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DESIGN AND MANUFACTURING OF SPECIAL PURPOSE MACHINE USED FOR CIRCULAR METAL INERT GAS WELDING

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ABSTRACT

The conventional welding is carried out by skilled operators using hand operated welding guns. During welding process lots of factors which needed to control, The factors are accuracy and precision. The repetitive of quality and precision is impossible with using manual processes. The various issues also occurs in the process like dimensional accuracy, Spatters, surface finish of welded part. During production process the product quality is controlled by operator and depends on the skill of operator. The conventional method increases the cost of production and also increases in production time. This directly effects on the profit margin of component. The manual operation also increases the waste and rejection of work piece. The use automated welding process helps to overcome the issues occurs during production. The automated welding process improves accuracy and precision of welded part which increases profit by reducing the defect free part. Due to automation of welding process there is no need of skilled labour which ultimately saves in operating cost. The automated welding production process increases the production rate and improves in quality of welding. Due to use of automation the safety issues also controlled because of operator free process. In this paper we study the application of PLC programming for the MIG welding process. In present project we use MIG welding process for shaft welding which is used in the electrical panel industry. The circular welding process is carried out by using PLC signal operating MIG welding machine. The function perform by this special purpose machine is to weld cams on circular shaft. This circular shaft can be used in automatic control panel. The fully automated concept will found in this project. There is a whole description regarding procedure of project. Implementation of this project gives a punch rise to the profit level of industry with increase in productivity. Focusing on other functions like pneumatic energy and electric energy were also used for completion of this project. Concluding this all aspects, implementation of this project is more efficient than conventional welding process.

I.INTRODUCTION

Welding is defined as the process of joining similar metals by the application of heat. Duringwelding, the edges of the metal pieces are either melted or brought to plastic condition. Thisprocess is used for making permanent joints, which is obtained by homogenous mixture of two materials. Now a days, welding finds wide spread applications in almost all branches ofengineering industry. It is extensively employed in the fabrication and erection of steel structure in industries and construction [1]. It is also used in various industries like aircraft frame works,railway wagons, furniture, automobile bodies, ship buildings, nuclear industries etc. depending ontheir application [2]. Arc welding is usually performed by a skilled human worker who is oftenassisted by a person called fitter. The working conditions of the welder are typically unpleasant.The arc from the welding process emits ultraviolet radiation which is injurious to human vision.Other aspects of the process are also hazardous. For instance, the high temperatures created in arcwelding and the resulting molten metal is inherently dangerous. The electrical current that is usedto create the welding arc is also unsafe. During the welding process, sparks and smoke aregenerated and these make the environment unsafe to the operator. As a result of these difficulties,robots are being employed on the production line to perform arc welding operations. The robot isprogrammed to perform a sequence of welding operation on the product as it arrives at theworkstation [3]. However, there are significant technical and economic problems encountered inapplying robots to arc welding. One of the most difficult technical problems for welding robots isthe presence of variations in the components that are to be welded [4]. One is the variation in thedimensions of the parts in a batch production job. This type of dimensional variation means thatthe arc welding path to be followed will slightly change from part to part. The second variation isin the position of orientation of work piece itself. These two problems can be overcome if we optfor a machine vision system. The machine vision system consists of a camera and a controller. As we know welding process is the part of production process which is very much responsible for the production rate and in turn in its cost of production.So in our project were tried to automate the welding process in a cost effective process. We have chosen MIG welding because MIG it is the most effective welding process with respect to other processes for its much greater penetration power and the automated electrode wire feed mechanism. Our project aims at developing a much cheaper but effective and advanced gas metal arc welding with automated kit for automating the whole welding process.Metal Inert Gas welding is one of the most widely used processes in industry. The input parameters play a very significant role in determining the quality of a welded joint. In fact, weld geometry directly affects the complexity of weld schedules and thereby the construction and manufacturing costs of steel structures and mechanical devices. Therefore, these parameters affecting the arc and welding should be estimated and their changing conditions during process must be known before in order to obtain optimum results; in fact a perfect arc can be achieved when all the parameters are in conformity. These are combined in two groups as first order adjustable and second order adjustable parameters defined before welding process. Former are welding current, arc voltage and welding speed. These parameters will affect the weld characteristics to a great extent. Because these factors can be varied over a large range, they are considered the primary adjustments in any welding operation. Their values should be recorded for the observation.

1.1 Problem Statement

Followings are main importance problems occurs during welding

- Weld porosity
- Lack of fusion
- Faulty wire delivery related to equipment set-up and maintenance.
- Production rate.

- Operators operating mistakes
- Quality of welding such as welding run, spatters, welding run depth
- Parts full proofing means locations of child parts as per job requirement.

1.2 Objectives

Primary objective of invention is to provide a supporting structure having greater capabilities and not only being used moreexpediously but also of handling structural assemblies which are bulky to be handled manually.Another objective is to provide a fixture which:

- It should occupy small space.
- Easy recover of cost of investment.
- It should rugged and durable.
- It must have efficiently and effectively fulfill its intended purpose.
- It should capable of handling small as well as large sized work pieces.
- It must have capabilities to retain framework in various positions into which it is swung.
- It has facilities to assembly of components in correct position.

1.3 NEED OF DEVELOPMENT

- Reduces welder fatigue.
- Increases welder safety.
- Improves weld quality.
- Increases productivity over manually positioning the parts.
- Assists welders in maneuvering and welding large weldments and parts.
- Ensures smooth welding table rotation.
- Faster welding speeds especially for obtaining X-ray quality welds.

II. LITERATURE SURVEY

The related approaches include design of automatic Welding machine based on PLC. This method presents an automatic welding machine used for the carbon dioxide gas welding, with the mechanical structure designed, and the working process of the automatic welding machine analyzed. Experimental operation results show that PLC-controlled automatic welding machine can improve welding quality and efficiency, reduce labour intensity and bring huge economic benefits [10]. Other methods include forward and reverse modeling in MIG Welding process using fuzzy logic-based approaches. It is an attempt to carry out the forward and reverse modeling of the MIG welding processusing fuzzy logic-based approaches [11].

This is an era of automation where automation is broadly defined as replacement of manual effort by mechanical power. Automatic welding system can be classified into two categories namely:

- System based on contact sensors
- System based on noncontact sensors

This paper focuses on the latter. There are three categories of non-contact sensors: [12]

i. Systems based on voltage through the arc welding

ii. Systems based on ultrasonic sensors

iii. Systems based on visual sensors

BeningoMaqueria, et al(1989) [13] developed an ultrasonic based robot to track the seam. He used an ultrasonic sensor which is interfaced to a P-50 process robot in an effort to achieve on-line seam tracking of joints, without the use of geometrical models or subsequent "teaching" routines. Ai-min Li, et al (2011) [14] designed an automatic welding machine based on PLC. He designed the machine to perform carbon-di-oxide gas welding.

III. METHODOLOGY

To achieve the above objectives D-optimal methodology has been selected. The D-optimal method is relatively a new technique, related to response surface methodology, used for carrying out the design of experiments, the analysis of variance, and the empirical modeling. The D-optimal criterion was developed to select design points in a way that minimizes the variance associated with the estimates of specified mode coefficients. In a sense this method is more useful than central composite design (a conventional response surface method) method that it demands smaller number of experiments to be conducted and also it can tackle categorical factors included in the design of experiments. Basic steps for achieving the desire objectives are:

- **Data Collection:** According to design matrix based on D-optimal design matrix, The experiments will be conducted on mild steel plate using 304 stainless steel electrodes.
- **Empirical Modeling:** Development of empirical model (relationship between GMAW responses and the GMAW parameters) using regression analysis.
- **Test for adequacy of develop model**: Checking of model significance, model terms significance using ANOVA analysis. This empirical model will helpful in optimal selection of GMAW parameters.
- **Optimization of GMAW Parameters:** Analysis and selection of optimal GMAW parameters for a low dilution rate.

IV. MACHINE PHOTOGRAPHS

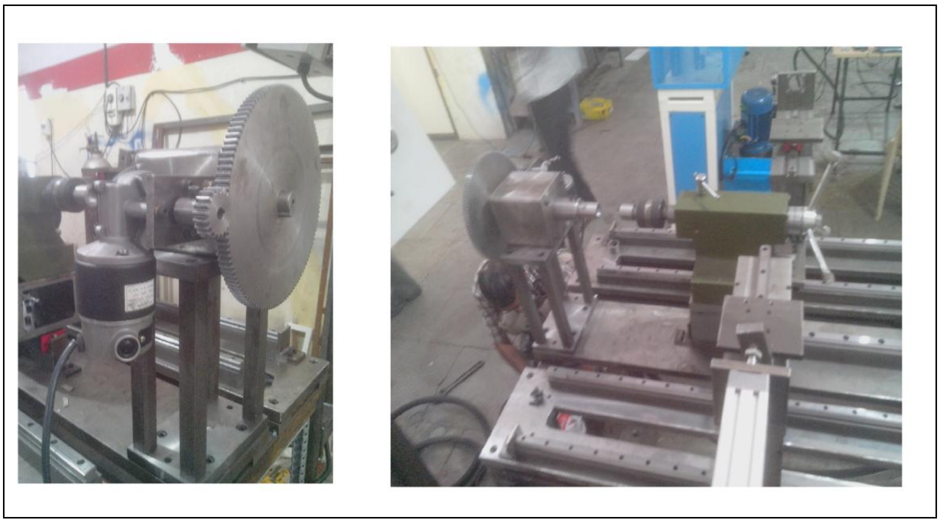

Fig.4.1 Assembly of Head Stock and Tail Stock

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Fig.4.2 Working on Machine

Fig 4.3 Working of Machine

Fig 4.4 Working on Machine

V. DESIGN

Ball screw

The specially designed gothic ball track can make the ball contact angle around 45^0. The axial force which comes from outside drive force or inside preload force causes two kinds of backlash. One is normal backlash, caused by manufacturing clearance between ball track and ball. The other is deflection backlash, cause by normal force which is perpendicular to the contact point. The clearance backlash can be eliminated by the preload internal force. This preload can be obtain via a double nut, an offset pinch single nut, or by adjusting the ball size for preload single nuts. The deflection backlash is caused by preload internal force and external loading force and is related to that of the effect of lost motion.

Preload calculation

Assumed working conditions

Condition	Axial Load(kgf)	Revolution (rpm)	Time Ration
1	100	100	10
2	200	50	20
3	300	20	30

- Average number of revolution,

$n_{av} = n_1 \times \frac{t1}{100} + n_2 \times \frac{t2}{100} + n_3 \times \frac{t3}{100} + \ldots\ldots\ldots$

$= 100 \times \frac{10}{100} + 50 \times \frac{20}{100} + 20 \times \frac{30}{100}$

$n_{av} = 26$ rpm

- The average operating load, f_{bm}

$= \sqrt[3]{f_{b_1}{}^3 \times \frac{t1}{100} \times f_p{}^3 + f_{b_1}{}^3 \times \frac{t1}{100} \times f_p{}^3 + f_{b_1}{}^3 \times \frac{t1}{100} \times f_p{}^3}$

$= \sqrt[3]{100^3 \times \frac{10}{100} \times 1.1^3 + 200^3 \times \frac{20}{100} \times 1.1^3 + 300^3 \times \frac{30}{100} \times 1.1^3}$

$f_{bm} = 235.39$ kgf

- Preload , P

P $= \frac{f_{bm}}{2.8} = \frac{235.39}{2.8} =$ **84.067 kgf**

- Torque calculation ,

Lead angle , $\alpha = \tan^{-1} \frac{l}{\pi D_m}$,

where l = lead , Dm= pitch circle diameter

$\alpha = \tan^{-1} \frac{25}{\pi * 25}$

$\alpha = 17.65$

Friction angle, $\phi = \tan^{-1} \mu$, where μ =coefficient of friction (0.003-0.01)

$= \tan^{-1} 0.005 = 0.2864$

- For common transmission (to convert the rotary to linear motion,)

$\acute{\eta}_1 = \frac{\tan\alpha}{\tan(\alpha+\beta)} = \frac{\tan 17.65}{\tan(17.65+0.2864)} = 0.9829$

- or Reverse transmission (to convert linear to rotary motion)

$\acute{\eta}_1 = \frac{\tan(\alpha-\beta)}{\tan(\alpha)} = \frac{\tan(17.65-0.2864)}{\tan(17.65)} = 0.9827$

Where, $\acute{\eta}_1$ & $\acute{\eta}_2$ are mechanical efficiencies

- Preload Drag torque , T_d

preload drag torque,

$k_p = \frac{0.05}{\sqrt{\tan\alpha}}$

$= \frac{0.05}{\sqrt{\tan^{-1}(17.65)}} = 0.088$

So, $T_d = \frac{k_p \times p \times l}{2\pi}$

$= \frac{0.088 \times 84.067 \times 25}{2\pi}$

$\boldsymbol{T_d}$ **= 29.43 kgf.mm**

- Common transmission torque T_a, (to convert rotary motion to linear)

Total load W= table weight + work piece weight (kgf)

= 335+2 = 337

Axial load $f_b = f_{bm}$+μ.W

= 235.39 + (0.005*337)

=237.075 kgf

So, $T_a = \frac{f_b \times l}{2\pi \eta_1}$

$= \frac{237.075 \times 25}{2\pi \times 0.9827}$

$\boldsymbol{T_a}$**=959.89 kgf.mm**

- Motor Drive Torque, Tm (kgf.mm)

$T_m = (T_a + T_d)\frac{N_1}{N_2}$

where, T_a = Common transmission torque

T_d =preload drag torque

N_1 =number of teeth on driver pulley

N_2 =number of teeth on driven pulley

So, $T_m = (959.89 + 29.43) \times \frac{10}{120}$

= 82.44 kgf.mm

According to above motor torque, it is must that D.C. motor is prefer having torque is more than above calculated value,

- Buckling load,

  The ball screw shaft when subjected to an axial compressive force may be undergo a visibly large deflection. The axial force is called as buckling load.

Permissible load, $f_k = 40720 \left\{\frac{N_f \times d_r^4}{L_t^2}\right\}$

Where, N_f= factor of mounting (here mouting type is fixed- fixed, N_f= 1) std

d_r= root diameter of screw shaft (mm)

= 34.91 mm (std)

L_t= distance between two support (mm)

= 2200 mm

So, $f_k = 40720 \left\{\frac{1 \times 34.91^4}{2200^2}\right\}$

= 12495.73

Max. Permissible load,

f_p= 0.5 f_k

= 0.5× 12495.73

= 6247.86 kgf

- Critical speed, *Nc*

$Nc = 2.71 \times 10^8 \times \frac{M_f \times d_r}{L_t^2}$

$= 2.71 \times 10^8 \times \frac{1 \times 34.91}{2200^2}$

Nc= 1954.67 rpm

Max permissible speed,

$Np = 0.8 \times Nc$

$= 0.8\times 1954.67 = 1563.73$ rpm

- Stiffness , k_{bs}

$$\frac{1}{k_{bs}} = \frac{1}{k_s} + \frac{1}{k_n}$$

where, k_{bs} = total stiffness of ballscrew (kgf/μm)

Screw spindle stiffness,

$k_s = 67.4 \times \frac{{d_r}^2}{L_t}$.....for fixed-fixed mounting

$=67.4 \times \frac{34.91^2}{2200}$=37.33 kgf/μm

Nut stiffness ,

$$k_n = 0.8\times K \left(\frac{p}{0.1\times C}\right)^{\frac{1}{3}}$$

where K= stiffness in dimension table

C= dynamic load in dimension table

$$k_n = 0.8\times 74 \left(\frac{84.07}{0.1\times 5370}\right)^{\frac{1}{3}}$$

= 31.90 kgf/μm

So, total stiffness, $\frac{1}{k_{bs}} = \frac{1}{k_s} + \frac{1}{k_n}$

$$\frac{1}{k_{bs}} = \frac{1}{37.33} + \frac{1}{31.90}$$

$k_{bs} = 17.20\ kgf/\mu m$

- Deflection ,δ

$$\frac{\delta}{2} = \frac{f_{bm}}{k_{bs}}$$

$$\frac{\delta}{2} = \frac{235.39}{17.20}$$

δ =27.37 μm

δ =0.02737 mm

For pneumatic cylinder

Assumed D = 40mm, L = 200mm, d = 16mm

Material = Alloy steel,

Yield strength from PSG Design data boaok

Y_t = 240 N/mm^2, FOS = 2.5

- Allowable stress ,

$\sigma = \frac{Yt}{FOS} = \frac{240}{2.5}$ = 96N/mm^2

Pressure = 6 bar

$= 6 \times 10^5$ N/m^2 = 0.6 N/mm^2

- For forward stroke ,

Area = $\frac{\pi}{4} D^2$

$= \frac{\pi}{4} \times 40^2$

= 1256.63 mm^2

= 2.01 in^2

Volume = Area × Length

= 1256.63×200

$=251326\ mm^3$

$=16.08\ in^3$

- Force = $\frac{\pi}{4} D^2 \times P$

$= 1256.63 \times 0.6 = 753.97\ N$

Pressure is less that the material stress, so Design is safe.

- For Backward stroke :

Area = $\frac{\pi}{4}(D^2 - d^2)$

$= \frac{\pi}{4}(40^2 - 16^2)$

$= 1055.57\ mm^2 = 1.6889\ in^2$

- Volume = Area × Length

$= 1055.57 \times 200$

$=211114\ mm^3$

$=13.51\ in^3$

- Force = Area × P

$= 1055.67 \times 0.6$

$= 633.40\ N$

Flow requirement :

$$=\frac{volume \times no.\ of\ cylinder \times (60/3)}{231\ inch^3\ per\ gallon}$$

= 1392.63 gpm (gallon/min)

$= 1392.63\ lit^3/min$

= 13.92 m/min

- Cylinder Volume capacity = $\frac{area \times stroke}{231}$

= 0.05382 gallon of fluid

- Minimum thickness :

$$t = \frac{di}{2}\left(\sqrt{\frac{\sigma_{all}}{\sigma_{all} - \sqrt{3}\,Pi}} - 1\right)$$

$t_{min}= 0.08716$

VI. CONCLUSION

This conclusion is made on the basis of collected information regarding the work. Now a day's every manufacturers intend to atomise every machinery for better production rate and quality assurance. Our special purpose machine design is PLC operated based. The main purpose of our machine is to weld the lever and various child parts to the circular shaft hence the main aim of this work is automation of circular welding process. The circular welding shaft assembly is used to manipulate the switches of the control box. This automated welding process results in uniform cross section having no spatters on the welding surface. The automated welding process avoids the limitations which occurs In the conventional welding process such as the quality of the weld is so poor, spatters on welding surface, lack of welding penetration, uneven welding thickness of weld, so our design helps to attain higher quality of the weld which results in reliable product. The stresses which were affecting the quality of the product were reduced to get a better productivity. The overall lead time required for the process is reduced drastically by implementation of our design. Due to implementation of the fixture the cams were situated at desired position with proper inclination.

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