

FEA Analysis and Performance Evaluation of Tesla Turbine Manufactured by FDM Process

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ABSTRACT

There are many instances and applications in process industry where the processing of a fluid stream (gas/air) requires its pressure to be reduced. This pressure reduction is usually accomplished through use of a throttling valve . In this method the energy of fluid stream is lost , Currently , emphasis is being placed on more effective energy usage in processing industry. As a consequence , areas in which energy is wasted are being closely monitored and methods of energy recovery are being investigated. This calls for developing of effective low pressure recovery systems (pressure 2.5 bar to 5 bar). This Paper deal with modelling and analysis of bladeless turbine with four vane profile mechanism manufactured using FDM process. The vane profile for rotor and casing disk will be developed using Unigraphix Nx-8 , and strength analysis will be done using ANSYS workbench 16.0. The vibration characteristics as to RMS displacement , velocity and acceleration will be measured at varying pressure conditions using vibrometer.

Keywords: Waste Heat And Pressure, Bladeless Turbine, Energy Recovery.

I. INTRODUCTION

Waste low pressure energy (Pressure 2.5 to 5 bar) is the process of capturing pressure energy discarded by an existing industrial process and using that pressure energy to generate power (see Figure 1). Energy intensive industrial processes—such as those occurring at refineries, steel mills, glass furnaces, and cement kilns-all release hot exhaust gases and waste streams that can be harnessed with well established technologies to generate electricity. The recovery of industrial waste pressure energy for power is a largely untapped type of combined pressure energy and power (CHP), which is the use of a single fuel source to generate both thermal energy (pressure energying or cooling) and electricity. CHP generally consists of a prime mover, a generator, a pressure energy recovery system, and electrical interconnection equipment configured into an integrated system.In this paper we are considering bladeless radial turbine. A Radial turbine is a turbine in which the flow of the working fluid is radial to the shaft(i.e, 90degrees). It is also known as the boundary layer turbine, cohesion-type and Prandtllayer turbine in general turbine, nomenclature. In this paper we have manufactured the bladeless turbine using FDM process. Fused deposition modeling (FDM) is an additive manufacturing technology commonly used for modeling, prototyping, and production applications. It is one of the techniques used for 3D printing.FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from a coil and supplies material to produce a part. Adhesion and viscosity are the two properties of any fluid, these two properties work together in the bladeless turbine to transfer energy from the fluid to the rotor or vice versa. As the fluid moves past each disk, adhesive forces cause the fluid molecules just above the metal surface to slow down and stick. The molecules just above those at the surface slow down when they collide with the molecules sticking to the surface. These molecules in turn slow down the flow just above them. The farther one moves away from the surface, the fewer the collisions affected by the object surface. At the same time, viscous forces cause the molecules of the fluid to resist separation. This generates a pulling force that is transmitted to the disk, causing the disk to move in the direction of the fluid.



Figure 1.1. Bladeless Turbine

II. MATERIAL USED FOR TURBINE:

ABS polymer filament

Objectives

- 1. To design and develop bladeless turbine and to decide number of disc for reaction purpose to generate maximum speed and power.
- Design, development and derivation of turbine dimensions for operating range of 2.5 bar to 5 bar by theoretical method, drawing and modelling of Turbine using Unigraphix Nx-8 and analysis of turbine components using ANSYS Workbench 16.0

3. When turbine will be run at different pressures, the expected rpm generated will be from 2000 rpm to 10000 rpm , the device if not balanced will vibrate tremendously hence the vibration characteristics as to RMS displacement , velocity and acceleration will be measured at varying pressure conditions using vibrometer.

III. DESIGN& ANALYSIS

Design of Main Shaft:

Material Selection: Refer PSG (1.10 & 1.12 & 1.17)

Table 1

Ultimate	Yeild Strength
Tensile	N/mm ²
Strength	
N/mm ²	
720	600
	Ultimate Tensile Strength N/mm ² 720

 $fs \text{ allowable} = 0.18 \text{ x } 720 = 130 \text{N/mm}^2$

 $T_{d}= 1.016 \text{ Nm}$

 $fs_{act} = 10.2 \text{ N/mm}^2$

Finite Element Analysisof Main Shaft:



Figure 1.2

Design of pressure Disc: Material Selection:ReferPSG (1.10 & 1.12) + (1.17)

Table 2

Designation	Ultimate Tensile	Yeild Strength
	Strength	N/mm ²
	N/mm ²	
ABS polymer	48	36

 $\label{eq:sallowable} \begin{array}{l} fs \, {\rm allowable} = 0.18 \, x48 = 8.64 \, N/mm^2 \\ T_d = 1.016 \, Nm \\ \mbox{Check for Torsional Shear Failure} \\ fs \, {\rm act} = 0.33 \, N/mm^2 \end{array}$

Finite Element Analysis of Disc:



Figure 2.1



Figure 2.2

Result & discussion:

Table 3				
Part	Maximum	Von-	Maximum	Result
Name	theoretical	mises	deformation	
	stress	stress	mm	
	(MPa)	(MPa)		
Main	10.2	0.608	6.9481e-5	safe
Shaft				

- Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the main shaft is safe.
- 2. Main Shaft shows negligible deformation under the action of system of forces

Disc:

Result & discussion:

Table 4				
Part	Maximum	Von-	Maximum	Result
Name	theoretical	mises	deformation	
	stress	stress	mm	
	(MPa)	(MPa)		
Disc	0.33	1.0297	2.7812e-5	safe

- 1. Maximum stress by theoretical method and Von-mises stress are well below the allowable limit, hence the Disc is safe.
- 2. Discshows negligible deformation under the action of system of forces.

IV. TESTING

Experimental Set-up:



Figure 3.1. Experimental set up

Input Data:

Pressure range 2 to 4.5 bar

Procedure:-

- 1) Connect pressure inlet to the FRL unit.
- 2) Maintain pressure at 2bar
- 3) Note speed of turbine.
- 4) Note value of vibration displacement.
- 5) Note the value of vibration acceleration

V. RESULT AND DISCUSSION

Table 5				
Pressure	Speed (rpm)	Vibration	Vibration	
(bar)		Disp. (mm)	Accn	
			(mm/sec2)	
2	2000	0.256	3.45	
2.5	2850	0.263	3.76	
3	3900	0.274	3.84	
3.5	5500	0.281	3.96	
4	5990	0.284	4.1	
4.5	6310	0.288	4.23	

Graphs:

1. Graph of Speed (rpm) Vs Pressure



The speed of turbine increases with increase in pressure.



Vibration displacement increases with increase in turbine inlet pressure

3. Graph of Vibration Acceleration Vs Pressure



Vibration acceleration increases with increase in turbine inlet pressure.

VI. CONCLUSION

1. Maximum stress by theoretical method and Vonmises stress are well below the allowable limit, hence the Main shaft is safe.

2. Maximum stress by theoretical method and Vonmises stress are well below the allowable limit, hence the Disc is safe.

3. The speed of turbine increases with increase in pressure.

4. Vibration displacement increases with increase in turbine inlet pressure.

5. Vibration acceleration increases with increase in turbine

inlet pressure

2. Graph of Vibration Displacement Vs Pressure



Figure 4

VII. REFERENCES

- Conservation of Power and Water Resources; Part 292-Regulations under Sections 201 and 210 of the Public Utility Regulatory Policies Act of 1978; Subpart A – General Provisions, 292.101 Definitions.
- [2]. Waste Heat Recovery: Technology and Opportunities in U.S. Industry, BCS Incorporated, Report to U.S. DOE Industrial Technologies 2008. Available Program, March at:http://www1.eere.energy.gov/manufacturing/in tensiveprocesses/pdfs/waste_heat_recovery.pdf Monarch K. Warambhe, Gautam R. Jodh "Design and Analysis of Clutch Using Sintered Iron as a Friction Material" International Journal of Innovative Technology Exploring and Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-7, December 2013.
- [3]. Recycling waste pressure into electricity By Sean Casten, Turbosteam Corp COMBINED HEAT AND POWERCombined heat and power options in most modern steam plants are an opportunity waiting to happen. Energy conservation at our nation's colleges, mills, and hospitals goes way beyond changing light bulbs and thermostat set points. This exclusive report by the CEO of a member of the U.S. Combined Heat & Power Association.N.V.Narasimharao.L, Ch.Chandrarao

"Static and Dynamic Analysis of Clutch Plate With Crack" IJRMET Vol. 4, Issue Spl - 1, Nov 2013 - April 2014

- [4]. PetrBloudicek, David Palousek. "Design of tesla turbine". Konferencediplomovychpraci 2007. Warren Rice, "Tesla Turbomachinery", Proc. IV International Nikola TeslaSymposium (Sep. 23 – 25 1991).
- [5]. A New Approach to Waste Pressure energy and PressureEnergySystemsUpendra S. Gupta, Sankalp Kumar Mishra, MurtazaBohra S.V.I.T.S, Indore, Madhya Pradesh, India IJRMET Vol. 4, Issue 1, Nov 2013 - April 2014

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