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Design Modeling And Analysis Of Lobe In Twin Blower

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1.ABSTRACT

The current rotor is as casted with S.G. iron material. After wearing of shaft the entire rotor needs to be replaced.Further due to stringent requirement of design with S.G. iron rotor, the shaft diameter is very large causing use of heavy ball as well as roller bearings & shaft. Present paper is based on Manufacturing of twin lobe roots blower using steel shaft & lobe. All these conditions leads to increase in cost and delay in production activity. In new design we are planning to introduce steel shaft & twin lobe blower as against existing as cast S. G. Iron shaft & blower. Hence, it is necessary to ensure two things. First , the shaft should withstand with the existing twisting as well as bending stress & lobe should withstand the high pressure and secondly, the centre line matching of machined lobe and shaft. Here it is necessary to ensure the proper molding of steel in S.G. iron. This types of blower are used in various purpose such as such as pneumatic conveying, aeration in Effluent Treatment Plant, cement plants, water treatment plant for filter back wash, aquaculture aeration, Thermal power plant, Biogas Boosting etc. In this design stage includes the design of steel diameter and lobe design, after diameter is decide, then selection of ball as well as roller bearing. This design is base on the ASME standards.. For the modeling of steel shaft with lobe the CATIA is used. For the analysis purpose, ANSYS software is used

Keywords: Case, Housing, Rotor, Foot , Gear carrier, Retainer, Sleeves, Gear, Gear Cover, End cap.

2. INTRODUCTION

Twin lobe or tri lobe blowers fall under this category. They have higher efficiency at moderate compression ratios and are most efficient in the compression ratios of 1.1 to 1.2.They are used where constant flow rate at varying discharge pressures .These are generally available for capacities 10 m3/ hr to 10000 m3/ hr for pressures up to 1 Kg/ cm2 in single stage construction. [1] The twin lobe rotor belongs to the category of positive displacement blower. They consist of a pair of in volute shaped lobes/ rotors rotating inside a oval shaped casing, closed at ends by side plates. One end is a driving lobe which is driven by the external power source, while the driven gear is driven by a pair of timed spur gears. Both the lobes thus rotate at equal speed and in opposite direction. As the rotor rotates, the air is drawn inside the inlet side of the cylinder and forced out against the outlet side against system Pressure.[2] With each revolution four such volumes are thus displaced. The air which is thus forced out is not allowed to come back due to the small internal clearance within the internals of the machine except a very small amount called as "slip". There is no change in the volume of the air within the machine but it merely displaces the air from suction end to the discharge end against the discharge system resistance i.e. no compression takes place in the machine.Since the lobe run within the machine with finite clearances, no internal lubrication is required. The air thus delivered is 100% oil free. These blowers delivers practically constant flow rate independent of the discharge pressure conditions. The flow rate depends largely on the operating speed. Due to these constructional features it has following distinct characteristics.[2]

1. The flow is depending on the operating speed.
2. The input power is totally depend upon the pressure across the machine.
3. The suction and discharge pressure are determined by the system conditions.
4. The temperature rise of the discharged air is largely dependent on the differential pressures across it

3. ADVANCEMENT FOR STEEL SHAFT & ROOT TWINE LOBE

The manufacturing stage involves mainly manufacturing of rotor, lobe, housings, sleeves, end cap, gear covers etc. Initially the drawings of parts to be manufactured are prepared in 3D modeling software and 2D drafting in Auto Cad as well as in CATIA V5 R21. These drawings are used to prepare the process sheets as well as tooling drawings, quality plans etc.[3]

3.1 Rotor & Lobe: -

In order to create swept volume per revolution this item is used. The rotor is manufactured as stub shafts .The two shafts are manufactured on S.P.M. The holes in the rotor are provided for positive fastening of rotor to the lobe.

3.2 Housing:- To hold the rotor subassembly this part is used with the help of bearing. There are two types of housings in a blower assembly viz. BB housing and RB housing.BB housing supports Ball bearing and RB housing supports Roller bearing. Both housings and Case forms an airtight assembly.

3.3 CASE: - This create working chamber & work as a space between two housings. Case is a central part of blower. On its one side RB housing is fastened and on another side BB housing is fastened. There are fins provided on the case outer periphery for effective heat transfer. [3]

*3.4 Gear Cover***:-** The gear cover acts as a housing for the pair of spur gears. It also acts as a sump for oil which is used for lubrication of the gear.

4. DESIGN OF STEEL SHAFT AND ROOT TWINE BLOWER

It is necessary to have design related basic information about various components of blower before attempting to design steel shaft. The design of steel shaft is based on the ASME standards.For the design of shaft we know the various data for calculation.

4.1 Data available for steel Lobe:

Input data used for designing the steel shaft is as follows.

Model Name:- SR069

Material- C45

S_{ut}= Ultimate tensile Strength= 630 N/mm2

S_{yt}= Yield tensile strength =380 N/mm2

Shaft Power =44 KW

Gear pitch circle diameter =117 mm

Motor pulley diameter d_1=315 mm

Blower pulley diameter d_2= 190 mm

Maximum speed of the rotor N = 3500 rpm

Swept Vol :- 6.9 lit./rev.

Air Flow:- 1250 – 1330 m3/hr

Max. Pressure:- 1035m bar(Continuous/ Intermittent)

4.2 Design procedure for steel Lobe: [3]

The following procedure is followed to design steel shaft.

4.2.1 Torque at blower shaft:-

$$Mt = \frac{60x106 \text{ x } KW}{2\pi N}$$

$$= 120109.19 \text{ N-mm}$$

$$= 120*103 \text{ N-mm}$$

4.2.2 Calculation for permissible shear stress

According to A.S.M.E. code,

$\tau d = 0.3 (Syt)$

$= 0.18 (Sut)$ Whichever is minimum.

$\tau d = 0.3(380)$

$= 114$ N/mm2

$\tau d = 0.18(630)$

$= 113.4$

4.2.3 Calculation for Power transmitted: [4]

KW = (T1–T2)xv / 1000 ---------------- (a)

Also $v = \pi d_2N / 60x1000$

$v = 3.14 \text{ x } 190 \text{ x } 3500/ 60x1000$

$v = 34.80$ m/s

4.2.4 Now for V belts: [4]

Assume, β = 200 = Groove angle

μ = 0.25 = Coefficient of friction

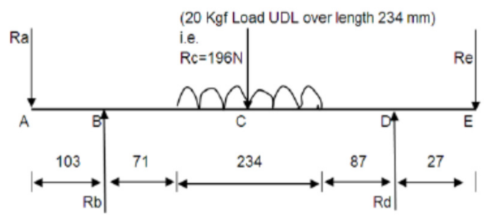
Angle of contact for blower pulley is,

$\alpha_s = 180 – 2sin – 1\{d_1–d_2/ 2C \}$

$=167.80 \text{ x } (\pi/180) = 2.92$ c

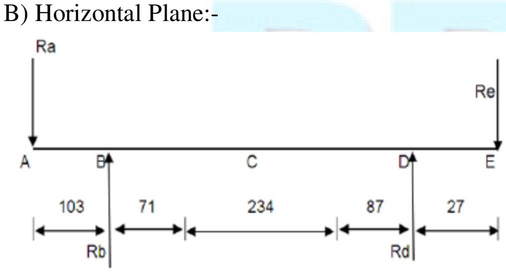
4.2.5 Calculation for Shear force and bending moment’s diagram: [6]

A) Vertical Plane:-



Let, Considering equilibrium for vertical forces, ΣV=0
−RA+RB−RC+RD−RE = 0
−353+RB−196+RD−811.50=0
RB+RD=1360.5 ------------------- (4)
Now, considering equilibrium of moments at B, ΣMB=0 −36359+36848−RD x 392+340018.5 = 0 RD = 868.641 -------------------- (5)
Now Bending moments at various positions are as follow-
Bending moments at A = 0
Bending moments at B =−353x103=−36359 N−mm
Bending moments at C =−102723+92469.492 =−10253.50 N−mm
Bending moments at D =−174735+19280.872−39984=−21910.28 N−mm
Bending moments at E = -184266+206088.921 –68208+23453.30
Let, Considering equilibrium for vertical forces,

B) Horizontal Plane:-



ΣV = 0 – (T1+T2) +RB+RD–Pt = 0 RB+RD = 3654.75 N -------------------- (6)
Now, considering equilibrium of moments at B, ΣMB=0 – (1603.75) x 103–RD x 392 + 2051 x 419 = 0 RD = 1770.87 N
From equation (6),
RB = 1883.87 N Bending moments at B = –165186.25 N–mm
Bending moments at C =–466691.25 + 354167.56 =–112523.69 N–mm
Bending moments at D =–793856.25+738477.04 =–55379.21 N–mm
Bending moments at E = 0

4.3 Calculations for rotor diameter: [3]

Assuming minor shocks i.e. load applied suddenly, Kb=1.75 7 & □□ = 1.25.

$$d=3\sqrt{\frac{16}{\pi\times\tau}}\times\sqrt[2]{(kb\times Mb)2+(kt\times Mt)2}$$

d=3√[16/(π × 85) × √(2&(1.757 × 169140.39)2) + (1.25 × 2120)2
d=27.08mm

After diameter is selected as factor of safety as 1.5. Then for the analysis purpose ANSYS software is used. For that purpose we select the material as C45. For that material, select the Youngs Modulus as 0.27-0.30. Possions ratio as 190-200 GPA. Force acting at center of lobe is taken as 20 kgf, For that analysis, we select the boundary condition.

4.4 Stress Analysis of Lobe Procedure

The geometry of the model was created using CAD program based on the original shape of the model. The model is then imported to FEA program to perform the modal analysis. In the pre-processor stage, the FFE (fast finite element) solver used subspace method to calculate 20 modes in addition to any rigid body modes available in the model. The default FFE solver detects rigid body modes (modes with zero frequency) automatically. All the four bolts holes are fixed. In addition, the rigid body modes are not counted among the requested number of modes. In the solution processing stage, the program runs a linear static analysis to calculate the deformed shape and then calculates the frequencies and mode shapes.

During the post processing stage, The mesh was generated by ANSA with hex elements. We also use ANSA to assignment of the materials properties, define contacts, and set appropriate boundaries and loadings during analysis. The operation of a specific code is usually detailed in the documentation accompanying the software, and vendors of the more expensive codes will often offer workshops or training sessions as well to help users learn the intricacies of code operation

4.5:- Stress analysis of lobe on shaft-

The analysis of lobe on shaft is carried out in the Finite element analysis software named ANSYS.The actual load conditions are worked out .The boundary conditions are given. By using the ANSYS software, meshing of shaft is done [13].

The data used for preprocessor are-

Material- C45.

Youngs Modulus-Y-190-200 GPa.

Possions ratio -0.27-0.30.

The load conditions and boundary conditions of the lobe on shaft are as follow.

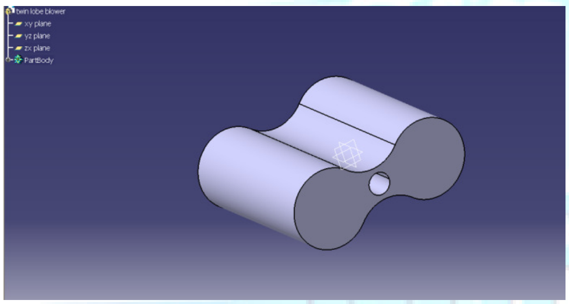


Fig. 1 3D model of lobe blower

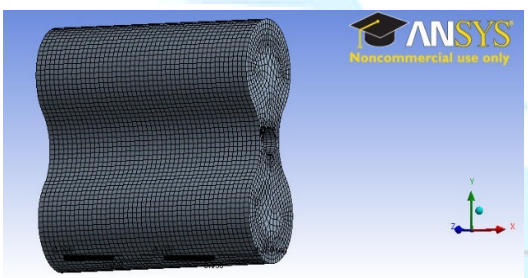


Fig .2 FE model meshing of lobe blower

Table No.1 Meshing quality criteria.

Sr. No.	Features	Ideal	Actual
1	Warp angle	0	19.05
2	Jacobin	1.0	0.7
4	Aspect ratio	1.0	4.6489
5	Skew	0^0	29^0
6	No. of nodes	31098	-
7	No. of elements	6776	-
8	Element size	06	-
9	Meshing type	3D solid	-
10	Meshing element	brick	-

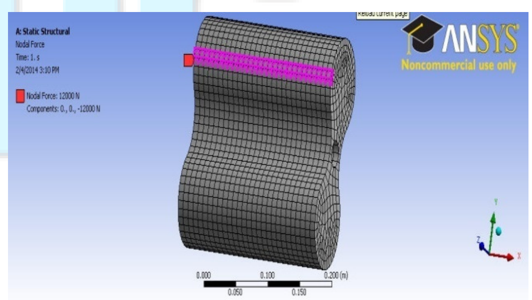


Fig. 3 Boundary conditions for Lobe Blower

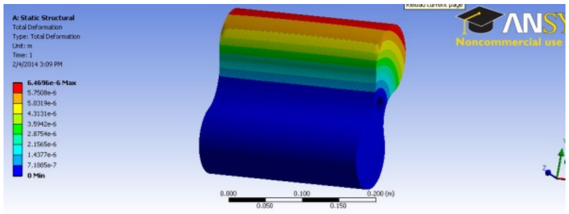


Fig. 4 Total Deformation of lobe

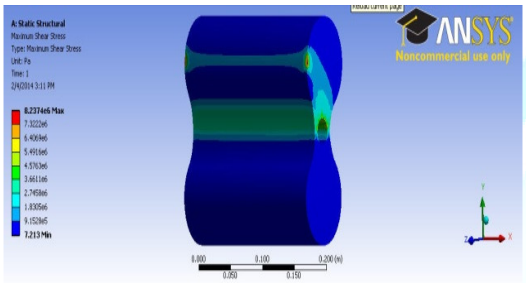


Fig. 5 Maximum Shear Stresses of lobe

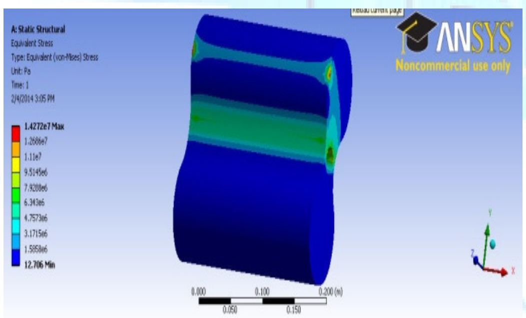


Fig. 6 Von Mises Stresses of lobe

4.6 Bearing Details-[9]

Bearing Type=Cylindrical Roller bearing.
Bearing inner diameter=45 mm
Bearing outer diameter=100mm
Bearing width=25
Bearing number=N309 ECP
Dynamic load capacity=1, 12,000 N
Static load capacity=1,00,000N
Limiting speed=8500 RPM

5. COMPARISON OF OLD AND NEW BLOWER

To increase the productivity, reduce cost and to enhance the quality of rotor machining, it is planning to change the material of rotor from S.G. Iron (FG 600) to steel viz. C45, En 8. Constraints in existing method-The current rotor is as casted with S.G. iron material. After wearing of shaft the entire rotor needs to be replaced. Further due to stringent requirement of design with S.G. iron rotor, the shaft diameter is very large causing use of heavy ball as well as roller bearings. Rotor lobe is machined with integral shaft. No manufacturing flexibility. When rotor shaft worn out, entire rotor lobe assembly needs to be replaced. In new design of blower planning is to introduce steel shaft as against existing as cast S.G.Iron shaft .Hence , it is necessary to ensure two things .First , the shaft should withstand with the existing twisting as well as bending stress and secondly, the centre line matching of machined lobe and shaft..Rotor lobe and shaft can be separately machined. Greater manufacturing flexibility. When rotor shaft wears out, only worned shaft can be replaced. Same lobe can be utilized.

6 TESTING PARAMETER

Testing parameter of blower consist of various parameter such as noise ,vibration, power consumption air flow, pressure rise and temp. Rise. Blower performance is monitored with respect to this parameter. After monitor performance of blower observation are as below such as noise = 95 DBA, Vibration=10 mm max, power consumption=45 KW, Air flow=1146.47 Cub.m/hr, pressure rise=1000 milibar, temp. Rise=115°C.

7 CONCLUSIONS

The design of blower on shaft is done by using standard practice. By considering existing geometry limitations and theoretical results the factor of safety taken as 1.5.The shaft diameter of the steel shaft is 42mm. Shaft power is 44 KW. The stress acting on lobe max shears stress 8.237X10^{6}N/mm^{2} & static structural stress 6.469 X10^{-6}N/mm^{2} max & von miss stress 1.4272 X10^{7}N/mm^{2} The analysis of blower on shaft is carried out in the Finite element analysis software named ANSYS. The actual load conditions are worked out. Design modification of blower on shaft gives rise to change in the design of housings, sleeves, bearings etc. Rotor lobe and shaft can be separately machined which gives greater manufacturing flexibility. When rotor lobe wears out, only wormed lobe can be replaced and same shaft can be utilized.

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