iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 Issue: VI Month of publication: June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35429

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Design and Development of Drilling Indexing Mechanism

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Abstract: Quality and productivity plays important role in today's manufacturing market. Automation provides high end quality. Drilling machine is most common and vital for producing holes. In this paper, an attempt is made to reduce effect of machining ideal time because of mounting, dismounting, marking, etc. The effort is to investigate optimal time of producing hole and their contribution on higher productivity and less cost optimization.
Keywords: Indexing, Drilling, Quality, Automation, Productivity, cost

I. INTRODUCTION

In process of drilling, drilling across PCD is most commonly used. This process majorly used for flanges. Generally in small scale industries to manufacture flanges, marking and punching are carried out by labor. But in this way manual error is seen maximum. This manufacturing is also can be carried out by NC, CNCs, etc. machines but such machining requires high capital and skilled operators. Hence drilling indexing mechanism is focused on drilling concentrating along PCD as much less labor and simple bar mechanism is used to change positions of work piece and drilling carried out much easily.

II. ABOUT

A. Problem Statement

There are two types of manufacturing methods used for drilling flanges; i) by using templates by marking and punching the jobs and then drilling it. ii) By using jigs. In marking method manual error is large and eventually job gets rejected as well as in Jigs/Templates we have to create templates every time job changes its size or number of holes. To overcome this problem we have developed indexing mechanism.

B. Work Piece

Flanges are semi-permanent connection used to joint two parts specifically pipes. a) They can be frequently or occasionally dismantled b) are light enough to move easily c) cannot be welded due to heat sensitivity they needed to be fitted with nut and bolts for proper joint.

There are different types of flanges:
1) Blind flange
2) Lap joint flange
3) Orifice flange
4) Threaded (screwed) flange
5) Welding neck flange
6) Forged flange
7) Slip on flange

III.THEORY

Mechanism is a system where we transfer motion in the way we want. Indexing mechanism generally converts rotation or oscillatory motion into series of step movements of output link or shaft. In machine tools the cutting tool has to be indexed in tool turret after every operation. Also in production machines the product has to be indexed from station to station and needs to be stopped if any operation is already being performed on the station. Such motions can be achieved by indexing mechanism. Indexing mechanisms are also useful in tool feeds. There are several methods for indexing like ratchet and pawl, rack and pinion, Geneva, cam drive, etc.

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A. Ratchet and Pawl Mechanism

A ratchet is a device that allows linear or rotary motion in only one direction. Above figure shows schematic of the same. Ratchet consists of gearwheel and pivoting spring loaded pawl that engages the teeth. The teeth or pawl are at angle so that when the teeth are moving in one direction pawl slides in between the teeth. The ratchet and pawl are not mechanically interlocked hence easy to install. Maintenance of this system is easy.

B. Rack and Pinion Mechanism

A rack and pinion gear arrangement usually converts rotation from a pinion to linear motion of a rack. But in indexing mechanism we can convert linear motion into rotating. To drive the rack the device uses a piston, which allows the pinion gear and attached indexing table to rotate. A clutch is employed to supply rotation within the desired direction. This mechanism is straightforward but isn't considered suitable for high-speed operation.

C. Geneva Mechanism

The Geneva mechanism is additionally commonly known as Maltese cross mechanism. The Geneva mechanism translates endless rotation into an intermittent rotation. The rotating drive wheel is assembled with a pin that comes in contact with driven wheel. The drive wheel also have raised circular blocking disc assembles with it which allows to lock the driven wheel in required position between motions. There are three basic sorts of Geneva motion mechanisms namely external, internal and spherical. The spherical Geneva mechanism is very rarely used. In the simplest form, the driven wheel has four slots and hence for every rotation of the drive wheel it advances by one step of 90°. If the driven wheel has number of slots, it moves forward by 360°/n per full rotation of the drive wheel

D. Cams Mechanism

Cam mechanism is most accurate and reliable indexing method. It is preferably used in industries even if the cost is higher than other alternative mechanisms. The cam is originally designed to achieve variety of velocity and dwell characteristics. In indexing mechanism the follower has unidirectional rotary motion instead of oscillating, which is mostly used in case of axial cams. The cam surface geometry is more complicated in a cross over indexing type of cam.

E. Rotary Indexing Table

These are used for the simultaneous transfer of small parts from one station to next station at single work centre. The work parts are indexed around a rotary table. The workstations are stationary and usually located around the outside periphery of the dial as shown in above Fig. The parts placed on the rotating table are positioned at every station for their processing or assembly operation. This type of system is known as an indexing machine or dial index machine.

IV. PROPOSED INDEXING MECHANISM

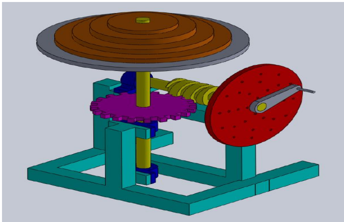

Fig.1 Proposed work

Controlled dimensions and parameter by using indexing mechanism for drilling machine: -

1) PCD pitch circle dimension
2) Number of holes
3) Hole diameter

In this proposed project work we will develop the bar link mechanism which will link in between drilling head and indexing plate in such a way that, by using spigot pin arrangement we can able to drill on flange / work piece as per given/ required standard. When we will select the proper hole on indexing plate at that time drill head moves and set its location for drilling operation.

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V. DESIGN OF EXPERIMENTAL SETUP

A. Selection of Motor

Ideally we have considered PMDC (Permanent magnet DC motor 40 rpm).
So Base plate speed = 1 rpm
Selection of motor-
The load required to rotate the base considered = 10 kg = 100N
So Base plate dia. considered as per flange outside dia. of 4 inch flange = 300mm
Design load considered = 1.2 x 100N
= 120N
= 120N considered.
The Worm gear diameter = 150mm
So it is assumed that the force required to rotate the gear = 120N
So Maximum Torque T = Effort x Radius of wheel
Total torque on crank = 150 /2x 120 = 9000 N-mm
We know that, power (P)
P = (2*Π*N*T)/60
P = 37.69 watt
So we have selected PMDC wiper motor of 4 wheeler.
Specifications of Wiper PMDC motor:
Motor power = 175watt
Motor speed = 40 rpm
Motor supply 12V DC
Motor operating current = 3.7 amp
So considering extra jerk and friction in the mechanism the selected motor and its power is suitable.

B. Selection of Bearing

$F_a/F_r = 0 \leq e$
So x=1 & y=0
∴ Equivalent dynamic load
$P = X F_r + Y F_q$
P = RB = 277.5 N
Life in hrs = 10000 hr
Life in millions (L):

$L = 60nL_b / 10^6$
L = 36 millions of rev

Where, Dynamic load capacity:
$L = (C/P)^a$
a = 3 for ball bearing

From SKF bearing catalogue we have selected the bearing static capacity for shaft dia. 20mm = Co = 2.32 KN
From above equation = C = 234 N

So calculated dynamic capacity C < bearing catalogue dynamic capacity C = 4.32KN
Hence from catalogue bearing selected = 61804

C. Design of Drive Shaft

Fig.2 Drive shaft

P = Load due to seed carrier

T = Max Torque generated due to bevel gear / Due to rotating wheel (whichever is max)

RA and RB = Support reactions.

As per Design data book shaft material is selected Carbon steel C40

C40=Sut=580 N/mm^2

Yield strength = 435 N/mm^2

σ = 145 N/mm2

As per ASME code

0.3 X Yield strength N/mm2

0.18 X ultimate strength N/mm2} whichever is smaller

0.3 x 330 = 99 N/mm2 ………………………………………….(a)

0.18 x 580 = 104 N/mm2 ……………………………………..(b)

From equation (a) & (b)

Allowable stress value will be 99 N/mm2

If key ways will provide to shaft then

τ = 99 x 0.75 = 74.25 N/mm2

Max torsional moment equation is given by

We know,

$T_e = (\Pi/16)\, d^3 \tau$

Where T = 9000N-mm

By using above equation drive shaft dia.

d = 8.510mm ……………….A

We know that,

Max bending moment equation is given by

We Know,

$M = (\Pi/32) * d^3\, \sigma$

The maximum force applied on the base plate is = 50kg (considered)

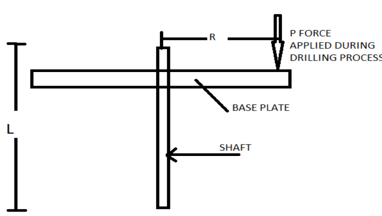

Fig. 3 BMD diagram

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VI. CONSTRUCTION

The drawing / model show the arrangement of drilling indexing fixture. In this arrangement we have used indexing mechanism, Indexing mechanism is nothing but in which 40 teeth's gear and single start arm is used. In which to complete one revolution of worm gear we have to rotate worm with 40 rev. Hence because of this advantage of worm and worm wheel we can do indexing easily.

Fig.4 Actual model

According to number of holes given in the Flange drilling standard we can rotate the worm and achieve required location .So in this indexing arrangement we only locate the position of holes.

Also these locations of holes are fixed along with PCD with their size. So to identify the PCD as per shown in the fig we have did marking so that as per size of the flange we can able to do setting according to points x1 y1 , x2 y2 and x3 y3. So these points we have set according to flange size.

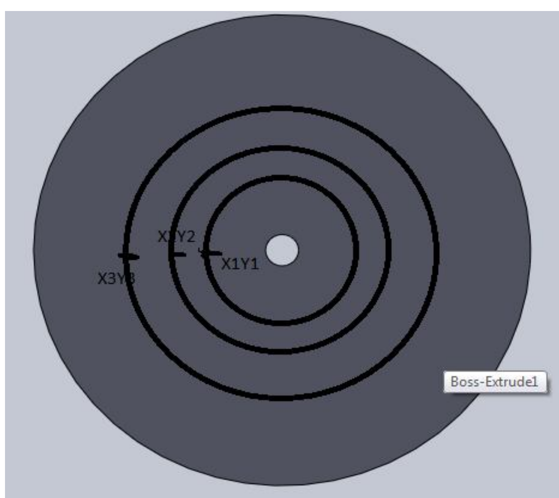

Fig.5 Determining PCD

Electronic systems were used to make the instrument more accurate and can have more control over the machine. Arduino unit is used because it can have both programmed and physical microcontroller. This allows to write and upload computer code to the IDE (integrated Development Environment) Arduino provides reset button which is which gives access to stop or change program. There are many types of circuits out of which we are using NASJ type board with ATMEGA328 microchip.

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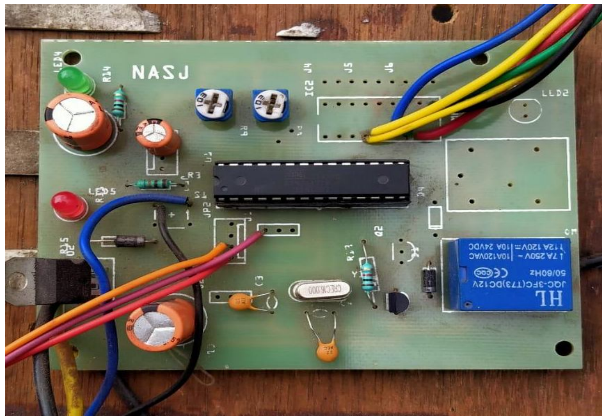

Fig.6 Arduino Unit

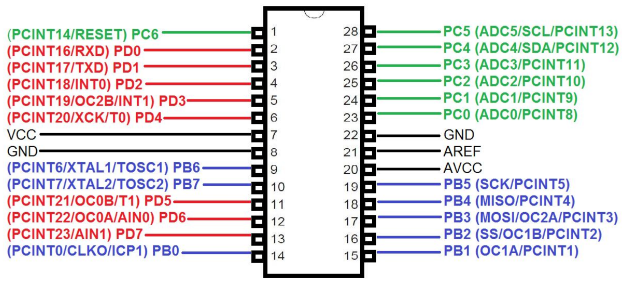

Fig.7 Atmega 328 pinouts

VII. TESTING OF MACHINE

To test and confirm the working of developed mechanism for flange drilling as per ISO and IS standard we have taken practical demonstration at various small scale industries. Also we have collected the feedbacks and improvements points in developed model.

Testing points and concluded points as below:-

Table no. 1 Testing of Machine

Sr. No	Points observed	Existing manual method		New developed Drilling indexing method mechanism
		Using templates	Manual marking method	
1	Labour requirement	02 LABOUR 01 = Skilled labour 01 = Unskilled labour	02 LABOUR 01 = Skilled labour 01 = Unskilled labour	01 LABOUR 01 Un-Skilled labour
2	Time required for production per flange	6 Min per flange	17 Min per flange	3Min per flange
3	Space required for storage of accessories	Storage racks are required	Storage space / cupboard required for tools and Marking instruments	No requirement
4	Electricity required for mechanism or accessories	Not required	Not required	Required but 12 volt DC supply
5	Material handling	More than developed mechanism	More than developed mechanism	Material handling is very less
6	Accuracy	1 % rejection per 100 flanges	4 % rejection per 100 flanges	1 % rejection per 100 flanges

VIII. RESULT AND CONCLUSION

Table no. 2 Result and conclusion

Sr No	Points considered / activity / cost	Cost for manual Method	Cost for developed Mechanism
1	Labour Cost	Labour requirement = 02 numbers Cost for skilled labour = 400 per day Cost for Unskilled labour = 300 per day Total cost = 400 + 300 = 700 Rs.	Labour requirement = 01 numbers Cost for Unskilled labour = 300 per day Total cost = 300 x 1 = 300 Rs
2	Maintenance cost	Minimum 150 Rs. per year	10 % of initial cost =1450 Rs
3	Storage cost	Neglected	Not required
4	Rate of Production per day	70 per day	85per day
5	Days required for 300 Flanges per month	4.2 days	3.5 Days
6	Days required per year	4.2 x 12 months = 50.4 days	3.5 x 12months = 42 days
7	Total cost per year	a) Per day labour cost = 700 Rs Total Labour cost per year = 50.4 x 700 = 35280 Rs b) Maintenance cost = 150 Total cost 35280 + 150 = 35430 Rs	a) Per day labour cost = 300 Rs Total Labour cost per year = 42 x 300 = 12600 Rs b) Maintenance cost = 1450 Total cost 12600 x 1450 = 14050Rs
	Total saving per year	= 35430 – 14050 = 21380	

So from above analysis it is concluded that

Payback Period = Total Project Cost / Annual Saving

= 14500 / 21380
= 0.67 year

So from above analysis it is seen that the payback period for developed Drilling indexing mechanism is **0.67 year. (Approx. 6 months)**
(Payback period is the length of time required to recover the cost of an investment)

IX. CONCLUSIONS

From above results we can state that indexing mechanism is more convenient than conventional method. The instrument gives total control over the process reducing excessive errors. The production profit is increased more than 25%, with reduction in operational time and manual error. The cost of the instrument can be recovered in approximately 6 months. As per the results we are sure that the scope of this concept can be seen in medium and small scale industries.

X. ACKNOWLEDGMENT

I thank my guide Dattatray Patil, Professor of Nanasaheb Mahadik College of Engineering and all employees of Sponsor Company HI-tech industries who helped us.

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