International Journal of Research and Innovations in Science and Technology
Volume 2 : Issue 1 : 2015

ISSN (Online): 2394-3858
ISSN (Print) : 2394-3866

International Journal of Research and Innovations in Science & Technology,
©SAINTGITS College of Engineering, INDIA
www.journals.saintgits.org
Research paper,

Design of a Power Tool Attachment for Sawing Operation

Mayur Appaiah[1]*, B. Ramesh Nayak[2]

[1]*Assistant Professor, B.M.S. College of Engineering, Bangalore*
[2]*Associate Professor, B.M.S. College of Engineering, Bangalore*
**Corresponding author E-mail: mayurappaiah.iem@bmsce.ac.in*

Abstract

The Design of a Power Tool Attachment for Sawing Operation is discussed. First, the Target Specifications are established. The Design work is carried out, especially that of the Main Shaft and Support Tube. Calculations and Finite Element Analysis (FEA) are also done. The Prototype is fabricated and assembled. The Testing of the prototype is done, by Sawing commercial plywood of maximum thickness 25mm. Weight of the Attachment is 1.3 kg, and the Machine is easy to use, benefitting unskilled users.

Keywords: *Design, FEA, Manufacturing, Power Tools, Saw*

1. Introduction

The Design of an Attachment for an Electric Drill (a Power Tool) was done by the Authors. This Attachment would enable the Drill to also perform sawing operation, apart from its' primary drilling function. The minimum power required to operate the attachment was determined to be 313 Watts [1]. Sufficient power of 450 watts was available. The requirements and Target Specifications were made in the "Need-Metric Statement" format as proposed by Eppinger, et al [2], which is shown in Table 1 below.

Table 1 Target Specifications of Attachment

Need No.	Metric Statement	Units	Target Specification
1	Functions are easy to understand	List	< 5
2	Industrial Standard Test	Binary	Pass
1,3	Actual cutting done by machine, User only Guides it	Subj.	None
4	Cutting Speed in millimeter per minute	mm/min	> 250
5	Provision for Hand Guard, isolation from Blade	List	None
6	Unit Manufacturing Cost	INR	2000
7	Time for Assembly/Disassembly	Minutes	< 8
7,8	Quick Blade Removal	Minutes	< 5
9,10	Total Mass (Attachment)	Kg	< 1.8
10	Total Volume	mm^3	200*200*200
7,11	Tools required for maintenance	List	Minimum

2. Design of Attachment

Based on the Specifications, a Design for the Attachment was generated and selected. This envisaged the use of a Gearbox with Bevel gears to drive the Attachment through a Pinion Shaft. A Support Tube was to be used as the load bearing member. The Attachment consisted of both Standard Parts like Bearings, Shafts, Bevel Gears, etc. as well as parts designed by the Authors. Here, we concentrate on the Designed Parts, namely the Pinion Shaft and the Support Tube.

2.1. Design of Pinion Shaft

The Pinion shaft is designed, considering the dimensions of gearbox housing and Diameter of the bearing. It is supported by the bearing, and subjected to Torsion and Bending Moment [3].

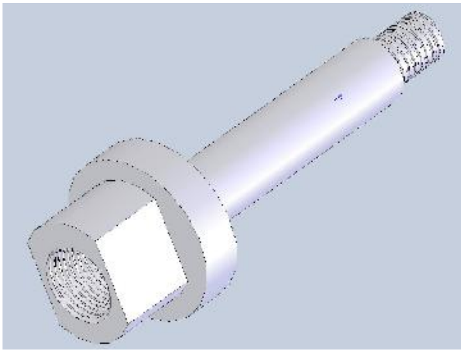

Figure 1 3D Model - Pinion Shaft

The Pinion shaft is designed, considering the dimensions of gearbox housing and Diameter of the bearing. It is supported by the bearing, and subjected to Torsion and Bending Moment [3].

Let d_p = the diameter of the pinion shaft to be calculated
P = 450 watts, Power available
N_p = 7000 rpm, Maximum rpm of Pinion Shaft
Velocity Ratio V.R. = 2.5
$\theta_{p1} = 21.80^0$
$Ø = 20^0$
Overhang = 25mm
Diameter of Pinion Gear = 19.3mm
Radius of Pinion Gear R_M = 9.65mm
Shear stress τ is assumed as 40 N/mm^2 for the shaft material.

a) Torque on Pinion

$$T = \frac{450 \times 60}{2\Pi \times 7000} = 613.88 \quad Nmm$$

b) Tangential Force on Mean Radius,

$$W_T = \frac{T}{R_M} = \frac{613.88}{9.65} = 63.61\ N$$

c) Axial force on Pinion Shaft,

$$W_{RH} = W_T . \tan \varphi . \sin \theta_{p1}$$

$$W_{RH} = 63.61 \tan 20° . \sin 21.8° = 8.6\ N$$

d) Radial force on Pinion Shaft,

$$W_{RV} = W_T . \tan \varphi . \cos \theta_{p1}$$

$$W_{RV} = 63.61 \tan 20° . \cos 21.8° = 21.5\ N$$

e) Bending Moment due to W_{RH} and W_{RV}

$$M1 = WRV \times Overhang - WRH \times RM$$

$$M1 = 21.5 \times 25 - 8.6 \times 9.65$$

$$\text{Or} \quad M1 = 454.51 \quad N - mm$$

Bending Moment due to W_T,

$$M2 = WT \times Overhang = 63.61 \times 25$$

$$M2 = 1590.25 \quad N - mm$$

Resultant BM,

$$M = \sqrt{(M_1{}^2 + M_2{}^2)}$$

$$M = 1653.93\ N - mm$$

f) Equivalent Torque T_e is given by,

$$Te = \sqrt{(M^2 + T^2)}$$

$$Te = 1764.18\ N - mm$$

Using $T = \frac{\pi d^3 \tau}{16}$ Or $d^3 = \frac{16T_e}{\pi \tau}$

On Calculating, we get the Pinion Diameter, d = 6.07 mm.
As actual diameter used in Pinion Shaft is 8mm, the design is safe.

2.2. Design of Support Tube

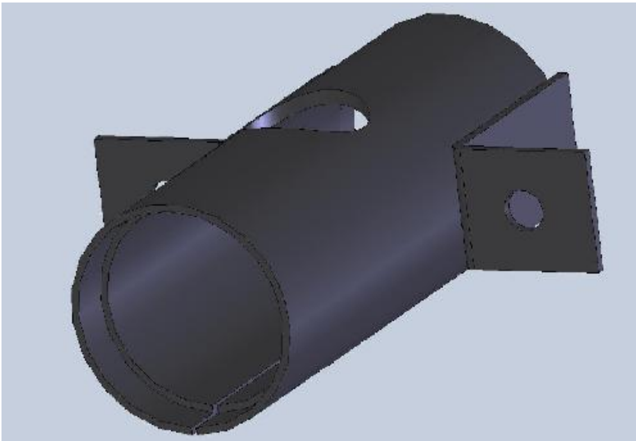

Fig 2 3D Model - Support Tube

The Support Tube withstands the weight of the Gearbox, Shafts, etc. It is idealized as a Cantilever Beam, with a point load at one end, and supported by 2 bolts at the other end. We need to determine the bolt diameter required to withstand the load.The total weight on the Support Tube is about 1.3 kg. Here, the design is carried out for a load of about 10kg, or 100 N.

Let,
d_c = Bolt Diameter (to be calculated)
L = distance of load from tilting edge = 125 mm
n = no. of bolts = 2
R = Radius of Flange = 24 + 30 = 54mm
r = Radius of Bolt Pitch Circle = 24 + 23 = 47mm
W = Load acting at end = 100 N
σ_t = Allowable Stress on Bolt material (Assumed as 30 N/mm^2)

Load acting on the Bolt is given by

$$W_t = \frac{2WL(R+r)}{n(2R^2+r^2)}$$

Solving the above equation; $W_t = 157\ \mathrm{N}$

Also,

$$W_t = \frac{\pi d_c^2 \sigma_t}{4} \quad \text{Or} \quad d_c^2 = \frac{W_t \times 4}{\sigma_t \times \pi}$$

Solving

$d_c^2 = 6.66$ mm Or $d_c = 2.58$ mm

The bolts used are of Metric Size M6, with an effective or pitch diameter 5.350 mm [4]. Hence, the design is safe.

2.2.1 Finite Element Analysis of Support Tube

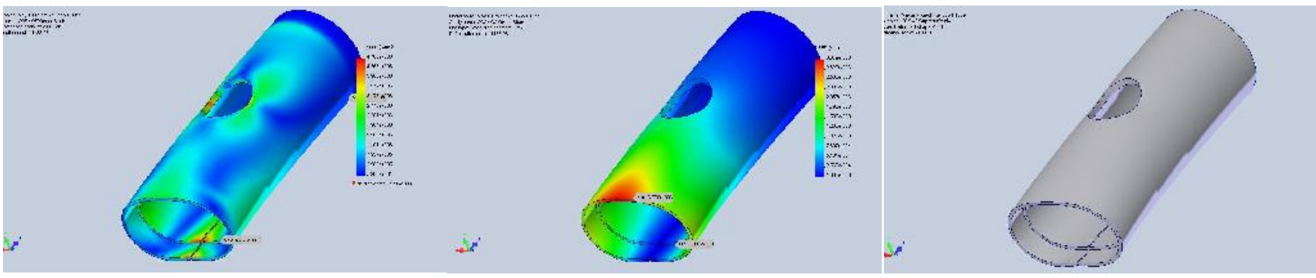

Figure 3. Left to Right: Von Mises Stress; Displacement of Support Tube; Deformed Shape of Support Tube

The Material Properties used for the Finite Element Analysis is shown in Table 2 below.

Table 2 Material Properties of FE Analysis

Material Properties	
Material	Plain Carbon Steel
Mass	366 grams
Material Type	Linear Elastic Isotropic
Young's Modulus	2.1e + 011 N/m^2
Poisson's Ratio	0.28
Yield Strength	2.2059e + 08 N/m^2
Load Condition	100 N, Normal to Top Plane
Mesh	Solid Type Standard Mesh
Element Size	3.61 mm
No. of Elements	8537
Nodes	17461
Tolerance	0.18054 mm

2.2.2. Discussion on FEA Results obtained

The FEA results obtained give an indication of how the Support Tube will perform under conditions of load. The Final Deformed Shape, Stress Distribution in different regions and Deformation Values are seen. As Maximum Von Mises Stress of 4.76e+006 N/m^2 is less than the Yield Stress of the Material (2.206e+008 N/m^2), the Support Tube is safe. Maximum deformation seen is less than 1 mm (approx 0.0030 mm), showing that Factor of Safety is quite acceptable.

3. Fabrication and Assembly of the Attachment

The parts of the Attachment were fabricated and then assembled together, and the Bill of Materials (BOM) was generated. The BOM is shown in Table 3 below.

Table 3 Bill of Materials

Sl. No.	Item	Material	Type	Quantity
1	Gearbox Housing	Aluminum	Standard Part	1
2	Bevel Gears	Steel (Hardened)	Standard Part	2
3	Bearings	GCR 15 (High Carbon Chromium Steel)	Standard Part	2
4	Main Shaft	HSS	Standard Part	1
5	U-Bolt	Steel (Cold Forged)	Standard Part	1
6	Fasteners (All)	Steel (Cold Forged)	Standard Part	14
7	Safety Guard	Mild Steel (Powder Coated)	Standard Part	1
8	Alignment Plate	Mild Steel (Plated)	Standard Part	1
9	Pinion Shaft	Mild Steel Blank Ø25 x 55	Manufactured	1
10	Intermediate Shaft	Mild Steel Blank Ø25 x 55	Manufactured	1
11	Support Tube	Mild Steel Tube Ø50-OD x Ø40-ID x 130mm- Length	Manufactured	1
		Total No. of Parts		**26**

The Assembled Prototype is shown in Figure 4 below.

Figure 4 Left to Right: Prototype (Fully Assembled); 3D Model of Prototype

4. Results of Testing the Prototype

The testing was done in an actual working environment, to get a deep understanding about the working of the product, and see whether it is able to perform its intended function. During testing, the machine worked efficiently by sawing plywood of maximum available thickness [5], and human fatigue was also reduced. The Primary Machine Function of Drilling was not affected at all. The testing of the machine is shown in Figure 5 below.

Figure 5 Test of the Sawing function of the Prototype; Primary Drilling function

Based on the results obtained from the tests of the Prototype, the Final Specifications of the product are laid down in Table 4 below. The Target Specifications set during the concept design stage are also presented.

Table 4 Target Specifications v/s Final Specifications

Metric Statement	Units	Target Specification	Final Specification
Functions are easy to understand	List	< 5	< 3
Industrial Standard Test	Binary	Pass	Pass
Actual cutting done by machine, User only Guides it	Subj.	None	All
Cutting Speed in millimeter per minute	mm/min	> 250	> 350
Provision for Hand Guard, isolation from Blade	List	None	All
Unit Manufacturing Cost	INR	2000	1000
Time for Assembly/Disassembly	Minutes	< 8	< 3
Quick Blade Removal	Minutes	< 5	< 2
Total Mass (Attachment)	Kg	< 1.8	< 1.4
Total Volume	mm^3	200 x 200 x 200	150 x 150 x 150
Tools required for maintenance	List	Minimum	Minimum

From the above table, we can see that the Final Specifications are very much comparable to the Target Specifications, and, based on Field testing of the Prototype, the results achieved are positive.

5. Conclusion

The prototype is able to cut plywood up to 25mm thick, which is the maximum available thickness [5]. The weight of the Attachment alone is 1.3 kg, and the machine and its various functions are easy to use, benefitting users who are unskilled. Primary Machine Function of Hand Drilling is retained and not affected in at all.

Acknowledgements

We would like to thank the HOD, IEM Department, B.M.S. College of Engineering, Bangalore, for his encouragement and guidance in writing this paper. We are grateful to the Principal, B.M.S College of Engineering, Bangalore, for his support and encouragement in writing this paper.

References

[1] Online: http://www.sawdesigner.com/calc , last visit:11.06.2014
[2] Ulrich Karl T., Eppinger Steven D., Goyal Anita, Product Design and Development, Tata McGraw-Hill, New Delhi, 2007.
[3] R.S.Khurmi, J.K. Gupta, A Textbook of Machine Design, Eurasia Publishing House Pvt. Ltd, New Delhi 2005.
[4] Online: http://www.tribology-abc.com/calculators/metric-iso.htm, last visit:14.06.2014
[5] Online: http://www.kitply.com/products/plywood/kitplygold/index.html, last visit:12.06.2014