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Design, Modeling and Analysis Of Double Acting Reciprocating Compressor Components

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Abstract : The present day concept of automation has increased the use of compressed air in every field of industrial life. An attempt has been made to design double acting air compressor with an intention to provide the operating pressure required for pneumatic tools within less time taken by single acting compressor to generate the same pressure of 9 kg/cm2 at 925 rpm of compressor for piston displacement of 21.4 cfm. Basic component of double acting reciprocating air compressor are designed. The modeling, and analysis of double acting reciprocating air compressor were done by using CATIAV5R10 software. Theoretically, all the components are found to work within safe stress limits..

Key Word : Double Acting Reciprocating Compressor, Stress Analysis, Material Properties, CATIAV5R10, Failure Mode.

1. INTRODUCTION

Compressed air is used in Air refrigeration, cooling of large building for cleaning purposes, blast furnaces, bore wells, spray painting, in super charging IC engines and gas turbines, starting of IC engines, fuel atomizers, compressed air is widely used in braking system of automobiles, railway coaches, wagons etc. and the list is endless where the compressed air is used. In fact today, we find it is extensively used in all fields of application due to Wide availability of fresh air. Compressibility, Easy transportability of compressed air in pressure vessel, containers and long pipes., Fire –proof characteristics of the medium. High degree of controllability of pressure. The detail study of different types of compressor is very much essential. The current study is focused at the study of double acting reciprocating compressors. The advantage of double acting compressor is that it delivers almost double compressed air (almost in half time) which saves time and money of the user. The aim for the current study is to replace the single acting compressor by double acting compressor which generates 9 kg/cm^2 compressed air on the basis of the tools used in the industries which are generally operated with a maximum pressure of 9 kg/cm^2. The study is focused on a compressor available in Manoj motor mechanic and servicing center Pusad, which is used for water serving and also for the tyre remolding with the following specifications:

2. OBJECTIVE

The main objectives are to:

- Design Cylinder and Piston for Double acting reciprocating air compressor which generates 9 Kg/cm^2 compressed air.
- Model and perform stress analysis for Cylinder and Piston .

3. LITERATURE REVIEW

Heinz P Bloch and John J. Hoefner worked on the Development of a Double acting free piston expander for power recovery in transcritical CO_2 cycle.[5]. Sun et al. developed New method of thermodynamic computation for a reciprocating computer simulation by Si – Yieng .[6] W.Norman Shade et.al. suggest optimization and revitalization techniques on compressors used in air drilling, air procession and air separation etc. and emphasis on the fact that virtually any size model can be considered for improvements, A. Al masi worked on reciprocating compressor design and manufacturing with respect to performance, reliability and cost. And suggested methods for optimum reciprocating compressor. A.P.Budagyan and P.I. Plastinin devoted on design and optimization on reciprocating compressors [10] and minutely studied the effect of temperature variation on the overall performance of the reciprocating compressors and cooling of compressors. Due consideration is given on optimal basic geometric dimensions of reciprocating compressors .

4. Methodology

4.1 Design of Cylinder and Piston for double acting compressor.

Maximum pressure	= 9 kg/cm^2 ,
Diameter of cylinder of piston	93.25 mm
Thickness of cylinder	= 8 mm
Factor of Safety for cylinder	10
Radius of crank	= 75 mm
Thickness of cylinder flange	= 9.6 mm

Size of studs	8
Depth of piston ring	= 4.875 mm
Distance between bottom of piston to bottom of second ring	= 6.42mm
Number of piston rings	2
Thickness of web of piston	= 10 mm
Mass of piston	= 0.9482 kg
RPM of compressor	= 925 rpm
Length of cylinder	= 205 mm
Material of cylinder	= FG 300
Stroke length	= 150 mm
L/D Ratio	1.6
No of studs	4
Thickness of Piston	= 30 mm
Distance between top of piston to top of first ring	= 6.42mm
Clear distance between two piston ring	=7.41 mm
Thickness of piston ring	= 10 mm
Volume of piston	131703.92×10-9 m3
Outer diameter of piston pin	= 15mm

5. MODELING AND ANALYSIS OF CYLINDER AND PISTON.

Modeling refers to the process of generating a model as a conceptual representation of some phenomenon. Typically a model will refer only to some aspects of the phenomenon.

Stress computation for cylinder: Table 1shows the various properties of the material used for cylinder and Table 2 indicate the loading on cylinder Since the maximum pressure inside the cylinder is 0.8829 N/mm^2

Table .1 Material properties for cylinder:

Material	Iron : Cast-Iron , Gray 4.5 % , ASTM A-48
Young Modulus	9.239e+010N_m2
Poisson Ratio	0
Density	7800kg_m3
Thermal Expansion	0.0000121
Yield Strength	3.1e+008N_m2

Table .2 Load computation on cylinder:

Fx = –3.137e – 012	N
Fy = 3.125e – 011	N
Fz = –1.207e + 004	N
Mx = 2.956e – 002	N-m
My = 5.285e – 003	N-m
Mz = 7.772e – 016	N-m

Material	Aluminum : Alloy 1100-H14
Young Modulus	7.5e+010N_m2
Poisson Ratio	0.346
Density	2800kg_m3
Thermal Expansion	0.0000236
Yield Strength	9.5e+007N_m2

Table 3. Material Properties for Piston

Table 4. Load Computation for Piston

Fx =	2.1144e-014 N
Fy =	1.1577e-014 N
Fz =	-9.6307e+003 N
Mx =	-2.1840e-002 N-m
My =	-4.2288e-003 N-m
Mz =	-1.2020e-019 N-m

Table 5. Forces and reaction for Cylinder

Components	Applied Forces	Reactions	Residual	Relative Magnitude Error
Fx (N)	-3.1370e-012	-5.4353e-012	-8.5723e-012	1.9157e-014
Fy (N)	3.1253e-011	1.0620e-010	1.3745e-010	3.0716e-013
Fz (N)	-1.2067e+004	1.2067e+004	8.1855e-011	1.8292e-013
Mx (Nxm)	2.9564e-002	-2.9564e-002	-1.4809e-011	1.6143e-013
My (Nxm)	5.2850e-003	-5.2850e-003	-1.4206e-011	1.5486e-013
Mz (Nxm)	7.7716e-016	-3.2615e-012	-3.2607e-012	3.5545e-014

Components	Applied Forces	Reactions	Residual	Relative Magnitude Error
Fx (N)	2.1144e-014	-2.6219e-012	-2.6008e-012	6.3020e-014
Fy (N)	1.1577e-014	-2.6312e-013	-2.5155e-013	6.0953e-015
Fz (N)	-9.6307e+003	9.6307e+003	1.8190e-011	4.4077e-013
Mx (Nxm)	-2.1840e-002	2.1840e-002	-1.2267e-013	6.3412e-014
My (Nxm)	-4.2288e-003	4.2288e-003	-3.9167e-013	2.0247e-013
Mz (Nxm)	-1.2020e-019	-1.8957e-014	-1.8957e-014	9.7996e-015

Table 6. Forces and Reactions on Piston

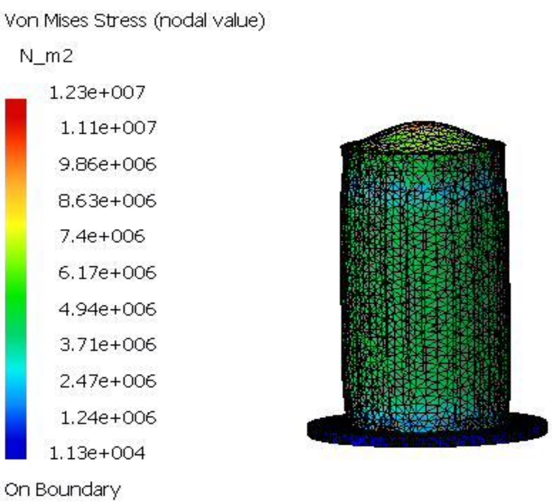

Figure 1. Deformed mesh for cylinder with nodal stresses value

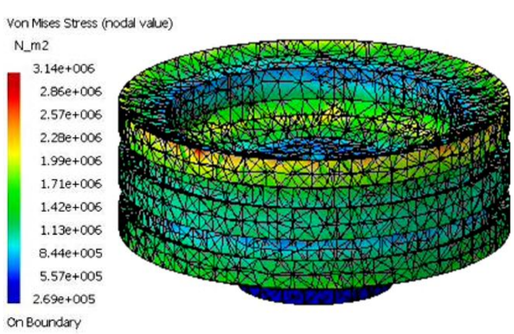

Fig. 2 : Deformed Mesh for Piston with Nodal Stress Values

Entity	Size
Nodes	8547
Elements	35622

For Cylinder

Entity	Size
Nodes	9076
Elements	32627

For Piston

6. RESULT AND DISCUSSION

In this an attempt has been made to design a double acting reciprocating air compressor components such as piston and cylinder for maximum pressure of 9Kg/cm^2 at 925 rpm , for piston displacement of 21.4cfm The fundamental dimensions of each components of double acting compressor were found out analytically and checked for various failures due to induced stresses. The modeling of double acting reciprocating air compressor components were carried out by using CAD software Pro-E Wildfire 4.0 and analysis by using CATIAV5R10 software. Theoretically all the components are found to work within safe stress limits.

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