International Journal For Advanced Research
In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

STATIC ANALYSIS OF CNC ROTARY TABLE

P. Ravikanth Raju
Dept. of Mechanical Engineering, J. B. Institute of Engineering & Technology, Moinabad(Mdl) Hyderabad -75, India

Abstract - Now a day's machining of component in single setup is more important concept for manufacturing any product. The objective of this paper is to give a design of CNC rotary table, this paper discuss design and analysis which include the finite element analysis of pallet with the structural static and modal behavior, The work focuses on design of rotary table used to support and hold components weighing up to 815 kg for machining, The rotary table should be designed with positional accuracy of ±10 with repeatability of four seconds .CNC rotary table is a work holding device used on cnc machining centers to position the component in desired angle to do multi-face operation in one setup. The main purpose is to design and select Critical Components Like Servomotor, Worm Gear Mechanism, Angle Encoder, Worm Gear Support Bearings, Bellow Coupling for connecting two shaft, Table Support Bearings.

Keywords: **rotary table, pallet, dynamic analysis, ANSYS.**

I. INTRODUCTION

The trends of performance requirements for mechanical manufacturing are characterized by the constantly growing requirement for the machine tools positioning precision, the challenge also consisting in the ability to produce mechanical component with very high

precision and also at reasonable production costs [1].

In order to meet these ambitious demands, it is necessary to find solutions concerning the shortening of the process time, which can be accomplished by increasing the productivity of the manufacturing process, since increasing the precision of the procedures is in many cases limited by the physical principles which underly these procedures and by the performances of the mechanical part of the machine tool (2)

Rotary tables are used to index parts and components in defined, angular increments so that

they can be machined, worked in multiple operations .Rotary tables have either fixed or adjustable indexing angles. For all of a given time interval in each revolution, the table stops for a specified period of time so that an operation can be performed at each station. Rotary tables are powered by pneumatic and electric motors, hydraulic drives, and manual actuation. Drive mechanisms can be located above, behind, or to the side of the table surface. Pneumatic rotary tables are suitable for small and medium loads. They are powered by one of more pneumatic cylinders, each of which represents an index. Electrically-powered tables are generally faster than pneumatic devices and can handle heavier loads. Tables that are powered by hydraulic drives use a pressurized fluid that transfers rotational kinetic energy.

II. MODE OF OPERATION

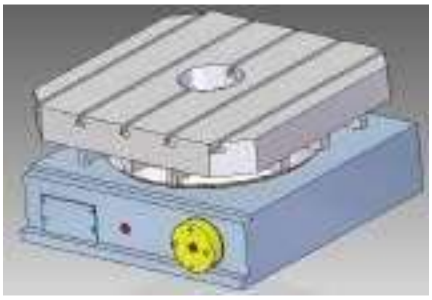

Fig .1.Design Of Rotary Table

The circuit diagram of a rotary table as shown in Figure 1. in which MP scale or encoder which is coupled with the table. In this servomotor is coupled with the worm gearing mechanism which is used to reduce the large speed reduction and also transfers the rotation into 90º angle. Indexing angle of the rotary table is controlled by an MP scale (encoder) in which the output signal from the encoder is sended pre-amplifier where the input signal from encoder is amplified for further operation then, the output signal from the Pre-amplifier is transferred to the A/D converter where these signals are converted into an analogue to digital signal then send to the Servo amplifier for further amplification then, output signal is send to servomotor to control the moment of the Rotary Table.

III. DESIGN AND SELECTION OF CRITICAL COMPONENTS –

Machining Force Calculation

In HMC machine the maximum diameter of the tool used for machining the component on rotary table is 80 mm which gives the maximum tangential force and depth of cut .

Diameter of the cutter ,D =80mm

Cutting speed, V= 350m/min

Revolutions per min, n = (1000xV) / (π x D)

n = 1392.425

rpm =~ 1400 rpm

Metal removal rate, Q = b t Sm÷1000

Q = 1038.6 mm³/min

Average chip thickness, as = 57.3 Sz x Sin x (cosΨ1-cosΨ2) /Ψs°

as = 0.3508mm

Tangential cutting force, Pz = 6120N) ÷V (3.1)

Pz = 106.5 kgf

The machining force on the Rotary table will be 1020 N.

A. .Selection of module –

Using formula,

$\cot^3\lambda = VR = 60$

$$\lambda = \frac{1}{\tan 3.91}$$

λ=14.63

$$m = \frac{Pa}{\pi} = \frac{13.75}{\pi} = 4$$

C.Design of Worm &Worm wheel

Axial pitch of thread - Pa = Π x m = 12.568 mm

Lead - P z = Z x Pa = 12.568 mm

Reference Diameter of worm

-d1= Q x m = 40 mm

Tip diameter of worm -

da1= d1+2 ha1 = 48 mm

Root diameter of the worm

– df1 = d1-2 hf1 = 30.4 mm

Pitch circle diameter of worm wheel

– d2 = Z 2 x m = 240 mm

Throat diameter of worm wheel

– da2 = d2+2 ha2 = 248 mm

Root diameter of the worm wheel –

df 2 = da2-2(ha1+hf2) = 230.3362 mm

External diameter of worm wheel –

de2 = da2+ m = 251.9282 mm

4. Gear Force calculations

Tangential load by Lewis,

WT = (σ0 c v) b π m y = 3926.808 Mpa

Dynamic load,

WD = WT ÷ CV = 4090.425

Mpa Tangential Force on worm,

Ft1 = 2 T / 60 Ft1 = 0.363657 KN

Axial Force on worm, Fa1 = Ft ((cos α cos γ – μ sin Y) / (cos α sin γ + μ cos Y)= 1.0680KN

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
ISSN: 2457-0362
www.ijarst.in

5. Selection of Bearing Arrangement for Worm Shaft Support

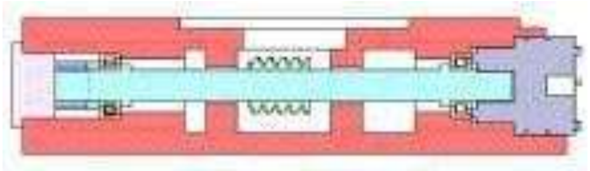

Fig -2 Worm Shaft Supported By Taper Roller Bearing

For Taper Roller Bearing:

Diameter of the bearing, D = 30 mm

Outer Diameter of the bearing, Do= 62 mm

Basic Dynamic load, C = 65000N

Basic Static load, Co =77000 N

Equivalent Dynamic load, P = XFr1+YFa1 P = 1808.108 N

Life of the bearing,

$L = (1000000 \div 60n) X (C \div P)^{a}$

Where,

a = 10/ 3

L= 51620.77 Hrs

In above arrangement both end of the shaft is supported by a taper roller bearing because it takes the axial and radial loads and also which gives the more rigidity and also life of the bearing is greater than the single row deep groove ball bearing and angular contact ball bearing. The main advantage of this bearing is it takes loads when table rotated clockwise and anticlockwise direction as shown in Figure 2

6. Bearing Arrangement for Table Support –

The top surface of the table is supported by a Four point Angular contact ball bearing .The bottom surface of the table is supported by an Angular contact ball bearing .

7. Selection of Encoder –

A rotary encoder also called as a shaft encoder, is an electro-mechanical device that converts the angular position or motion of a shaft to an analog or digital code.

Encoder Specification

Series RON/ERN 200

System accuracy ± 10 sec

Recommended mean step 0.001º

8. Drive for Worm Shaft from Servomotor through Coupling :

Torque of the shaft 1200 N m

Corrected Torque T d = Service factor x

Speed Td = 1.4 X 1200 == 1680 Nm

Servo Motor Specification

Diameter of Shaft 30 mm

Rated output 1.5 KW

9. Selection of Lock nut

Lock nut is selected depending upon the tightening torque:

Tightening torque $M = fa \times (f \times \frac{Dm}{2} + F1 \times \frac{Dt}{2}) \times 10^{-3}$………(1); M =1.1Nm

MKR series is the axial locking. 30 is the thread diameter is selected .

4. Static structural analysis of critical Component –pallets

Load acting on the Pallet:

Weight of the work piece = 800kg

Cutting Force in Y direction = 1020N

Cutting Force in Z direction =1000 N

4.1 Static analysis of Ribbed Pattern Pallet

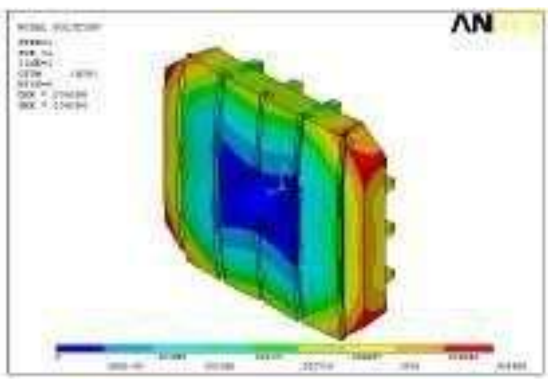

Figure 3- Deflections in FG300 Ribbed Pattern Pallet.

IJARST
International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

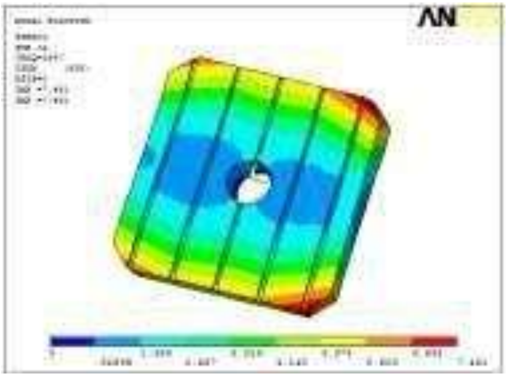

Figure 4- Deflections in FG300 Solid Pallet

Static analysis of Solid Pallet

From the above analysis, it is evident that the deflection is 4.8 microns which is lesser than the allowable deflection of 10 microns (HMC machine accuracy).For the margin of factor of safety 2 applied than also design is safe.

4.3 Comparison of results -

Table no- 1

Model	Ribbed Pattern Pallet	Solid Pallet
Material	Grey cast iron (FG 300)	Grey cast iron (FG 300)
Weight	118 kg	146 kg
Total Deflection	0.0048 mm	0.0047mm
Vonmises Stress	11.7 MPa	11.1MPa
Model	Ribbed Pattern Pallet	Solid Pallet
Material	Grey cast iron (FG 300)	Grey cast iron (FG 300)
Weight	118 kg	146 kg
Total Deflection	0.0048 mm	0.0047mm
Vonmises Stress	11.7 MPa	11.1MPa

5 .Dynamic analysis (modal) of critical Component – pallet

5.1 Modal Analysis of Ribbed Pattern Pallet –

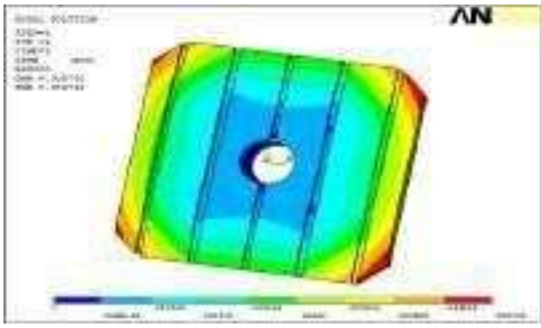

Figure 5 Ribbed pattern Pallet Frequency 1806 Hz

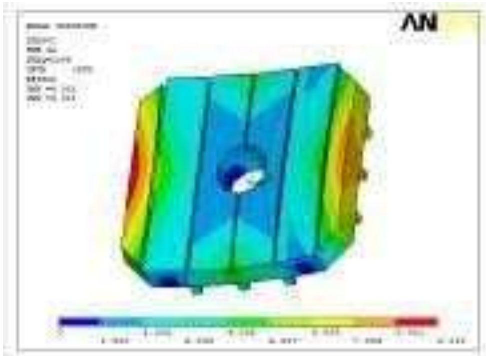

Figure 6 -Ribbed pattern Pallet Frequency 1932 Hz

5..2 Modal Analysis of Solid Pallet

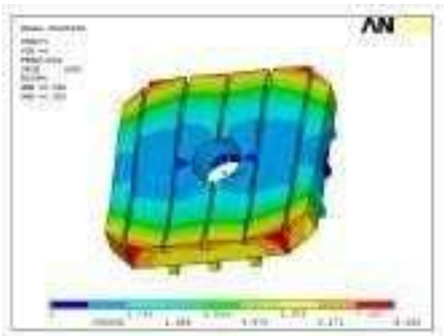

Figure 7 - Solid Pallet Frequency 1762 Hz

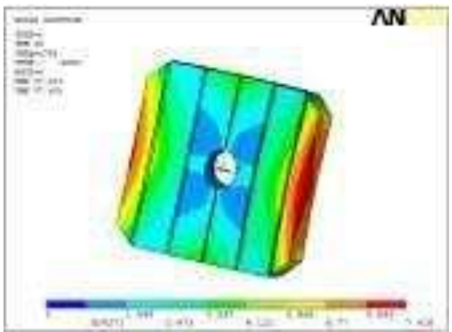

Figure 8 - Solid Pallet Frequency 1867 Hz

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

5.3 Comparison of Modal Frequency of pallets –

Mode	Modal Frequencies	
	Ribbed pattern pallet	Solid Pallet
I	1806	1762
II	1932	1867

Table no- 2

From the above comparison of modal frequency of both pallets is higher than the operating frequency (136 Hz), hence design of both pallet is safe

6. CONCLUSIONS

Based on the applied loads and machining force, the critical components of a rotary table such as worm gear mechanism, pallet and housing were designed and analysed for the values of maximum displacement, maximum stress and modal frequency.

The solutions such as displacements, stress and modal frequency were found to Be safe within limits. The margin of safety of the results was approximately two.Then the optimization of weight was done for the pallet components keeping the maximum displacement as the limiting value without comprising strength and stiffness. The 28 kg of weight reduction achieved by proving proper ribbed pattern to the pallet .

It can be concluded that the developed rotary table used in horizontal machining

centre was lighter and more efficient and economical compared to existing rotary tables.

REFERENCE-

1. Chryssolouris, G. (2005). Manufacturing Systems: Theory and Practice, Springer-Verlag, New York
2. Byrne, G., Dornfeld, D., Denkena, B. (2003). Advancing Cutting Technology, *CIRP Annals* 52/2:483-507
3. Ryuta SATO, ―Mathematical Model of CNC Rotary Table Driven by Worm Gear‖ Department of Mechanical Engineering, Kobe University, Kobe, Japan.
4. Alexandre Dolgui, graph apporch for optimal design of a unit head machines with a rotary table. Operation research labrotary Minasuk Belarus.
5. Pavel destrasil, productive design and calculation of intermittent mechanisms with radial parallel cams world academy science, engineering and technology