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Design Optimization of Air compressor Intake Valve using FEA - Review

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Abstract*: Air compressors are widely used in various industrial applications and chemical plants. The current research reviews the existing researches on air compressors based on experimental and numerical techniques. The operational and design factors affecting the compressor performance are presented. The maintenance and design procedures of compressor are also presented in detail. The use of coolants on heat transfer characteristics of compressor is also presented.*

Key Words: *Air Compressor, Stresses, Thermal*

1. INTRODUCTION

An air compressor is a device that converts power into potential energy by forcing air into a smaller volume and thus increasing its pressure. The energy in the form of compressed air can be stored in the tank while the air remains pressurized. These energies can be used for a variety of applications such as utilizing the kinetic energy of the air as it is depressurized.

2. LITERATURE REVIEW

A. Bar-Cohen [1] was analyzed the thermal staging of an array of least-material, optimally spaced, vertical, rectangular fins further suggested that a maximizing value of fin thickness exists for each distinct combination of environmental, geometric and material constraints. In air, this value of fin thickness closely approximates the optimum fin spacing and results in effective heat transfer coefficients that offer a 15 to 45- fold improvement over natural convection transfer from a non finned surface.

Keribar Rifat et al. [2] developed new methodology to calculate heat transfer in reciprocating compressors. It used predictions of in-cylinder velocities to calculate coefficient of heat transfer s as a function of pressure ratio, speed, properties of fluids and geometry of piston.

Arzano-Daurelle, D Clodic and B. Hivet [3] they utilized the mean temperature to find the variation in cylinder wall temperature and they investigated that compressor energy performance was increased when mass flow rate is increasing and input power and discharge temperature are decreasing.

D. Thornhill, A. Stewart and G. Cuningham [4] were experimentally investigated on s heat transfer coefficient of finned cylinders in a free air stream. Ten cylinders of motorbike were tested with four different pitches of fin and five different length of fin. The establishment of an overall heat transfer coefficient, the distribution of cooling around the circumference of each cylinder was also found. The cooling was found to be lowest on the front of the cylinder, which is the side where air stream first impinged.

Singh Pardeep et al. [5] were analyzed the heat exchange execution of fin by design with different expansions in like manner as rectangular shape augmentation, trapezium compose expansion, triangular shape expansions and round segmental augmentations. The heat exchange execution of fin

with identical shape having different augmentations, without expansions is looked at. Close about extending 5% to 13% higher heat exchange can be getting with these different sorts expansions on fin when contrasted with same shape of fin without these augmentations. Examination of performance of fin had been executed through the product Autodesk Simulation. In particular heat transfer investigation, temperature changes w.r.t. heat removal rate take place through the surface is examined

L. Prabhu et al. [6] investigated that transfer of heat through extended area of rectangular configuration was greater than that of other fin shapes. Temperature at the free end of fin with rectangular extension is less, as compare to fin with other types of configurations. The fin effectiveness with rectangular extensions is higher than other configurations.

R.C.Wadbudhe, Akshay Diware, Praful [7] kale presents a case study on reciprocating air compressor of a locomotive highlighting the associated problems, diagnosis and effective solutions supported by appropriate maintenance strategies for overhauling and repairing arising out due to frequent failure of parts. According to an aspect of the invention, they prepare a two stage reciprocating compressor includes a casing; a first compressing unit disposed in the casing and including a first piston and a first cylinder, the first compressing unit being driven by a reciprocating motor to linearly reciprocate the first piston in the first cylinder to suck in and compress gas; a second compressing unit disposed in the casing and including a second piston and a second cylinder, the second compressing unit being driven by vibration of the first compressing unit to linearly reciprocate the second piston in the second cylinder to suck in and compress gas; and a vibration transfer member that transfers the vibration from the first compressing unit to the second compressing unit. The first and second compressing units extend in parallel and face toward each other.

S. S. Verma [8] gives a brief introduction to the latest developments of a compressed-air vehicle along with an introduction to various problems associated with the technology and their solution. While developing of compressed air vehicle, control of compressed air parameters like temperature, energy density, requirement of input power, energy release and emission control have to be mastered for the development of a safe, light and cost effective compressed air vehicle in near future. Compressed air car engines are fueled by a tank of compressed air, instead of an engine that runs with pistons and an ignited fuel air mixture. Basically, compressed air cars are powered by the expansion of compressed air. Vehicles that run on compressed air sound like a fantastic idea on paper, but bringing this technology to the masses have proven, well, a difficult road to travel because of some inherited technical problems with compressed air.

Gaurav kumar Tandan [9] in his review study reveals aim is to run the four strokes bike with help of compressed air, it will try to achieve a 50 km/h speed and range of refilling compressed air is after running of 70-80 km. The single energy engines will be available in both Minicabs and City cats. These engines have been conceived for city use, where the maximum speed is50 km/h and where MDI (Motor Development International) believes polluting will soon be prohibited with use of compressed air technology which having zero pollution level. The dual energy engine, on the other hand, has been conceived as much for the city as the open road and will be available in all MDI vehicles.

Jitendra Kumar Sasmal , Amit Suhane, Geeta Agnihotri [10] presented an article that highlights the different failure modes of reciprocating compressor under varied operating conditions along with the appropriate maintenance strategies to diagnose and tackle the problems occurring very often. Condition monitoring technique is a vital step in maintaining the condition of working equipment at normalcy. It helps in detecting the premature and catastrophic failures leading to drastic productivity and system deterioration.

Ravishankar, Amit Suhane, Manish vishwakarma [11] presents a case study on reciprocating air compressor of a locomotive highlighting the associated problems, diagnosis and effective solutions supported by appropriate maintenance strategies for overhauling and repairing arising out due to frequent failure of parts.

Suraj Ghiwe, K.V. Srinivasan, Kiran Chaudhari [12] presented works that explore the effect of temperature on the filter performance of a Compressor i.e. filter efficiency and the pressure drop across it. Both experimental analysis as well as CFD analysis has been carried out to study the performance of filter at various temperature in the range of 10 ^{0}C to 35 ^{0}C.

Kanwar JS Gill et al. [13] studied esigning and fabrication of intercooler and control of three phase digitalized reciprocating air compressor test rig with automatic control drive unit, international conference of advance research and innovation. The air compressor test rig is designed to study the characteristics of a two stage reciprocating air compressor and the compressed airflow through flow arrangement. This unit is self-contained and fully instrumented with mild steel frame-mounted on raised foundation, with intercooler, air stabilizing tank and air receivers. The compressor is driven by an AC Moor. To provide adequate cooling to the system is the function of the intercooler and is supplied with pressure and temperature measuring instruments at the inlet and outlet. With the introduction of intercooler the volumetric efficiency has been increased to 100 %. In order to measure the air flow rate air stabilizing tank should stabilize the flow of air which is mandatory in this work. Actual volume of free air delivered by this compressor is 0.020 m3/sec with a work done of 77 N-m was the result obtained during test. Moreover

it was also found that the capacity to deliver air is about 1.02 kg/minute of this compressor, when the isothermal efficiency of the compressor is 45 %. If an intercooler is specially designed it has capacity of 2.049 kilojoules/kg of heat rejection.

Vijaykumar F Pipalia et al. [14], studied heating is an undesirable effect of the compression process at least as far as compressors is concerned and heat transfer is nature's way of driving systems towards stability. This has not only provided food for thought for researchers trying to understand its influence and quantify its effects, but also challenged designers to mitigate its impact and develop safe and efficient designs. Also this investigation is concerned with improving the efficiency of two stage reciprocating air compressor by providing water cooling source, radiator coolant and ethylene glycol. The experiments with air, water and different inter coolants are performed on a two stage double cylinder reciprocating compressor system.

Ravur et al. [15] find the compressed air usage is increasing quickly now a day. But the efficiency of compressor is low due to the many reasons like location, elevation, length of pipe lines, inter cooler performance, even atmosphere conditions also effects the efficiency of the compressor, which increases the power consumption of the compressor. The inter cooling is the best method to reduce the coolant. In this study we are extending the investigating by changing the temperature of the water and mixing of the different types of the coolants in water at different proportions. The selection of the coolants is depends upon their properties like miscibility, self-ignition temperature, boiling point and exploding range. For this investigation ethylene glycol and glycerol as coolants and a two stage reciprocating air compressor fitted with shell and tube heat exchanger is selected. This investigation shows the good arguments between the water, glycerol and ethylene glycol.

Tyagi et al. [16] showed intercooling of air compressors is necessary for increasing its efficiency. A shell and tube type of heat exchanger is particularly suitable as an intercooler between two compression stages of a compressor. A characteristic of heat exchanger design is the procedure of specifying a design, heat transfer area, pressure drops and checking whether the assumed design satisfies all requirements or not. The purpose of this research paper is to provide an easy and efficient way to design an intercooler for air compressor. This paper describes modeling of heat exchanger which is based on the minimization of heat transfer area and a flow chart is provided showing the designing procedure involved.

3. CONCLUSION

The performance of air compressor depends upon various operational and design parameters. These parameters include temperature, energy density, requirement of input power, energy release. The proper selection of coolants and maintaining recommended tolerances in compressor parts is essential for smooth functioning.

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