Design of Special Purpose Machine for Drilling and Reaming

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Abstract-*The project work is connected with improvement in the manufacturing process of thrust block and ½ U assembly. The thrust block is assembled to ½ U assembly (180^0 apart 2 no's). The thrust block made out of 15CDV6 hardened (38-40HRC) and ½ U Iso grid panels are realized from AA7075 alloy. The thrust block is accepted to carry the solid propellant booster rocket on either side. The present realization method is the use of master and sleeve jig concept (A new concept derived at HAL ASD). Now to improve productivity a* ***Special Purpose Machine*** *to drill and ream when thrust block and Iso grid are together on assembly is being thought off.*

Key Words*:* **Iso grid panels, master and sleeve jig, special purpose machine, Thrust block**

1. INTRODUCTION

Special purpose machine are those machine which are not accessible off the shelf. These are not secured in standard manufacturing programs. Therefore they must be designed and tailor made as per the customer's specific requirement. They are additionally called as 'Bespoke Machines'.

Exceptional reason machine is a piece of multi-tasking machine. In the event that we think about between common machine and unique reason machine as far as time, costs, number of steps included, and so forth. This is new way to deal with expansion the productivity of association the multi-tasking machine is favored decision. Innovation of special purpose machine is settled on the standards of minimization of cost, enhanced efficiency and enhanced security, better wellbeing and so forth. Which gangs with high beginning venture, higher support cost and so on. Special purpose machine is higher degree system in which human support is supplanted by mechanical, electrical, liquid force advances fit for doing physical exertion and even mental work as if there should arise an occurrence of CNC machine.

The special purpose machine and automatic machines are intended to operate continuously for 24 hours a day, with minimum supervision. The special purpose machine are generally product specific and they are required to be designed and developed for every specific requirement. At times it may be possible to cater to the jobs having similar features yet differing in dimensions by using change tooling concept.

2. LITERATURE REVIEW

P. R. Sawant et al. [1] developed machine which has main objective was to drilling and tapping of TATA cylinder block which has 8 drills in which 7 holes of Ø6.75mm and one of Ø 12mm also linear tapping operation for Ø12mm and angular tapping operation for Ø 5.1mm. It saves time for loading and unloading due to use of hydraulic clamping and increases production rate, less rejection of work due to automatic control.

Manish Kale [2] Studied on Design, fabrication and analysis of SPM for reaming and drilling. In this situation study they develop SPM for riveting and drilling of the work-piece of different sizes and thickness. The SPM uses pneumatically operated cylinder for drilling riveting operation. They also use ANSYS for checking stress analysis. The case study concludes that SPM is beneficial as it reduces process time.

Nikhil J Surwad [3] studied on design and develop a special purpose machine capable of performing trimming and drilling operations altogether on the tail lamp bracket casting of a motor cycle. In this study the design is to trim out the flashes generated after pressure die casting process from 14 different areas of the casting and to drill 2 holes on the same casting.

Prof. Chukwumuanya [4] investigated Design and develop multiple spindle drilling head for mass production of Peugeot 504 automobile brake drum. In this design they developed multi-spindle drilling head for drilling 6 holes at a time, in which 4 holes of Ø14.5mm and 2 holes of Ø8.5mm. They analysis the various gear forces theoretically. It conclude that mash increases production rate as compare to individual drilling operation.

Prof.Ms.A.A.Shingavi [5] concentrated on configuration and improvement of multispindle drilling head for process duration advancement of the part and examination of efficiency of segment utilizing ordinary outspread penetrating machine and unique reason machine. It reasoned that by utilizing multispindle penetrating head profitability will increment. Probability of opening missing is killed, in light of the fact that six gaps penetrated at once. The expense per piece is diminished.

Prof. M.B. Bankar [6] Studied Improvement in design and manufacturing of multiple spindle drilling attachment, in which they uses planetary gear system for drilling operation. This case study they briefly gives information about designing drilling attachment from motor selection to its gear box. This study concluded that Multi spindle drilling attachment increase productivity, reduces cycle of operation and perform drilling operation more accurately.

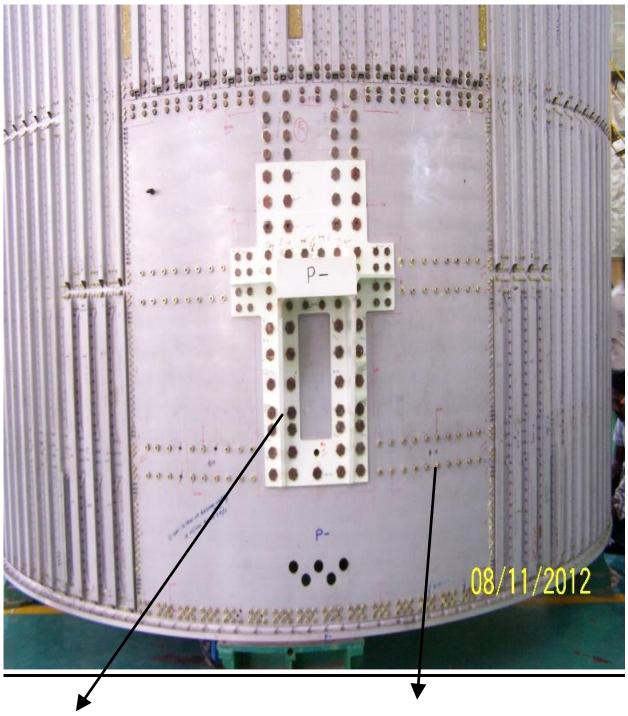
Pratik Parsania et al. [7] Studied on Design for Multi spindle drilling SPM. In this case study it is shown that how effectively SPM work as compare to conventional drilling machine. In conventional drilling machine it takes 8 hours for drilling 2400 pieces per day and by using it takes only 3.33hours for drilling 2400 pieces per day hence it is largely affects the production rate. Hence this case study concludes that use of SPM is most important in small scale industries.

Prof. Bajirao H. NangarePatil et al. [8] studied Design and development of gear box for multi-spindle drilling machine. This case study drilling of 26 holes of various sizes, are carried out on cylinder block. This study conclude that due to use of spur gear noise reduction, reduction in cycle time, increases production rate and also holes are drilled with required accuracy and tolerances are maintained.

Prof. Prasad Bapat et al. [9] outlined and made for particular occupations and such never created in mass such machines are finding expanding use in commercial enterprises the methods for planning such machine would clearly be entirely not the same as those utilized for mass delivered machine. It concluded that increase productivity and profit of the company.

M. Narasimha et al. [10] studied Design of adjustable multi-spindle attachment in this case study they design attachment for machining T-slots in a bolster plate. They studied milling of three T-slots in a single pass is done. The range of T-slot spacing for the present design is 40 mm – 160 mm. This study conclude that due use of this attachment milling three T-slots in single pass is done as compared to individual milling due to this production rate is increased.

3. PROBLEM IDENTIFICATION



THRUST BLOCK (Steel) ISO GRID PANNEL (Al-alloy)

Figure 1: Assembly of Isogrid and Thrust Block

Nomenclature	Material	Dia 16 in RPM	Dia 20 in RPM	Dia 24 in RPM
Thrust block steel	15CDV6	596	477	397
Iso grid Al-alloy	AA7075	1094	875	729

Table 1- Drilling speed

Nomenclature	Material	Dia 16 in RPM	Dia 20 in RPM	Dia 24 in RPM
Thrust block steel	15CDV6	298	238	198
Iso grid Al-alloy	AA7075	596	477	397

Table 2- Reaming speed

Cutting speed for Drilling

Free machining steel 20-30

Aluminium alloy 35-55

Cutting speed for reaming

Free machining steel 11-15

Aluminum alloy 25-30

Fig 3.1 and 3.2 which shows that assembly of isogrid and thrust block and weight of this assembly is 1000kgs. These two parts made out of two different material i.e. steel and aluminum. Both of these having different cutting speed, feed and it is required to drill or ream. Another requirement is hole should be radially drill and ream.

The thrust block is accepted to carry the solid propellant booster rocket on either side.

The table which shows that different diameter the requirement of speed for both drilling and reaming operation. Both operation having different speed for different diameter which cannot change immediately by using ordinary machine.

4. METHODOLOGY

The above stated problem which can be solve by using Special Purpose Machine both drilling and reaming operation. The Special Purpose Machine is design to the requirement of the problem.

The SPM having X, Y and Z axis. These three axis are which is manually.

4.1 Calculation Along X Axis

Calculations:

Some of the specification are distance 300mm – 1min

Diameter of screw rod = 30mm

Speed of motor= 1500rpm

50/1500 = 1:30 (WORM REDUCTION GEAR BOX)

One revolution= 6mm

For 300mm: 300/6= 50rpm

Pitch = 6mm 400kg

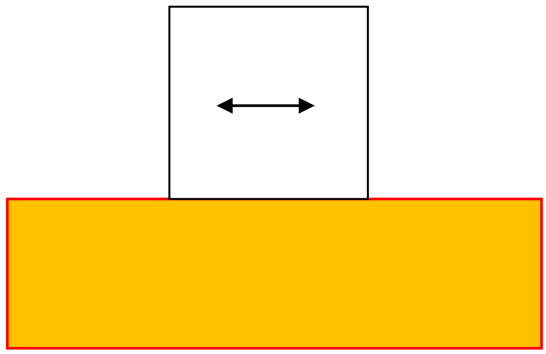


Figure 2: schematic diagram of lm guide way and column

Mean diameter d_m= 27mm

Friction force= $\mu * F_n$ 4.1

=0.3*3924

Friction force w = 120kgs= 1177 N

$$T = W\left[\frac{\tan\alpha + \tan\phi}{1 - \tan\alpha * \tan\phi}\right] * \frac{d}{2} \quad 4.2$$

From CMTI data handbook

$$\tan\alpha = \frac{p}{\pi d_m}, \ \tan\phi = 0.15 \quad 4.3$$

$$\tan\alpha = \frac{6}{\pi * 27} = 0070$$

$$T = 1177\left[\frac{0.070 + 0.15}{1 - 0.070 * 015}\right] * \frac{27}{2}$$

T=332.9 N-m

$$P = \frac{2\pi n T}{1000 * 60} \quad 4.4$$

$$P = \frac{2\pi * 50 * 332.9}{1000 * 60}$$

P=1743 W

P=2.33hp

4.2 Selection of the Motor for Spindle Unit

Operation	Drilling			
Diameter	6		30	
	Cutting speed	RPM	Cutting speed	RPM
Al alloy	35	1856	35	372
Steel	20	1061	20	212

Table 3-Speed for drilling

Operation	Reaming			
Diameter	6		30	
	Cutting speed	RPM	Cutting speed	RPM
Al alloy	25	1326	25	266
Steel	11	583	11	116

Table 4- speed for Reaming

From the above table get that min and max speed of the motor for both drilling and reaming. So selected motor i.e. **2 poles (3000 rpm)**

Calculations: drilling

Formula: $v = \frac{\pi d n}{1000}$ 4.5 Where, v= cutting speed, d= diameter, n= speed

Material: Al alloy

(1) $35 = \frac{\pi * 6 * n}{1000}$ n=1856 rpm (2) $35 = \frac{\pi * 30 * n}{1000}$

n = 372 rpm

Steel

(3) $25 = \frac{\pi * 6 * n}{1000}$ n = 1326 rpm (4) $25 = \frac{\pi * 30 * n}{1000}$

n = 266 rpm

Reaming

Al alloy

(a) $20 = \frac{\pi * 6 * n}{1000}$ n = 1061 rpm (b) $20 = \frac{\pi * 30 * n}{1000}$

n = 212 rpm

Steel

(c) $11 = \frac{\pi * 6 * n}{1000}$ n = 583 rpm (d) $11 = \frac{\pi * 30 * n}{1000}$

n = 116 rpm

Max power =27 kw and min power 1.5 Kw

2 poles (3000 rpm)

Declared speed, rpm 2785 2870

2870 2955

Output kW 0.37 3.7

3.7 37

4.3 Selection of Bearings for Spindle Unit

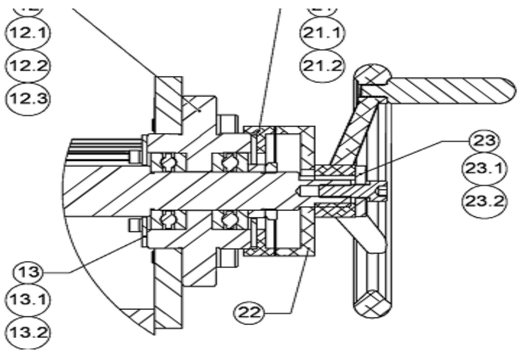


Figure 3: Bearing setup in SPM

4.3.1 Thrust ball bearing

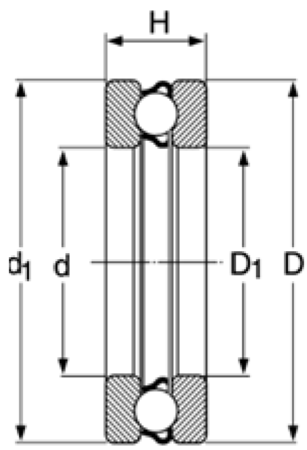


Figure 4: Thrust bearing

d in mm	D in mm	H in mm	Basic load rating in N		Fatigue load limit P_u	Minimum load factor A
			Dynamic	Static		
25	47	15	27600	50000	2040	13

Table 5: Thrust bearing values

Selection of bearing takes important role in any machine design. Bearing selection takes loading condition, diameter, speed and type of lubricant. Here thrust bearing has been selected because axial load only acting and speed also calculated. Selected data taken from CMTI data hand book.

4.4 Machining Time Calculation

Drill Diameter = d = 16 mm

Feed = f = 0.2 mm / revolution

Thickness of plate = t = 20 mm

Tool over travel = 6 mm

Cutting Speed = V = 15 m/min = 15 × 1000 mm/ min

Solution: -

We know that Cutting Speed is

V = Π d N / 1000

15 × 1000 = Π × 16 × N

N = 298.4 rpm

Assume N ˜ 300 rpm

Time required drilling a hole:

$$T = \frac{L}{fN} = \frac{thichness + overtravel + 0.3d}{fN} \text{ -}$$

$$= \frac{20 + 6 + 0.3 * 16}{0.2 * 300}$$

= 0.5 min

4.5 Design Procedure

To outline an extraordinary reason machine it has considered an exceptionally cautions approach, the aggregate configuration work has been partitioned into two sections.

Essentially;

- System design
- Mechanical design

Framework outline principally worries with the space prerequisites, course of action of different parts on the principle edge of machine, stature of machine.

In design, the components are categorized in two parts.

- Design parts
- Parts to be obtained

For configuration parts, subtle element outline is doneand measurements consequently acquired are contrasted and the parts which are promptly accessible in business sector, this disentangles the gathering and after creation overhauling work.

4.6 Design along X-axis

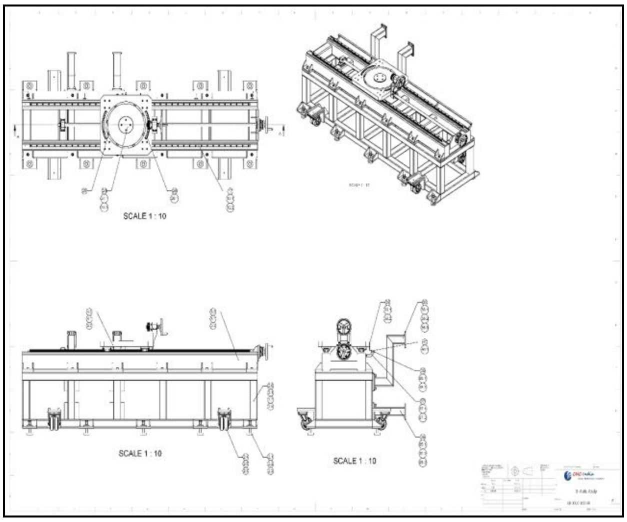


Figure 5: Design along x-axis

4.7 Assembly of special purpose machine with ½ U assembly

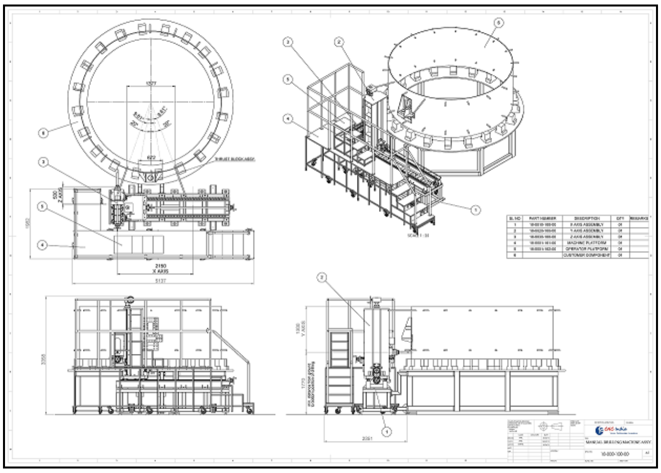


Figure 6: Assembly of Special Purpose Machine with iso grid panel

5. CONCLUSION

The primary design and scheme of the design to be accepted by HAL committee ASD tool office. The detail design like guide ways, bed, drilling head (variable frequency drive) staging has to be completed and it is under fabrication. The detail design has been completed by using CAD software. The lead time for manufacture of this is 10 months because of other process. Less time consuming, accuracy in finish, less labor, 24 hours machine can ran without stress compared to existing machine and the experienced designer view the machine would be 100%successful.

ACKNOWLEDGEMENT

I have immense pleasure in expressing thanks to our Director, **Dr. S.Y.Kulkarni**, School of Mechanical Engineering, REVA University, for providing me an opportunity to carry out this project work and for his motivating support, keen interest which kept my spirit alive all through.

I am extremely thankful to **Dr. T Krishna Rao,** Director, School of Mechanical Engineering, REVA University, for his constant encouragement, direction and support throughout the course.

I am extremely grateful to **Dr. MANJUNATHA L H,** PG Coordinator, Professor, School of Mechanical Engineering, for providing all the facility to carry out the project work.

I am extremely grateful to **Prof. ANAND S.N,** Project coordinator, Associate Professor, School of Mechanical Engineering, REVA University, for guiding us throughout the project amidst his tight schedule.

I am extremely grateful to **Prof. NIRAJAN HIREMATH,** Assistant Professor, for his valuable guidance and useful suggestions, which helped me in completing the project work on time.

I am extremely grateful to **MR. A. SHASHI KUMAR (DGM),** External guide **Tool Design Dept. HAL (ASD)** who has been very supportive and encouraging during project and also providing us with facilities required to complete the project.

REFERENCES

[1] Prof. P.R. Sawant and Mr. R. A.Barawade, "Design and development of SPM-a case study in multi drilling and tapping machine", International Journal of Advanced Engineering Research and Studies.Volume 1, Issue 2, January-March, 2012, 55-57.

[2] Manish Kale, Prof. D. A. Mahajan and Prof. (Dr.) S. Y. Gajjal, "Design, Fabrication and analysis of special purpose machine for drilling and riveting operation", International journal of research and scientific innovation, Volume 2, Issue 6, June 2015.

[3] Nikhil J Surwade, Vinay K Thute "Design and Development of a Special Purpose Machine for Combined Trimming and Drilling Operations on Tail Lamp Bracket Casting of a Motor Cycle" International Journal of Innovative and Emerging Research in Engineering Volume 2, Special Issue 1 MEPCON 2015

[4] Chukwumuanya, Emmanuel O, Obuka, Nnaemeka Sylvester P, Onyechi, Pius C, and Okpala Charles*, "Theoretical design and analysis of a semi-automatic multiple-spindle drilling head (msdh) for mass production processes in developing countries", International journal of engineering and innovative technology (IJEIT) Volume 2, Issue 5, November 2012, 260-266.

[5] Prof.Ms.A.A.Shingavi, Dr.A.D. Dongare, Prof. S.N.Nimbalkar "Design of Multiple Spindle Drilling Machine" International Journal of Research in Advent Technology (E-ISSN: 2321-9637) "ICATEST 2015", 08 March 2015

[6] Prof.M.B. Bankar, Prof. P.B. Kadam, Prof. M.R. Todkar, "Improvement in design & manufacturing process of multiple spindle drilling attachment", IOSR Journal of Engineering, Volume 3, Issue 1, Jan 2013, 38-43.

[7] Pratik Parsania, Prof. Jignesh Dave and Brijesh Garala, "Design of hydraulic power pack for SPM (Multi Spindle Drilling)", Indian journal of applied research, Volume 3, Issue 6, ISSN- 2249-555X , June 2013.

[8] Bajirao H. NangarePatil, and Prof. P. R. Sawant, “Design and Development of Gearbox for MultiSpindle Drilling Machine (SPM)”, International journal of engineering research & technology (IJERT) Volume 2, Issue 5, ISSN: 2278-0181, May-2013.

[9] Prof. Prasad Bapat Prof. J.Y. Acharya “Case Study of Designing a Special Purpose Machine” International Journal of Innovations in Engineering Research and Technology [Ijiert] Volume 1, Issue 1 Nov—2014

[10] M. Narasimha, R. Reji Kumar, R. Srinivasa Moorthy, “Design of adjustable multi-spindle attachment”, International journal of engineering research and development (IJERD), Volume 4, Issue 2, May –August 2013.