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INCREASE OF WEAR RESISTANCE OF CENTRIFUGAL COMPRESSOR SHAFT BUSHINGS.

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Abstract. This article contains a scientific novelty devoted to the study of the wear of bushing joints in shafts, particularly in compressed gas compressors. The aim of the article is to identify the various factors that contribute to the occurrence of faults that prevent the smooth operation of these compressors.

The methodology involves a comprehensive study of the bushing connections and proposes new compositions of materials for compressor bushings. These new materials would replace bronze, potentially by incorporating nonferrous elements into bronze alloys. This alteration aims to enhance the wear resistance of the bushings against friction, ultimately improving the efficiency and longevity of the compressor's operation.

This research could have significant implications for the field, potentially leading to advancements in compressor technology and improved performance in various industrial applications.

Keywords: *Compressor, friction force, shaft, bushing, friction, temperature, and wear resistance.*

Introduction.

Compressors are classified to compress gas and transport it to users. In this thesis issue with centrifugal type compressor bushing wear was analyzed, which manufactured By MAN turbo manufacturer. In this type of compressor industries suffer from vibration of compressors, which based on wearing, abrasion of shaft bushing materials.

Based on mentioned issue new composition material offered, which will replace original material by increasing wear resistance.

This thesis consists of 4 sections. In first section introduction to issue and actual solving results, in second section basics concepts to dynamic compressors, third section research methods and analysis of the results carried out by the proposed method, simulations, finally in fourth section offered results are described.

Basic consepts to dynamic compressors

Dynamic machines make use of rapidly rotating impellers to accelerate the gas to high speed. By changing the direction and decelerating the gas much of its kinetic energy is converted to pressure energy. Centrifugal compressors use the same operating principle as centrifugal pumps. They can be single stage or multiple stages. A casing can have multiple rotors, but the casing can be one stage in a multi-stage process. The word "stage" usually refers to the stage in a process.

The part of the centrifugal compressor that moves the gas is the impeller. The gas enters through the eye of the impeller and the rotating impeller accelerates the gas towards the outer rim. When the gas reaches the tip of the impeller blades it is at its maximum velocity and possesses the maximum amount of energy. As the gas leaves the impeller it is pushed into passageways called diffusers. The flow area in the diffuser is larger than that in the impeller so the velocity of the gas begins to decrease. This causes the gas pressure to increase. The diffuser converts the kinetic energy of the gas to increased pressure.

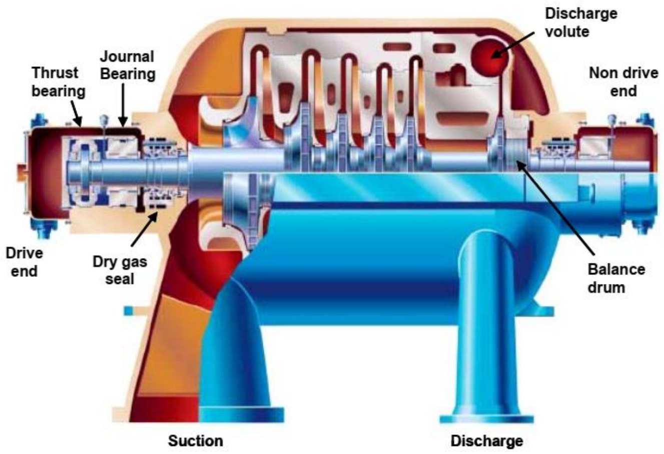

Figure 1. Centrifugal compressor

This compressor can be one stage in a process. The pressure difference between discharge and suction produces an axial thrust on the shaft in the direction of the suction. This force can be in the order of 10 tones in mainline compressors. The balance drum is used to oppose the axial thrust. The outboard side of the balance drum is connected to the suction by a balance line. The difference in pressure on the two sides of the drum will oppose most of the axial thrust acting on the shaft.

The internal compressor stages (and the rim of the balance drum) have simple labyrinth seals. The dry gas seals at the drive and non-drive end are described in the next pages. Because of the balance line both dry gas seals are only subjected to suction pressure.

Dry gas seals in compressors are similar in operation to mechanical seals on pumps. Instead of using a flushing liquid [as in pumps] dry gas seals use dry gas.

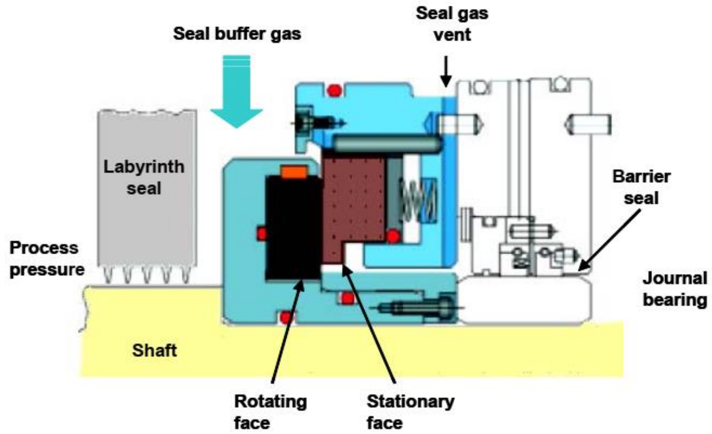

Figure 2. Dry gas seal shaft friction -contact area

The seal gas pressure is controlled slightly above the process pressure. A small amount of seal gas will leak through the labyrinth into the process. The rotating face of the seal has spiral grooves that drive the seal gas toward the shaft. This gas creates an aerodynamic wedge that separates the seal faces by microns. Seal gas must be perfectly clean and dry. The gas will exit through the seal gas vent.

The function of the barrier seal is to keep lubricating oil out of the seal. The seal has micron size clearances. Any oil or particulate contamination will ruin the seal.

The purpose of the Flash gas compressors are used in oil processing facilities to compress gases that is "flashed" from a separation of hydrocarbon liquid when the liquid flows from a higher pressure to a lower pressure separator. Flash gas compressors typically handle low flow rates and produce high compression ratios.

Research methods.

The wearing of centrifugal compressor shaft journal bushings made of bronze due to high temperature and friction is a common issue encountered in industrial applications. Centrifugal compressors commonly operate under conditions of elevated temperature owing to the compression of gases. Such thermal conditions may accelerate the degradation of bushing surfaces, particularly if the lubricating properties of the oil deteriorate in response to heat exposure.

The interaction between the shaft and the journal bushing, especially under conditions of substantial loads and high rotational speeds, can result in abrasive wear and surface deterioration. This frictional activity contributes significantly to the generation of heat, thereby exacerbating the wear phenomenon.

To resist such working environment special bronze alloys used at compressor thrust and journal bushings. The prevalent usage of bronze in journal bushings is attributable to its commendable mechanical attributes and resistance to corrosion. However, when subjected to high temperatures and substantial loads, bronze bushings may experience accelerated wear and potential deformation.

Above operation conditions of centrifugal compressors lead to wearing by friction, that result in vibration issue at compressors. Vibration transmitters detect high vibration and shutdown compressor, which lead to additional flaring of natural gas and environmental pollution. To prevent these happening changes should be done at compressor bushing and sleeve material by adding additional nickel and molybdenum alloys to increase it wear resistance and produce more durable material bushings.

The determination of axial force in a centrifugal compressor is an important aspect of its operation and maintenance. Axial force refers to the force acting along the axis of rotation of the compressor. It typically arises due to various factors such as impeller design, operating conditions, and mechanical interactions within the compressor. The axial force in a centrifugal compressor can have significant implications for its performance, reliability, and longevity. Excessive axial force can lead to issues such as increased wear and tear on components, vibration, and reduced efficiency. Therefore, it is essential to accurately determine and manage axial forces in centrifugal compressors. To determine axial force in a centrifugal compressor, engineers typically conduct analyses based on factors such as impeller geometry, fluid dynamics, and operating conditions. Experimental methods, numerical simulations, and analytical calculations may be employed to assess axial forces under different scenarios.

Once the axial force is determined, appropriate measures can be taken to address any issues or optimize the compressor's performance. This may involve adjusting operating parameters, modifying impeller design, or implementing maintenance strategies to mitigate excessive axial forces and ensure reliable operation of the centrifugal compressor.

In a centrifugal compressor, erosion can occur due to various factors such as the presence of abrasive particles in the gas being compressed, high gas velocities, or inefficient flow patterns within the compressor. Erosion typically affects components such as impeller blades, diffusers, and casings, leading to material loss and degradation of performance over time. When erosion is detected at the distance of the determined axial force, it suggests that the erosion is likely occurring in areas where the axial force is exerted on the components. This could indicate that the erosion is being exacerbated by the mechanical forces acting on the components due to the axial force. The detection of erosion at the location of the axial force highlights the importance of considering mechanical factors, such as axial force, in understanding and addressing erosion issues in centrifugal compressors. It also suggests that addressing the underlying causes of the axial force, such as imbalances in the compressor or inefficient flow patterns, may help mitigate erosion and prolong the life of the compressor components.

To address erosion in this scenario, strategies such as redesigning components to improve erosion resistance, optimizing flow patterns to reduce abrasive wear, and implementing erosionresistant coatings or materials may be considered. Additionally, regular inspection and maintenance to monitor erosion progression and take preventive measures can help minimize the impact of erosion on compressor performance and reliability.

The provided statement outlines a specific action taken to increase the friction resistance of a part, specifically the bushing in a centrifugal compressor. There was likely an observed problem with friction in the bushing of the centrifugal compressor, which could lead to issues such as wear, heat generation, or reduced efficiency. A contact strip was chosen as a solution to address the friction issue. Contact strips are often used to modify surface properties and improve friction characteristics in mechanical systems. The selected contact strip was impregnated with a composition containing nickel powder. Nickel powder is known for its ability to enhance surface hardness and wear resistance when applied to materials. After impregnation with the nickel powder composition, the contact strip was reinforced using laser technology. Laser reinforcement involves using a laser to heat and bond materials, often resulting in improved mechanical properties and durability. By impregnating the contact strip with nickel powder and reinforcing it with laser technology, the goal was to enhance the friction resistance of the bushing in the centrifugal compressor. This process likely aimed to reduce wear and improve the overall performance and longevity of the compressor system. Overall, this approach demonstrates a proactive method to address friction-related issues in mechanical systems, utilizing advanced materials and manufacturing techniques to optimize performance and reliability.

The research conducted based on the reinforcement of the centrifugal compressor bushing material yielded significant improvements in resistance to abrasion. Specifically, the resistance to abrasion increased by up to 2.5 times compared to the material's original state or previous performance. This outcome suggests that the impregnation with nickel powder composition and reinforcement with laser technology effectively enhanced the durability and wear resistance of the bushing material. The nickel powder likely contributed to increased hardness and wear resistance, while the laser reinforcement further improved the bonding and mechanical properties of the material. Achieving 2.5 times increase in resistance to abrasion indicates a substantial improvement in the performance and longevity of the centrifugal compressor bushing. It implies that the implemented solution successfully addressed the underlying friction-related issues and mitigated the effects of wear and tear, ultimately leading to a more reliable and efficient operation of the compressor system.

This research outcome underscores the importance of utilizing advanced materials and manufacturing techniques to enhance the performance and durability of critical components in industrial machinery such as centrifugal compressors. It also highlights the effectiveness of proactive measures in mitigating wear-related problems and optimizing the reliability of mechanical systems.

The prevalent usage of bronze in journal bushings is attributable to its commendable mechanical attributes and resistance to corrosion. However, when subjected to high temperatures and substantial loads, bronze bushings may experience accelerated wear and potential deformation. Alternative materials exhibiting superior resistance to heat and wear, such as babbitt alloys or ceramic coatings, warrant consideration. Augmenting the lubrication system to ensure adequate oil flow and cooling to the bushing surfaces is imperative, as it serves to mitigate frictional forces and thermal effects.

Application of surface treatments or coatings to the bushing surfaces represents a viable strategy for enhancing wear resistance. Techniques such as thermal spraying can facilitate the deposition of robust coatings such as chromium carbide or tungsten carbide.

Design optimization of the bushing housing and shaft geometry can help minimize stress concentrations and optimize load distribution, thereby mitigating wear on the bushing surfaces.

Calculating stress and force on a centrifugal compressor shaft and bushing connection point involves several factors, including the operating conditions, geometry of the components, material properties, and applied loads.

Stress analysis conducted at CAESAR II simulation software and force applied to compressor shaft bushing connection regarding to API 617 standards and shaft seal John Crane Dry gas seal first critical lateral speed 1034 RPM and last critical speed 13801 rpm given to compressor after replacing composition of shaft bushing sleeve connection. Modern bronze is typically 88 % copper and about 12 % tin. After this simulation it was identified that replacing bronze material composition and adding nickel alloy by 1 % increases temperature resistance of material and increases torsional critical strength.

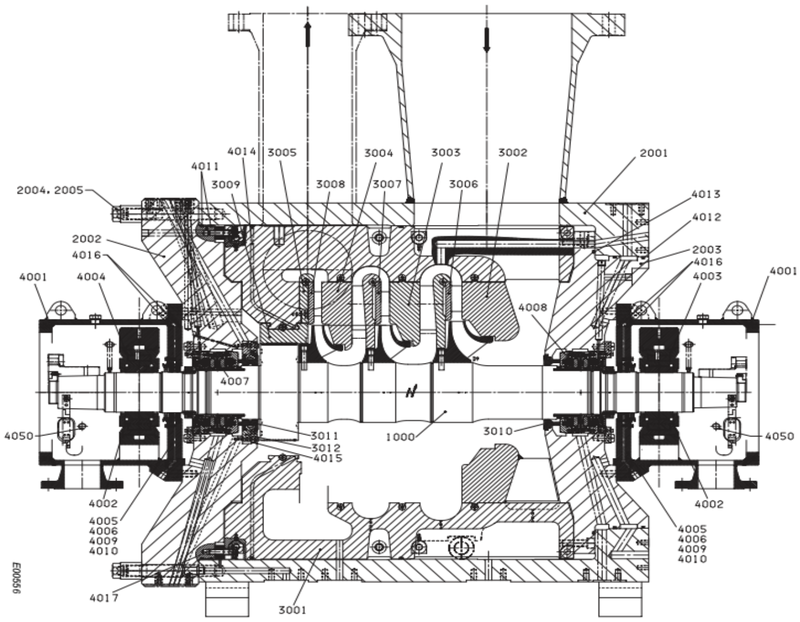

Figure 3. Shaft end overview of bushing, sleeve.

Table 1. Compressor simulation data sheet value from CAESAR II

Centrifugal compressor data sheet (API617-6th)	Values	Units
SPEEDS Max Cont.	11646	RPM
Lateral Critical speed (Damped)		
Torshinal critical speed 1st critical 2nd critical 3rd critical 4th critical	 1034 3447 6935 13801	RPM
Vibratin	27	µm
Casing thicknes	70	mm
Corrosion allowance	3.2	mm

Conclusion

1. Axial force has been determined.
2. The process of erosion was detected at the distance of the determined axial force.
3. To increase the friction resistance of that part, the selected contact strip is impregnated with nickel powder composition and reinforced with laser.
4. As a result of research conducted based on reinforcement, resistance to abrasion increased up to 2.5 times.

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