Structural and Dynamic Analysis of Reciprocating Compressor under different operating loads

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Abstract

Four types of configurations of reciprocating compressor including validation model have been used with different profile of connecting rod with web thickness of 10, 20, 30, 40mm. An optimized model of connecting rod with web thickness has been developed. The simulation of the optimized model gives minimum value of stress and deformation at different operating load i.e. 17.23, 20.68, 24.13, 27.57, 31.02 MPa which has optimized and converged result compared to respected models of reciprocating compressor connecting rod, it has also been observed that stress and deformation was reduced at different operating load i.e. 17.23, 20.68, 24.13, 27.57, 31.02 MPain connecting rod of C70S6 material is reduced stresses in present optimized model and also observed higher structural performance.

Keywords— *Reciprocating Compressor,Connecting Rod, Web Thickness, Stress, Deformation, Natural Frequency.*

I. INTRODUCTION

Positive displacement compressors include reciprocating compressors in its category. Larger volumes of gas are compressed and brought to a greater pressure. The most popular type of positive displacement compressors are reciprocating compressors. The only moving parts of the device are a piston and a cylinder. The pressure rises as a result of the piston's upward and downward movement inside the cylinder, which squeezes the gas into a smaller volume. A single cylinder compressing on one side of the piston is the fundamental reciprocating compression element. The two fundamental single-acting components will be used on both sides simultaneously in a single up-down movement.

The crankshaft and piston rod convert the rotary motion coming from the engine or any other external driver going to the compressor into linear motion. The crankpin fastens the piston rod's end to the as the crankshaft rotates, one is reciprocated by the piston and the other by the crankshaft. The suction and discharge valves, which are essentially check valves that permit the one-way passage of the gas, are typically found at the top and bottom of the cylinder, respectively. The lower end of the cylinder will experience a partial vacuum as the piston rises; the pressure differential causes the valves to open, enabling gas to flow into the cylinder. However, for the When the cylinder's internal pressure is higher than the discharge line's internal pressure during a downward stroke, the valve will open, allowing gas to flow from the cylinder to the discharge. This is referred to as "single-acting" compression if it just affects one side of the piston, and "double-acting" compression if it affects both sides.

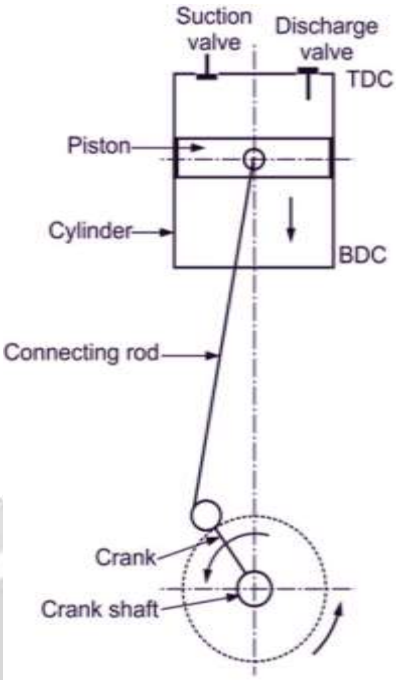


Figure1.1 –Reciprocating Compressor

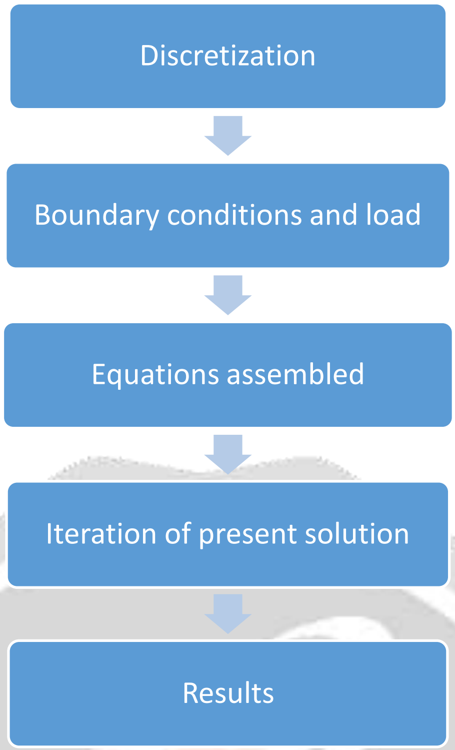
II. FORCING FUNCTIONS

Forcing Function	Dominant Frequency (Multiple of Run Speed)	How to Minimize Force
Mass Unbalance Mass unbalanced in opposing reciprocating components	*1X*, 2X	Minimize opposing mass unbalance (e.g. 0.5 to 1 lbs for 1000 RPM, 6" stroke unit).
Moment/Couple Created by the offset of opposed reciprocating components	*1X*, 2X	Inherent in design.
Alignment Angular and parallel alignment of driver and compressor	1X, 2X	Check angular and parallel alignment.
Pulsation *Pulsation induced shaking forces (see Section 2).	*1X, 2X*, 3X, 4X, …	Control pulsations using acoustical simulation techniques.
Cylinder Stretch *Elongation/shortening of cylinder assembly due to internal gas forces.	*1X*, 2X, 3X, 4X, …	Check that cylinder assembly bolts are properly torqued.
NOTE: *	- On average these forcing functions decrease with increasing multiples of runspeed. - The most significant forcing functions occur at 1X and 2X compressor run speed.	

III. METHODOLOGY

The procedure for solving the problem is

- Modeling of the geometry.
- Meshing of the domain.
- Defining the input parameters.
- Simulation of domain.



Objective

- The main objective of the proposed research work is to validate the experimental investigation of reciprocating compressor with result of different configurations of reciprocating compressor models.
- To optimize the different configurations of reciprocating compressor models with by optimizing connecting rod web thicknessi.e. 10mm, 20mm, 30mm, 40mm.
- To analyse the performance parameters vonmises stresses, deformation on different configurations of reciprocating compressor with different web thickness of reciprocating compressor connecting rod.
- To predict the stress and deformation on optimized reciprocating compressor model along the influences of different operating pressures.
- To predict natural frequency of reciprocating compressor of optimized connecting rod.
- To analyse the effect of random vibration in couple of natural frequency at different operating pressure of reciprocating compressor.

IV. RESULTS

Validation of the existing simulation results for different configurations of reciprocating compressor connecting rod models with experimental data of stress and deformation.

The Existing simulation results are obtained for stress and deformation w.r.t. thickness with different optimized model of reciprocating compressor connecting rod, thickness ranging from 10mm to 40mm also pressure ranging from 17.23 to 31.02 Mpa. The results are in graphs show less than 8% deviations between existing simulation results. But the deviations are not so large, and thus the existing simulation results of different configurations of different reciprocating compressorconnecting rod models in the research work can be regarded as reasonable.

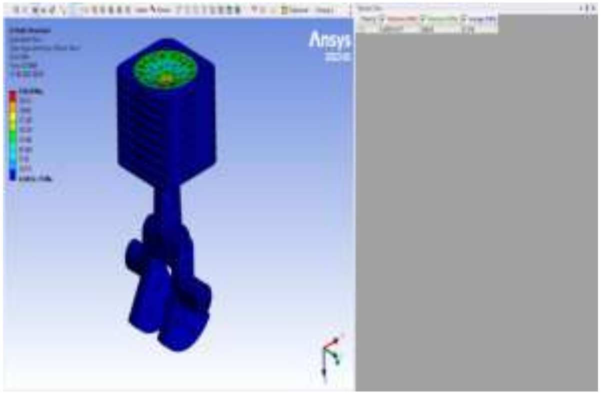


Figure 5.3 Stress values at a pressure of 17.23 Mpa

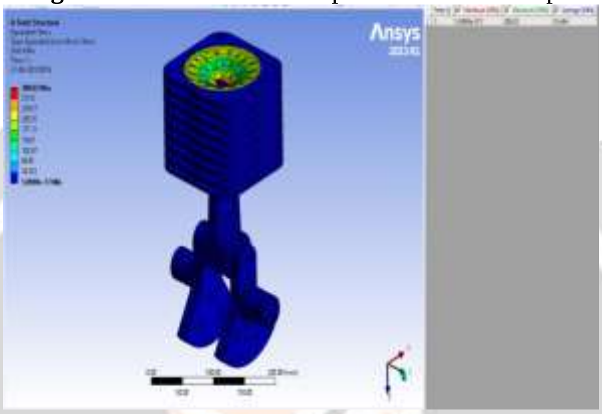


Figure 5.4 Stress values at a pressure of 20.68 Mpa

Figure 5.5 Stress values at a pressure of 24.13 Mpa

Figure 5.6 Stress values at a pressure of 27.57 Mpa

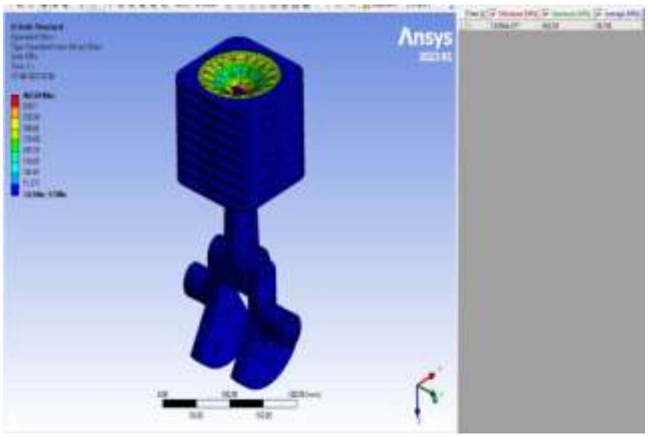


Figure 5.7 Stress values at a pressure of 31.02 Mpa

Table 5.1 Stress and deformation values with respect to pressure.

Experimental Data		
Pressure (Mpa)	**Stress**	**Deformation**
17.23	255.88	6.593
20.68	306.32	6.849
24.13	353.88	7.104
27.57	409.69	7.365
31.02	460.78	7.622

Table 5.2 Stress and deformation values with respect to pressure.

Validation of Experimental Data		
Pressure (Mpa)	**Stress**	**Deformation**
17.23	256.64	6.492
20.68	308.02	7.058
24.13	359.41	7.338
27.57	410.65	7.665
31.02	462.04	7.993

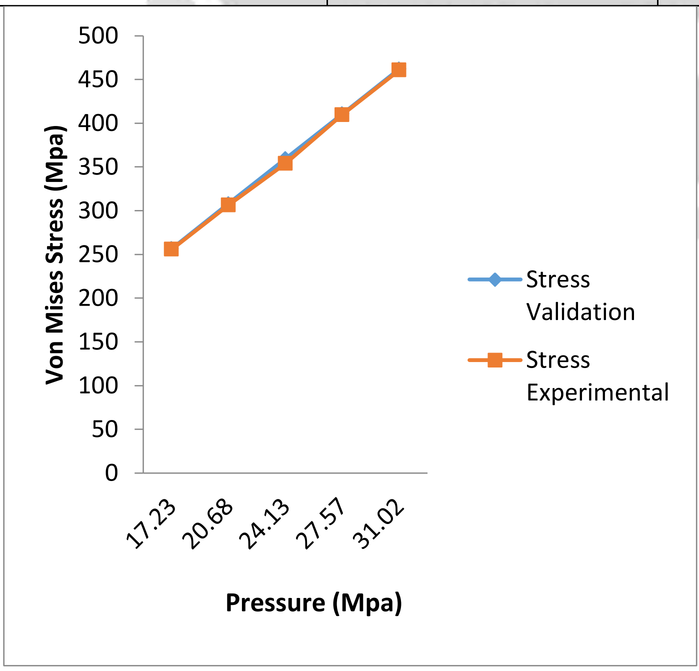


Figure5.8 Validation of present simulation result with experimental results with respect to vonmises stresses and pressure.

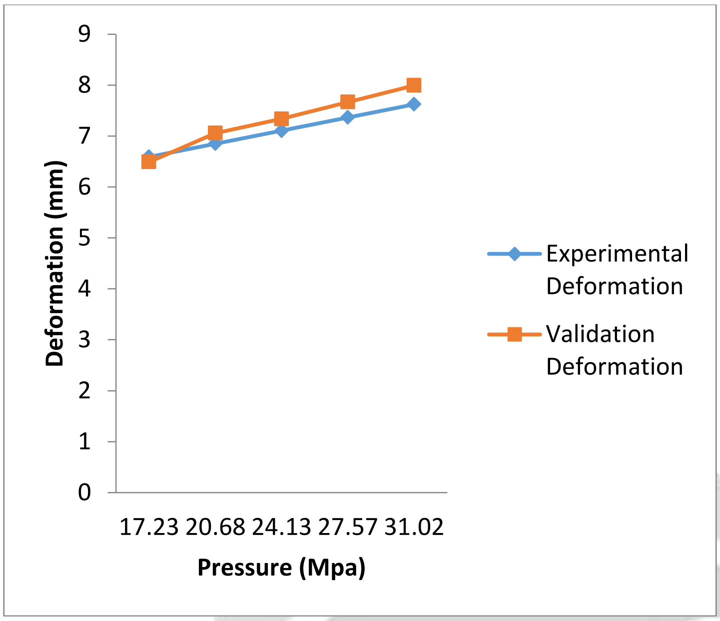


Figure5.9 Validation of present simulation result with experimental results with respect to deformation and pressure.

CONCLUSIONS

- In the study reciprocating compressor with connecting rod web thickness of 10, 20, 30, 40mm are the key geometric parameter on the performance of reciprocating compressor under different loading i.e. 17.23, 20.68, 24.13, 27.57, 31.02 with an implementation of reciprocating compressor with connecting rod of web thickness comprising 30mm, the developed stresses and deformation effect is improved.
- Results have least in reciprocating compressor of different configuration connecting rod web thickness, it concludes that at different loading i.e. 17.23, 20.68, 24.13, 27.57, 31.02, reciprocating compressor connecting rodwith web thickness of 30mmconfiguration having minimum stresses with a minimum deformation.
- The magnitude of frequency is minimum in the case of C70S6material profile of connecting rod with web thickness of 30mm. The nature of the natural frequency is maximum near its end in 3^{rd} and 4^{th},6^{th} mode

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