Design Analysis and Performance Evaluation of Combination Tool for Special Purpose Thrust and Radial Bearing in Wind Ventilator Applications

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Abstract: **-The project work involves the design development of multi tool device wherein drilling, counter boring and face grooving operations will be combined to drastically reduce the manufacturing time and cost. Wind turbine ventilators are ventilator which is powered by the wind to create effective ventilation. These type of ventilators are used in various industries. The design of wind turbine ventilators consists of a round metal vent with fins in them. Presently this system uses ball bearings for their operation however they offer lower life and the cost is higher. Thus they are to be replaced by combination of thrust and radial bearing. The manufacture of this bearing required a tool which can perform drilling and boring operation followed by a face groove. In order to reduce the time and cost of manufacturing it is required to develop a combination tool for the same. The tool geometry was developed using Unigraphics NX-8 software and the analysis was done using Ansys Workbench 16.0. The performance evaluation of the tool was done to determine the percentage error, reduction in cycle time.**

Keywords **- Drilling, Boring, Combination tool, Ball Bearing, Thrust Bearing, Radial bearing, Cycle time, Cost reduction.**

I. INTRODUCTION

Wind turbine ventilators are ventilator which are powered by the wind to create effective ventilation. These type of ventilators are used in various industries. This product works on wind assisted ventilation. The design of the wind turbine ventilators comprises of a round metal vent with fins in them and just a small amount of wind is enough for the wind turbine ventilators to rotate. The faster the wind, the faster the wind turbine rotates the faster the exhaust the heat, smoke, humidity, fumes, etc. goes out. The mechanics involved in the air movement is very simple. The hot air inside the shed tends to rise up as it is less dense.

When the turbines rotate, they suck the warm air out through the vent, thereby, bringing drop in temperature in the shed and allow supply of fresh air through doors and windows. The present system of ventilators uses ball bearings and thrust bearings which are required to be replaced from two main reasons:

1) Ball bearings are costly, require special casing for mounting that increases space requirement and weight. The ball bearings alone do not suffice the requirements of the balancing at the top end of the ventilator it also requires a thrust bearing.

2) The dust cover is required to be installed to protect the bearings from fume and dust, which increases system components.

M/s Paramount Industries are to develop a bearing element that uses a combination of pivot , needle roller baring and thrust bearing in a single bearing (combination bearing) this will reduce the cost by atleast 50 % and so also service life of the bearing is expected to increase by two times. The shape of bearing holder will be as shown below :

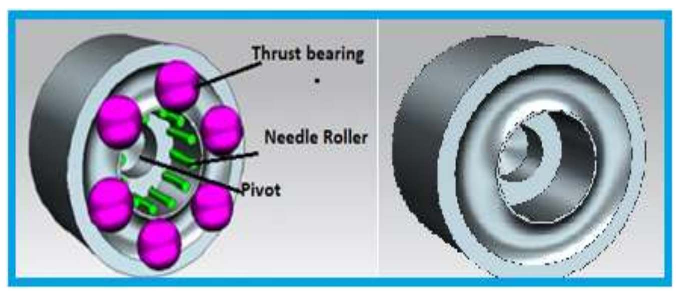

Fig.1. Details of the product for which tool is developed

II. DESIGN AND ANALYSIS OF TOOL HOLDER

Design and Analysis of Tool holder considering plain drilling and boring operation under action of maximum torque

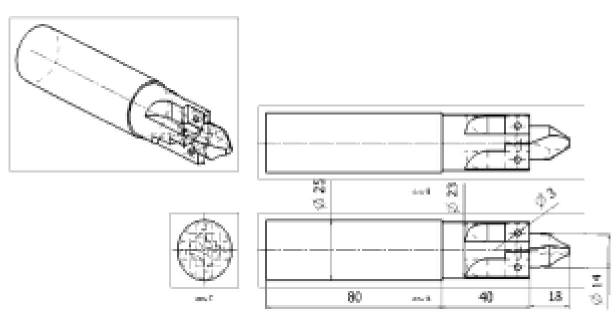

Fig.2. Detailed layout of Cutting Tool

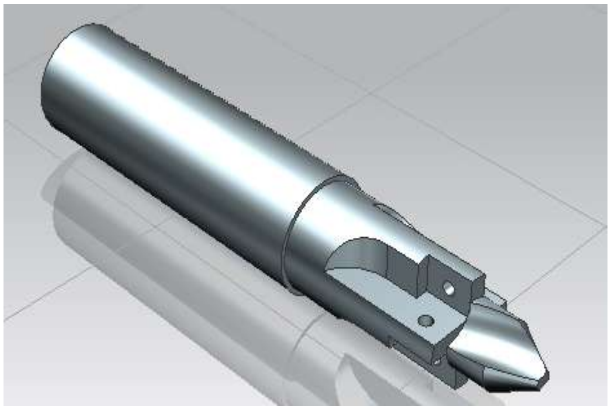

Fig.3. CAD model of Cutting tool.

Table I.Material Selection:-PSG (1.10 & 1.12) + (1.17**)**

Designation	Ultimate tensile strength (N/mm^2)	Yield Strength (N/mm^2)
En9	600	480

$$T_d = 8.743\ N - m$$

Considering the torsion failure of the hollow portion of the coupling shaft

$$T_d = \frac{\pi}{16} \times (\frac{D^4 - d^4}{D}) \times f_{s_{act}}$$

$$f_{s_{act}} = 4.24\ N/mm^2$$

As $f_{s_{act}} < f_{s_{all}}$, hence the tool shank is safe under torsional load.

Analysis of the Tool holder head:

Table II. Details of meshing in ANSYS

Statistics		
Nodes	Elements	Mesh Metric
3479	1817	None

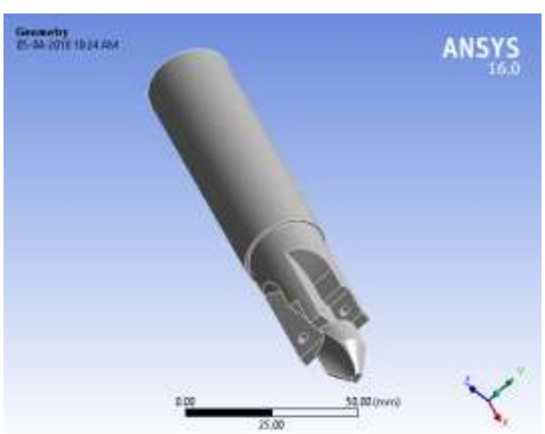

Fig.4. CAD model in ANSYS

Figure.4, shows the CAD model of the cutting tool in the ANSYS environment. Once the model is in the ANSYS, material is assigned to the CAD model. In our case the material is En9 which is a medium carbon steel grade.

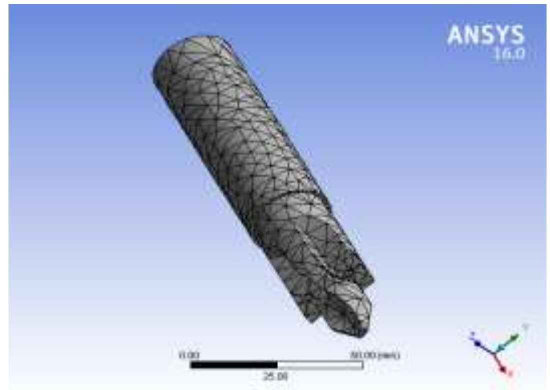

Fig.5. Meshed model of Cutting Tool in ANSYS.

Figure.5, provides the details of the meshing used on the CAD model in ANSYS environment. Table 2 provides the details of the nodes and elements generated while meshing in ANSYS.

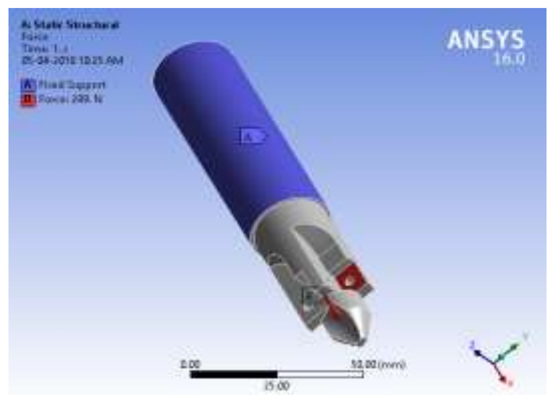

Figure.6. CAD model of Cutting tool with applied force

After meshing, force and constrained region are defined on the meshed model in ANSYS environment. Figure.6, shows the applied force and the constrained region.

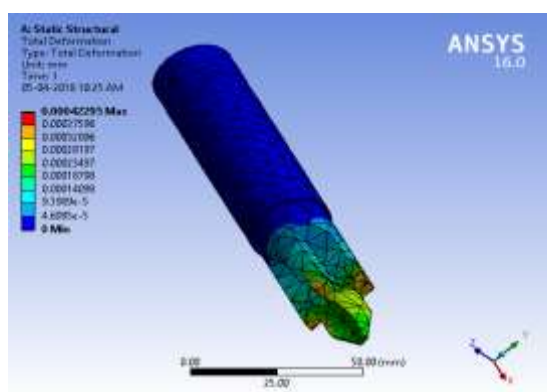

Figure.7. Impact of Force on Cutting tool.

Once the force and constrains are applied analysis run took place. Figure.7, shows the deformation of the cutting tool under the influence of the applied force and constrains. It was observed that the deformation is very negligible hence it was concluded that the tool is safe.

Another analysis run was applied to understand the impact of equivalent stress (Von-Mises Stress) on the cutting tool. It was observed that the maximum stress induced is 5.3247 MPa which is well below the permissible limit hence it was concluded that the tool is safe.

Figure - 8, shows the CAD model of cutting tool in ANSYS environment under the influence of force and showing the equivalent stress (Von-Mises Stress).

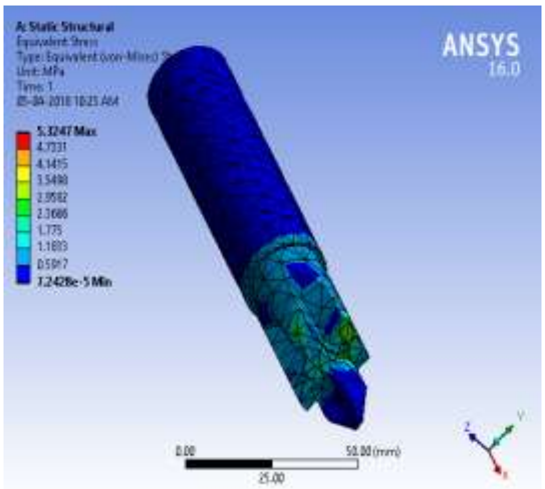

Figure.8. Impact of Stress on Cutting tool.

III. DESIGN AND ANALYSIS OF TOOL HOLDERHEAD

Design and Analysis of Tool Holder Head considering plain drilling and boring under action of maximum torque

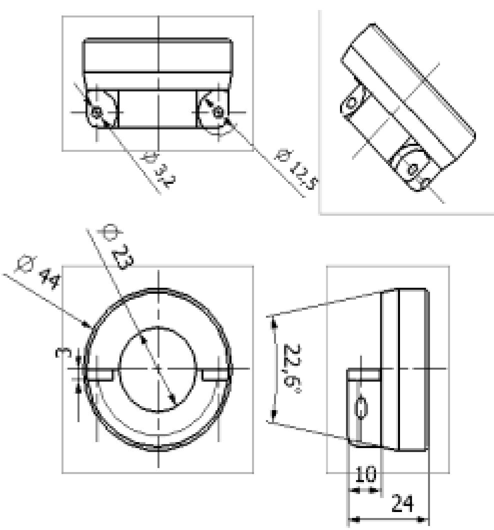

Fig.9. Detailed layout of Cutting tool holder.

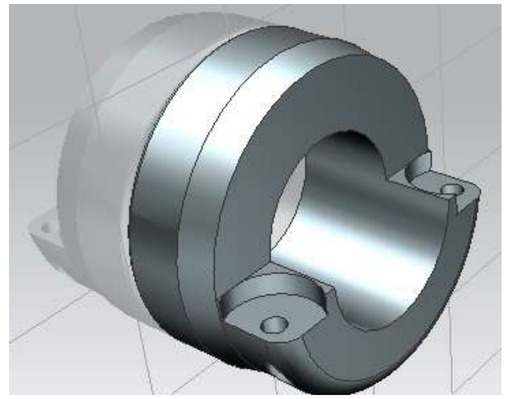

Fig.10. CAD model of Cutting tool holder.

Table III. Material Selection: - PSG (1.10 & 1.12) + (1.17)

Designation	Ultimate tensile strength (N/mm^2)	Yield Strength (N/mm^2)
En9	600	480

$$f_{s_{max}} = \frac{uts}{fos} = \frac{600}{2} = 300\ N/mm^2$$

$$T_d = 8.743\ N-m$$

$$f_{s_{act}} = 0.56\ N/mm^2$$

As $f_{s_{act}} < f_{s_{all}}$, hence the tool head is safe under torsional load.

Analysis of the Tool holder head:

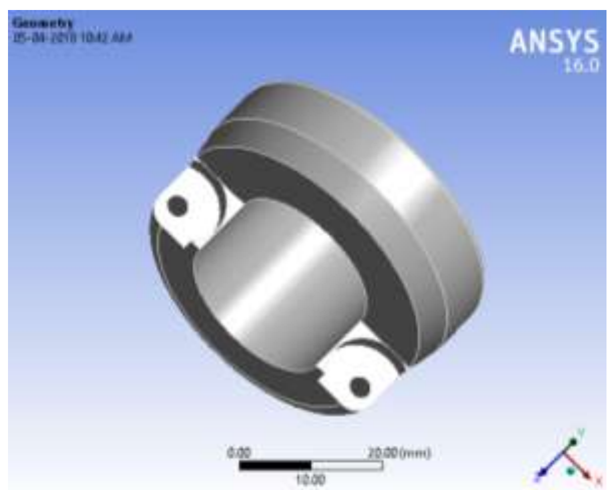

Fig.11.CAD model of Cutting tool holder head

Figure.11, shows the CAD model of the cutting tool holder head in the ANSYS environment. Once the model is in the ANSYS environment, material is assigned to the CAD model. In our case the material is En9 which is a medium carbon steel grade.

The details of the meshing used on the CAD model in ANSYS environment is provided in Figure.12. Table no - II provides the details of the nodes and elements generated while meshing in ANSYS.

Once meshing is complete, force and constrained region are defined on the meshed model in ANSYSenvironment. Figure.13. shows the applied force and the constrained region.

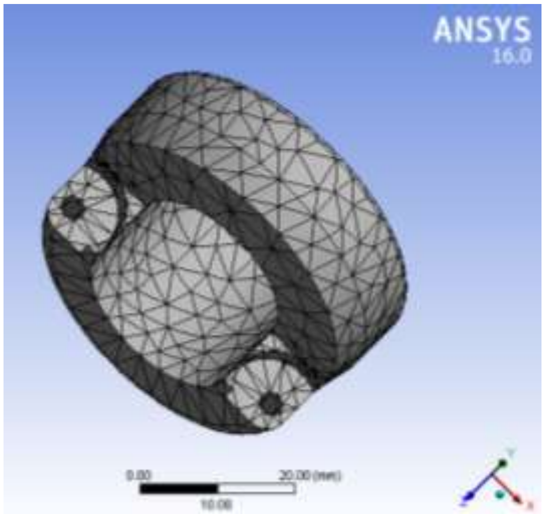

Fig.12. Cutting tool holder head in Meshed condition

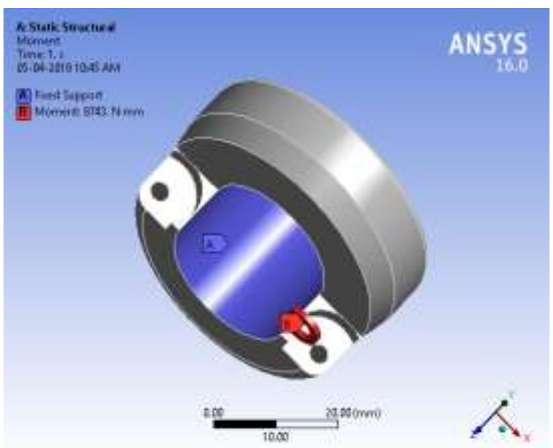

Fig.13. Model Showing Tool holder head in Loading Condition.

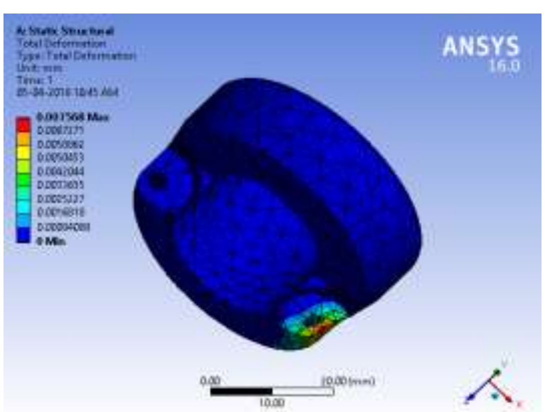

Fig.14. Meshed model of Tool holder head in ANSYS.

Figure.14, shows the deformation of the cutting tool holder head under the influence of the applied force andconstrains. It was observed that the deformation is very negligible hence it was concluded that the tool is safe.

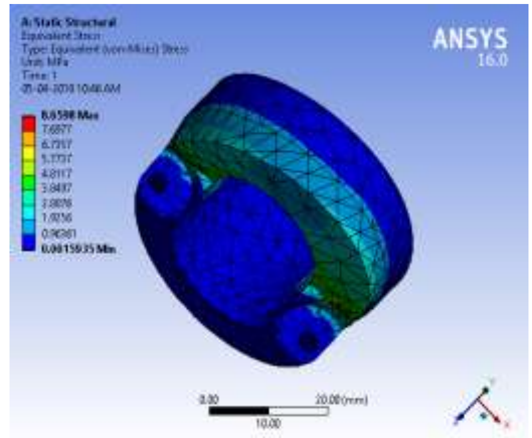

Fig.15. Meshed Model of Tool holder in ANSYS.

As the maximum stress is well below the permissible limit the tool head is safe as shown in Figure.15.

IV. RESULT OBTAINED AFTER PERFORMANCE EVALUATION OF THE COMBINATION TOOL FOR MANUFACTURING OF RADIAL AND THRUST BEARING OF NYLON -6 MATERIAL

Fig.16. Actual multi tool model.

Sr. No.	Speed (rpm)	Feed mm/rev	Drill Dimension(mm)	Bore dimension (mm)	% Errordrilling	% Errorboring	Machining time (Sec)	% Reduction in Cycle time
1	750	0.2	14.05	25.03	0.36	0.12	6	40
2	500	0.2	14.07	25.04	0.5	0.16	9	32.84
3	350	0.2	14.1	25.06	0.71	0.24	12	25.93
4	275	0.2	14.14	25.08	1	0.32	16	21.18

Table.1. Results of Tool analysis

Graph of % Error in drilling Vs Speed

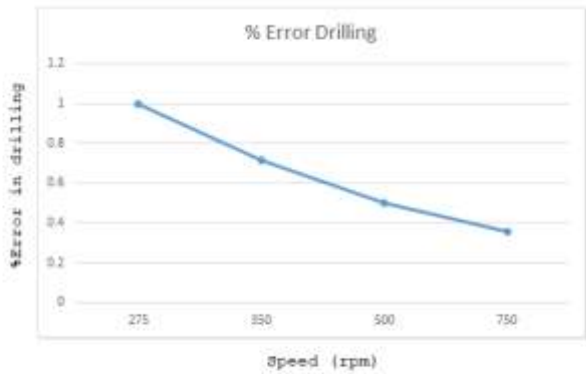

Fig.17. % Error in Drilling Vs Speed.

The figure.17. Shows that a maximum error of 1 percent is observed in the drilling process and the percentage error reduces with increase in speed.

Graph of %Error in boring Vs Speed

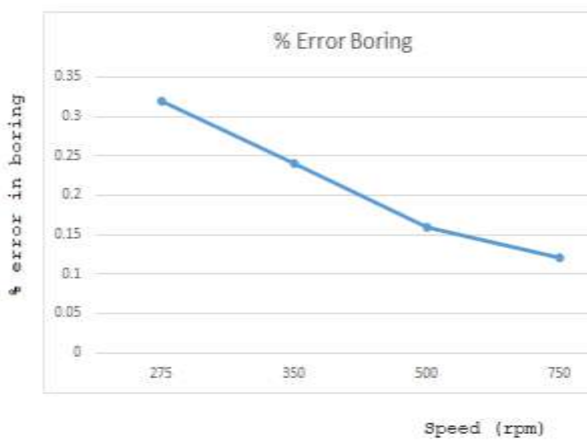

Figure.18. % Error in Boring Vs Speed.

The figure.18 shows that a maximum error of 0.32 percent is observed in the boring process and the percentage error reduces with increase in speed.

Graph of % Reduction in cycle time Vs Speed

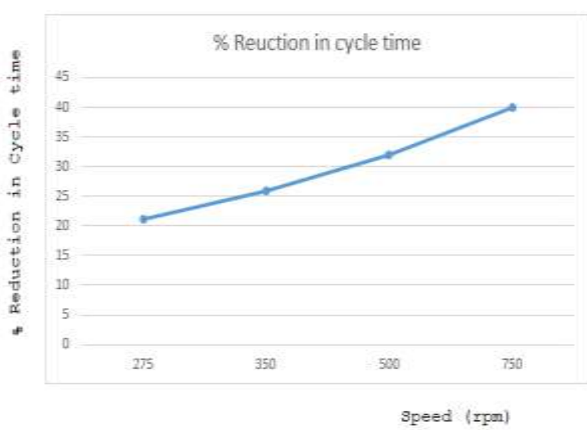

Figure.19. % Reduction in Cycle Time Vs Speed.

The figure.19 shows that a maximum reduction of 40 percent is observed in the cycle time and the percentage reduction in cycle time increases with increase in speed.

V. CONCLUSION

[A] The Drilling-boring tool head shows maximum stress well below permissible limit so also the observed deformation is negligible hence the tool head is safe.

[B] The face grooving tool head shows maximum stress well below permissible limit so also the observed deformation in negligible hence the tool head is safe.

[C] Maximum error of 1 percent is observed in the drilling process and the percentage error reduces with increase in speed.

[D] Maximum error of 0.32 percent is observed in the boring process and the percentage error reduces with increase in speed.

[E] Maximum reduction of 40 percent is observed in the cycle time and the percentage reduction in cycle time increases with increase in speed.

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