 N
T1 / T2 = eμ□/sin (θ/2) =4
T2 = 49 N
Tension in tight side of belt (T1) = 196 N
Tension in slack side of belt (T2) = 49 N

3.4 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 14C6 where as the worm wheel is made of Cast iron.
Z1 = 1 (Z1=No. of starts on Worm)
Z2 = 80 (Z2=No. of Teeth on Worm Wheel)
q= 10 (q=D1/m= Diametral Quotient)
m = 1.5 mm. (m=Module)
I = z2/z1 = 80 mm. (i= Speed Ratio)
N = 1200 rpm (N1=Worm Input Shaft Speed)
N2 = 1200/80 = 15 rpm (N2=Worm Wheel Output Shaft Speed)
D2 = m x z2 = 1.5 x80 = 120 mm.
TanU = z1/q = 5.71 0 (U = Lead Angle)
F = 2m sq.rt (q+ 1) = 9.94 (Face Width)
Da1 = m (q+2) = 13.5 mm. (Da1=outer Dia. of worm)
C = 0.2mcosU = 0.3(Clearance)
Lr = {da1+2c} sin-1[F/ (da1+2c)]
Lr = 632mm (Lr=Length of root of worm wheel teeth)
For case hardened steel Sb = 28.2 (Sb= bending Stress Factor)
For CI Sb = 6.2 (Sb= bending Stress Factor)
Speed factor for worm
Xb1 = 0.25 (From V.B. Bhandari book figure No. 20.14)
Speed factor for worm wheel
Xb2 = 0.48 (From V.B. Bhandari book figure No. 20.14)
Mt1 = 17.65 Xb1 Sb1m lr d2 cosU (Permissible torque on the worm wheel)
= 4.694 x 106N-mm
Mt2 = 17.65 Xb2 Sb2m lr d2 cosU
= 1.98 x 106 N-mm
The lower value of torque is on the wheel = 1.98 x 106 N-mm
KW = 2Π n2 Mt/60 x 106 (Power transmitting capacity)
KW = 7.46 KW
As the drive is capable of transmitting 7.46 KW and we intend to transmit 0.06 KW the drive is safe.

3.5 DESIGN OF WORM SHAFT.

MATERIAL SELECTION: -
Ref: - PSG (1.10 & 1.12) + (1.17)

DESIGNATION	ULTIMATE TENSILE STRENGTH (N/mm^2)	YEILD STRENGTH (N/mm^2)
EN 24	800	680

Table - 3

ASME CODE FOR DESIGN OF SHAFT.

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for the harmful effects of load fluctuations. According to ASME code permissible values of shear stress may be calculated from various relations.

= 0.18 x 800

= 144 N/mm2 OR

fs max = 0.3 fyt = 0.3 x 680 =204 N/mm

Considering minimum of the above values ;

$\Rightarrow$ fs max = 144 N/mm2

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

$\Rightarrow$ fs max = 108 N/mm2

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

3.6 TO CALCULATE WORM WHEEL SHAFT TORQUE:

$$\text{POWER} = \frac{2\,\Pi\,NT}{60}$$

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

The worm gear box is the reduction gear box with 1:38 ratio

Hence input speed at the input shaft = 1200/38 =31.5 =32 rpm (approx)

$$\Rightarrow T = \frac{60 \times P}{2 \times \Pi \times N}$$

$$= \frac{60 \times 60}{2 \times \Pi \times 1200}$$

$\Rightarrow$ T = 0.477 N-m

$\Rightarrow$ T design = 0.48 N-m

3.7 DESIGN (SELECTION OF WORM SHAFT BALL BRG 6003)

In selection of ball bearing the main governing factor is the system design of the drive i.e.; the size of the ball bearing is of major importance; hence we shall first select an appropriate ball bearing first taking into consideration convenience of mounting the planetary pins and then we shall check for the actual life of ball bearing .

3.8 BALL BEARING SELECTION: SERIES 62

Table: - 3

ISI NO	Brg Basic Design No (SKF)	d	D1	D	D2	B	Basic capacity	
							C kgf	Co Kgf
17A C03	6003	17	19	35	33	10	4650	2850

P = X Fr + Yfa.
Where;
P=Equivalent dynamic load, (N)
X=Radial load constant
Fr= Radial load (H)
Y = Axial load contact
Fa = Axial load (N)
In our case;
Radial load FR= BELT TENSION = 196 + 49 N
P= 245 N
$\Rightarrow$L= (C/p) p
Considering 4000 working hours (SPEED = 1200 RPM)

$$L = \left(\frac{60\ n\ L\ h}{10^6} \right)^3 \quad = 288 \text{ mrev}$$

$$\Rightarrow C = 1617 \text{ N}$$

AS; required dynamic of bearing is less than the rated dynamic capacity of bearing;$\Rightarrow$ Bearing is safe.

3.9 ASME CODE FOR DESIGN OF SHAFT:

Since the loads on most shafts in connected machinery are not constant, it is necessary to make proper allowance for the harmful effects of load fluctuations. According to ASME code permissible values of shear stress may be calculated from various relations.

$= 0.18 \times 800$

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

$fs_{max} = 0.3$ fyt

$=0.3 \times 680 \quad =204$ N/mm

Considering minimum of the above values

$\Rightarrow fs_{max} = 144 \text{ N/mm}^2$

Shaft is provided with key way; this will reduce its strength. Hence reducing above value of allowable stress by 25% $\Rightarrow fs_{max} = 108 \text{ N/mm}^2$

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

3.10 TO CALCULATE WORM WHEEL SHAFT TORQUE:

$\Rightarrow$ T design =Reduction ration x T (worm shaft) = 80 x 0.48 = 38.4 N-m

3.11 CHECK FOR TORSIONAL SHEAR FAILURE OF SHAFT:

Assuming minimum section diameter on worm wheel shaft = 22 mm

d = 22 mm

$$Td = \Pi/16 \times fs_{act} \times d^3$$

$$fs_{act} = \frac{16 \times Td}{\Pi \times d^3}$$

$$= \frac{16 \times 38.4 \times 10^3}{\Pi \times (22)^3}$$

fs_{act} = 18.36 N/mm^2 As $fs_{act} < fs_{all}$

I/P shaft is safe under torsional load.

IV. CONCLUSION

Automated welding Positioner machine for circular weld is totally satisfying the requirements. Developed Multi-axis welding Positioner with auto indexing reduces operator fatigue considerably. Because of this automation we achieved rise in production. At the same time there is reduction in rejection which results increase in the profit directly. Hence the cost of project can be recovered within one and half month. Easy operation, as table automatically stops as per indexer button position and next operation is started by merely pressing the inching switch. Hence it is easy to operate as well as precise with noiseless operation which leads to safety of operator. Auto stop feature, to start and end process operation at precise positions with multiple indexer positions, enables to make staggered welded joints. Compact, the entire drive assembly fitted below the table itself, and the controls are placed on the front at ergonomic positions. This system also required less amount of power, so it helps to achieve minimum power consumption.

REFERENCES

[1] Anatoly P. Pashkevich [1], Alexandre B. Dolgui[2], “Kinematic Control of A Robot-Positioner System for Arc Welding Application” Industrial Robotics: Programming, Simulation and Applicationl, ISBN 3-86611-286-6, pp. 702, ARS/plV, Germany, December 2006

[2] Ahmad, S. & Luo, S. (1989).Coordinated motion control of multiple robotic devices for welding and redundancy coordination through constrained optimization in Cartesian space. IEEE Transactions on Robotics and Automation, Vol. 5, No 4, (Aug. 1989), 409–417.

[3] Bolmsjo, G. (1987). A kinematic description of a positioner and its application in arc welding robots, In: Proc. of the 2nd Int. Conference on Developments in Automated and Robotic Welding, pp. 77-84., Nov. 1987, London, UK.

[4] Kay Thwe 1, Gao Gao 1, 2, Naing Thiha Soe3 “Current Welding Technology in Myanmar” [Journal of American Science 2010;6(1):99-104]. (ISSN: 1545-1003).

[5] S. SARAFAN, F. MALEK GHAINI, AND E. RAHIMI` “Effects of Welding Direction and Position on Susceptibility to Weld Metal Transverse Cracking in Welding High-Strength Pipeline Steel with Cellulosic Electrodes” Tarbiat Modares University, Tehran, Iran. E. RAHIMI is with AMA Industry Co., Tehran, Iran .JUNE 2012, VOL. 91

[6] T. A. PALMER, J. W. ELMER, D. BRASHER, D. BUTLER, and R. RIDDLE “Development of an Explosive Welding Process for Producing High-Strength Welds between Niobium and 6061-T651 Aluminum” Lawrence Livermore National Laboratory, Livermore, Calif. D. BRASHER and D. BUTLER are with High Energy Metals, Inc. Sequim, Wash. NOVEMBER 2006.

[7] Elmer, J. W., Terrill P., Brasher, D., and Butler, D. 2002. Joining depleted uranium to high-strength aluminum using an explosively clad niobium interlayer. Welding Journal 81(8): 167-s to 173-s.

[8] Juvinall, R. C. 1967.Engineering Considerations of Stress, Strain, and Strength. New York, N.Y.: McGraw Hill.