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"Modeling and Analysis of Reciprocating Compressor Valve using FEA Tool"

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Abstract : This study has been undertaken in the Reciprocating Compressors are among the most used types of compressors and their CAD modeling of the valve with analysis of compressor valve Equivalent Stress, temperature and flux. The analysis of the influence of the valve parameters on its dynamic behavior is also present in this study paper.

***Keyword* – CAD, Compressor, Valve.**

I. Introduction

Reciprocating compressors are among the most used types of compressors. They can be found in highly diverse fields of application, such as in the oil and gas industry or chemical industry, where these compressors are used mainly for their ability to deliver high-pressure gas. Basically, piston compressors are vital part in any process they are employed in; therefore their reliability has garnered widespread interest. As the limiting elements in the design of the reciprocating compressor, the compressor valves can be considered. They are often described as the heart of the compressor, due to the fact that should they fail, it would lead to the shutdown of the compressor and to costly downtimes. A compressor running at even moderate speeds such as 700 rpm requires for each valve to open and close over one million times a day. The main reason in developing this tool is to qualitatively assess the factors influencing the dynamic behavior. To validate the precision of this tool, the results are compared to freely accessible experimental data found in literature. However, the main goal of this study is not aimed at a quantitative estimation, since an experiment would be inevitable for the precise evaluation of the theoretical results. The analysis of the influence of the valve parameters on its dynamic behavior is also present in this paper.

II. TYPES OF RECIPROCATING COMPRESSOR

A. Single-Acting

Figure 1: Single Acting Compressor

This is the most typical air compressor in the market. They tend to be quite loud but can be relatively powerful for their size and weight. Given their portability, they can be placed close to point of use so if your needs are limited you can avoid installation of large amounts of piping and their simple design makes maintenance easier. As a rule they have a higher cost of compression than their double-acting siblings so they work best in environments where constant compressor use is not required.

B. Double-Acting

Figure 2: Double Acting Compressor

Reciprocating compressors are the most widely used compressors in almost all settings and regardless of the type, both versions of reciprocating compressors come with both single and multi-piston models, lubricated and non-lubricated, and can provide long-term and effective air compression depending on costumers' demand

III. ADDITION OF ISSUES

Advanced materials exhibit very excellent technical properties. However, the high cost of both raw materials and processing limit their use. Alternatively, advanced raw materials for high compression discharge valve have been implemented on several systems to enhance maximum fluid flow and minimizing leakage.

Mostly it has been observed that discharge valves get damaged due to extreme pressure and temperature acting upon flapper type valve and wear may occur or flap gets bend. Still flap valves are suited better action in single stage compression cycle so there is a scope of development.

IV. TARGET

a) To study about the influence of temperature and pressure on flap valve located in cylinder head of reciprocating compressor.
b) To design another flap valve and take series of experiments for determining life in with comparison of earlier.
c) To study about the best combination of solution for Material in manufacturing of valve plate.

V. VALVE MATERIAL AND PROPERTIES

- **SANDVIK 20C VALVE MATERIAL AND ITS PROPERTIES**

Sandvik 20C is a hardened and tempered carbon steel characterized by:

- High strength.
- High fatigue strength under bending and impact stress.
- Low level of non-metallic inclusions.
- Good wear resistance.

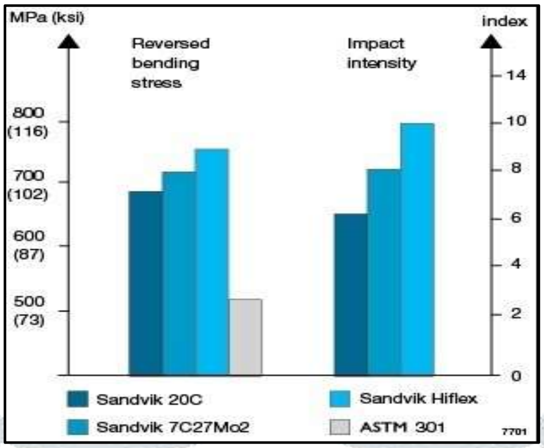
Compressor valve steel in Sandvik20C has excellent surface finish, good dimensional tolerances and good flatness.

STANDARDS

- ASTM: 1095
- W.Nr.:1.1274
- SS: 1870

VALVE TYPES:

- Flapper valves
- Reed valves
- Check valves



GRAPH 1: Comparison of fatigue properties for Sandvik's flapper valve steels and standard spring steel (ASTM 301)

VI. TECHNIQUES

- **Specimen Flapper Valve**

2 test valve specimens were prepared for the experimental work. The material valve was standard spring steel ASTM301 and Sandvik spring steel 20C..

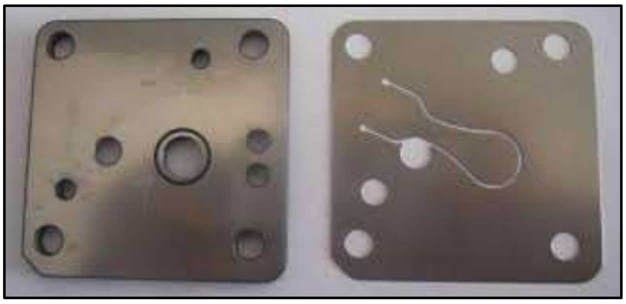


Figure 3: Test Specimen Sandvik 20c

Figure 4: Test Specimen Astm301

VII. CAD MODELING

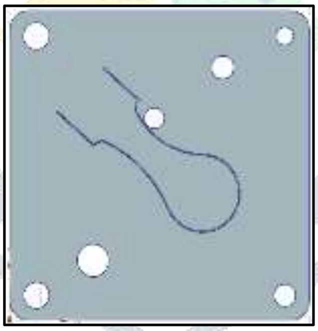


Figure 5: CAD Model of Flapper Valve

VIII. A GENERAL OPERATION FOR ANALYSIS FACILITY

Certain steps in formulating a finite element analysis of a physical problem are common to all such analysis, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages (some are mentioned in the following paragraphs) and are implicitly incorporated in this text, although we do not necessarily refer to the steps explicitly. The steps are described as follows.

A. Preprocessing :

The preprocessing step is, quite generally, described as defining the model and includes

- Define the geometric domain of the problem.
- Define the element type(s) to be used.
- Define the material properties of the elements.
- Define the geometric properties of the elements (length, area, and the like).
- Define the element connectivity (mesh the model).
- Define the physical constraints (boundary conditions).
- Define the loadings.

The preprocessing (model definition) step is critical. In no case is there a better example of the computer-related axiom "garbage in, garbage out." A perfectly computed finite element solution is of absolutely no value if it corresponds to the wrong problem.

B. Solution:

During the solution phase, finite element software assembles the governing algebraic equations in matrix form and computes the unknown values of the primary field variable(s). The computed values are then used by back substitution to compute additional, derived variables, such as reaction forces, element stresses, and heat flow. As it is not uncommon for a finite element model to be represented by tens of thousands of equations, special solution techniques are used to reduce data storage requirements and computation time. For static, linear problems, a wave front solver, based on Gauss elimination, is commonly used. While a complete discussion of the various algorithms is beyond the scope of this text, the interested reader will find a thorough discussion in the Bathe book.

C. Post processing:

Analysis and evaluation of the solution results is referred to as post processing. Postprocessor software contains sophisticated routines used for sorting, printing, and plotting selected results from a finite element solution.

Examples of operations that can be accomplished include:

- Sort element stresses in order of magnitude.
- Check equilibrium.
- Calculate factors of safety.
- Plot deformed structural shape.
- Animate dynamic model behavior.
- Produce color-coded temperature plots.

While solution data can be manipulated many ways in post processing, the most important objective is to apply sound engineering judgment in determining whether the solution results are physically reasonable.

IX. FEA SOFTWARE PACKAGES AND APPLICATIONS:

The rapid advance made in computer hardware and software led to significant developments in FEA software. FE programming gas emerged as a specialized discipline which requires knowledge and experience in the diverse areas such as FE technology including foundations of machines, and numerical analysis on the one hand and the computational skills in areas of software technology including programming techniques, data structure, data base management and computer graphics on the other hand. It requires several man years to develop general purpose finite element analysis software with a processing capability and facility for the user to have a wide choice of several types of elements, analysis for different types of problem-static, dynamic, material and geometric nonlinear, coupled situations, hear transfer, interaction problems etc. and pre and post-processing features. In 1975 the FEA software package was used for the analysis of aero plane parts. From the analysis it was predicted that the ansys packages gives better solution as compare to defining theory models. Thus the packages cover the industrial sector for analysis of various structural and mechanical parts. The main purpose of such packages is to obtain the solution without creating physical model. The figure shows memory allocation by ANSYS software package. The analysis software packages are applicable to static linear analysis, non-linear analysis, modal analysis, fluid flow analysis, thermal analysis, harmonic response analysis, steady state analysis, etc. As it is not possible here to review the capabilities and compare different commercially available finite element analysis packages only the names of some of the popular packages are given below: ABAQUS, ADINA, ANSYS, ALGOR, ASKA, COSMOS, GT-STRUDL, LISA, NISA, ASTRAN, PAFEC,PASTRAN,SAP.

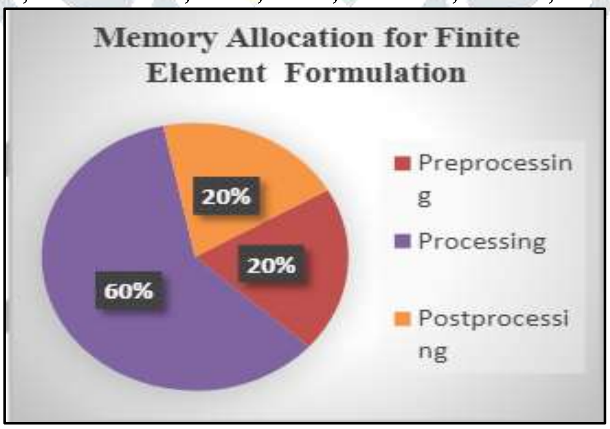


Figure 6: Memory Allocations for Analysis Software Package

X. ANALYSIS RESULT

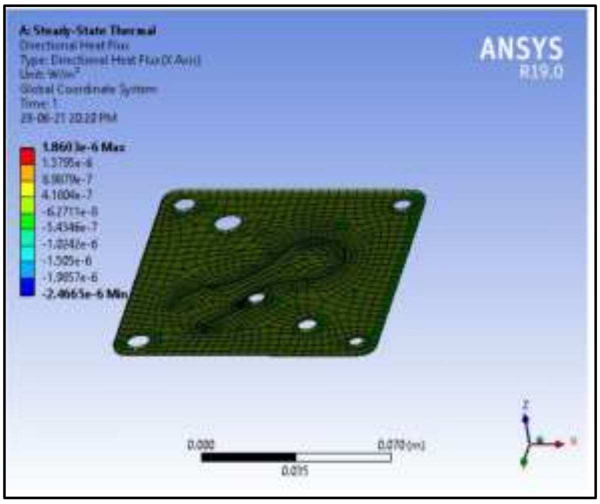


Figure 7: Directional Heat Flux

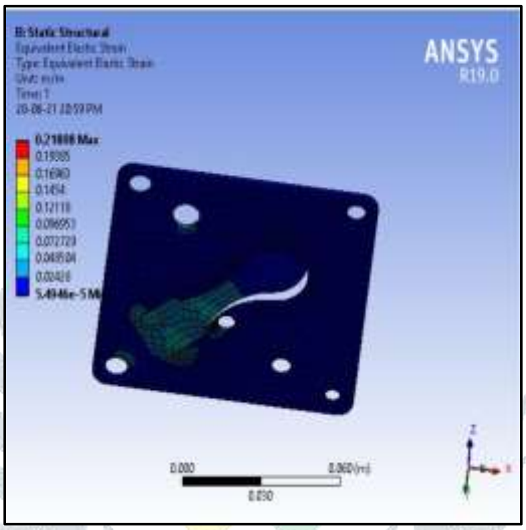


Figure 8: Equivalent Elastic Strain

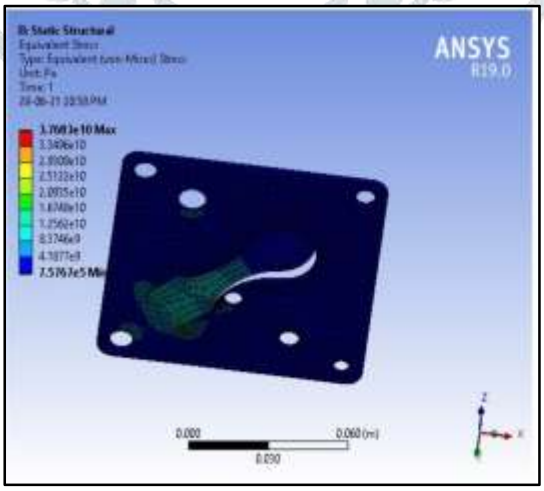


Figure 9: Equivalent (Von-Mises) Stress

Figure 10: Temperature

Figure 11: Total Heat Flux

XI. CONCLUSION

This paper has presented for optimization best suited material for flap valves of reciprocating compressor. As shown in this study, method provides a systematic and efficient methodology for determining optimal parameters like modeling and analysis with far less work than would be required for most optimization techniques. The confirmation experiments were conducted to verify the optimal parameters. It has been shown that Total deformation can be significantly improved in Flap valve materials using the optimum level of parameters.

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