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How to Improve Fatigue Life and Residual Stress in Compressor Reeds through Shot Peening

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Abstract: Numerous industrial areas involve the utilization of shot peening as a well-known surface enhancement method for increasing the fatigue life and residual stress of cyclically loaded crucial parts. This study examines the effects of shot peening on compressor reeds that can lengthen their life cycle with an accelerated rate of residual stress thereby improving reliability and performance of entire compressor system. The paper explains the principles behind shot peening, its influence on materials, and some specific advantages that it gives to thin reed compressors. Materials selection, parameters for shot peening and testing methods are described as experimental methods. Results from residual stress analysis show how much more efficient shot peening makes compressor reeds tough and reliable. Moreover, this paper provides insight into practical aspects, difficulties faced in practice and directions for further research when applying shot peeing to compressor's reed components.
Keywords: Shot Peening, Compressor Reed, Residual Stress, Surface Enhancement, Material Properties.

I. INTRODUCTION

Compressor reeds are vital components in reciprocating compressors, responsible for sealing gas passages and managing fluid flow within the system. These reeds experience substantial cyclic loading during operation, which can lead to fatigue failure over time. Improving the fatigue life and residual stress of compressor reeds is crucial for enhancing the reliability and longevity of compressor systems. Shot peening, a surface treatment technique, has proven to be a promising method to achieve these goals.

II. PRINCIPLES OF SHOT PEENING

Shot peening is a cold working process where the surface of a material is bombarded with small spherical media, typically composed of steel, ceramic, or glass, at high velocities. This process causes plastic deformation on the surface, generating compressive residual stresses while enhancing surface hardness and resistance to fatigue crack initiation and propagation.

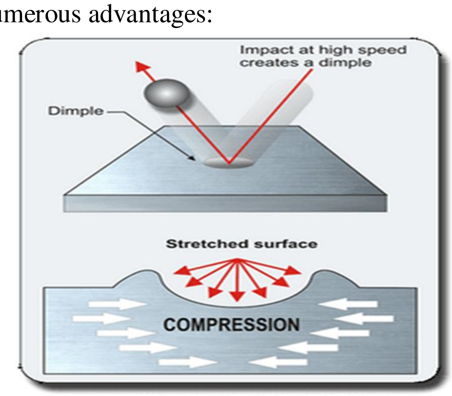
III. EFFECTS OF SHOT PEENING ON MATERIAL PROPERTIES

Shot peening brings about several beneficial changes in material properties, including:

1) Generation of compressive residual stresses.
2) Work hardening and improvement in surface hardness.
3) Reduction of surface roughness and microcracks.
4) Enhancement of fatigue strength and resistance to corrosion.

IV. APPLICATION OF SHOT PEENING TO COMPRESSOR REEDS

For compressor reeds, shot peening offers numerous advantages:



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1) Increased fatigue life: The compressive residual stresses induced by shot peening inhibit crack initiation and propagation, thereby extending the fatigue life of compressor reeds.
2) Improved sealing performance: Enhanced surface hardness and reduced surface roughness contribute to better sealing performance, minimizing gas leakage.
3) Enhanced durability: Shot peening helps reduce the effects of fretting wear and corrosion, prolonging the service life of compressor reeds.

The example demonstrates the residual stress profile resulting from shot peening. Illustrated are significant variations in stress with depth, encompassing four key aspects: (ref.1)

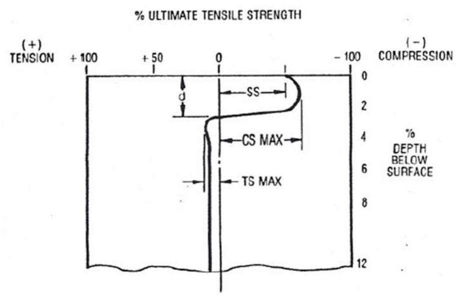


Fig.1

1. Surface Stress: The surface stress exhibits a superficial compressive nature.
2. Maximum Compressive Stress (CS max): This denotes the peak compressive stress encountered, typically found just beneath the surface.
3. Depth Stress: Stress diminishes as depth increases, crossing over from compressive to tensile.
4. Maximum Tensile Stress (TS max): This represents the highest tensile stress endured, usually occurring at the material's surface. Such stress profiles are crucial in understanding material resilience and preventing catastrophic failures.

John Almen proposed that any external tensile loads must first overcome residual compression before initiating cracks. Additionally, Almen noted that certain parts, such as springs, already harbored residual tensile stresses from manufacturing, which, when compounded with applied loads, accelerated early failure. He contended that Shot Peening reversed surface residual stress from tension to compression, resulting in significant enhancements in fatigue life. Despite opposition from the academic community, which initially disregarded residual stresses in engineering calculations, the emergence of Fracture Mechanics eventually validated Almen's stance. Presently, not only do we acknowledge residual stresses, but we also possess the capability to measure them accurately.

V. EXPERIMENTAL METHODOLOGY

The experimental study involves the following steps:

1) *Material selection:* The material selected is flapper valve steel (Sandvik 7C27Mo2), known for its high strength, fatigue strength, excellent surface finish, low level of non-metallic inclusion, good flatness, and wear resistance.

CHEMICAL COMPOSITION (NOMINAL)%

C	Si	Mn	P max	S max	Cr	Mo
0.38	0.4	0.6	0.025	0.010	13.5	1.0

2) *Shot peening parameters:* Determination of optimal shot peening parameters, including shot size, velocity, coverage, and duration.

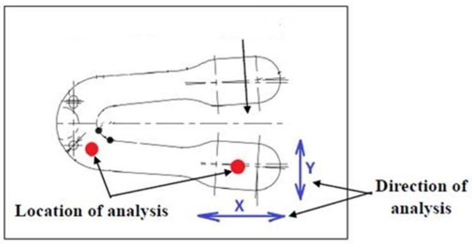
TABLE 1. Shot peening process parameters.

Parameter	Value
Shot size	G.B 0.1-0.2
Air Pressure	3.0 Kg/cm^2 max
Process time	20 s
Peening intensity	0.12 mm N

Peening pressure	4.8 bar (70 psi)
Coverage	100%
Nozzle ID	8 mm (0315")
Angle incidence	90°

3) *Residual stress analysis:* Employing techniques such as X-ray diffraction or hole-drilling method to measure residual stresses before and after shot peening.

Residual Stress Measurement location & direction of analysis



Location & direction of analysis

- Thickness of the part is 0.508 mm (0.02")
- Shot peening coverage area 100% both side.
- Material :- flapper valve steel

The purpose of this study is to measure residual stresses on compressor valve (reed) samples by X ray diffraction method.

- Presentation on X ray Diffraction methodology used for measurement of residual stresses in compressor Reed samples
- Stress measurements are done by X-ray diffraction. This method allows a non-destructive measurement of the deformation of the surface layers of polycrystalline materials by allowing calculation of up to residual stresses in the material.

X-ray diffraction measurements allow obtaining information in extreme workpiece surface. Measure surface stresses are non-contact and are non-destructive. However, with regard to the characterization of the material fatigue, by taking account of the residual stresses, the surface stresses are not sufficient. Factors that influence the fatigue behaviour are microstructure, surface appearance and residual stresses within the material. The surface stress condition booting the first fault, and constraints underlay determine fault propagation. It is therefore important to characterize the complete profiles of residual stresses.

In the case of realization of residual stress profiles, measurements are carried out simultaneously with passes of material removal by chemical means. This method allows you to remove layers of material without altering the surface and especially without introducing surface hardening and changing residual stresses.

			value (MPa)
Reed	1	X	-1036 ± 24
		Y	-1070 ± 11
	2	X	-989 ± 26
		Y	-1074 ± 10

VI. RESULTS AND DISCUSSION

The analysis of residual stress indicates that shot peening significantly enhances the performance of compressor reeds. Shot peened reeds show a marked improvement in fatigue life and exhibit higher levels of compressive residual stress when compared to untreated reeds. This section explores the mechanisms behind these improvements and their implications for the reliability of compressor systems.

VII. LIFE PREDICTION

The Paris equation describes the stage II crack growth behavior during fatigue in metallic materials and is used to evaluate crack propagation life. In this equation, 'da/dN' represents the crack growth rate, while 'ΔK' is the range of stress intensity factor (ΔK = Kmax - Kmin). The constants 'C' and 'n' are the Paris constants. With the introduction of the concept of crack closure by Elber, the Paris law was modified to use 'ΔKeff' instead of 'ΔK'. This modification accounts for the higher crack opening levels in peened components, resulting in a lower 'ΔKeff'. Here, 'Kop' is the crack opening stress intensity factor after shot peening, leading to a reduced crack growth rate in peened components (da/dN)p. The modified Paris law is expressed as (da/dN)p = C(ΔKeff)^n.

VIII. PRACTICAL CONSIDERATIONS AND CHALLENGES

Implementing shot peening for compressor reeds involves several practical considerations such as the availability of appropriate equipment, maintaining process control, and meeting surface finish requirements. Challenges like peening-induced surface roughness and potential material degradation must be addressed through process optimization and stringent quality control measures.

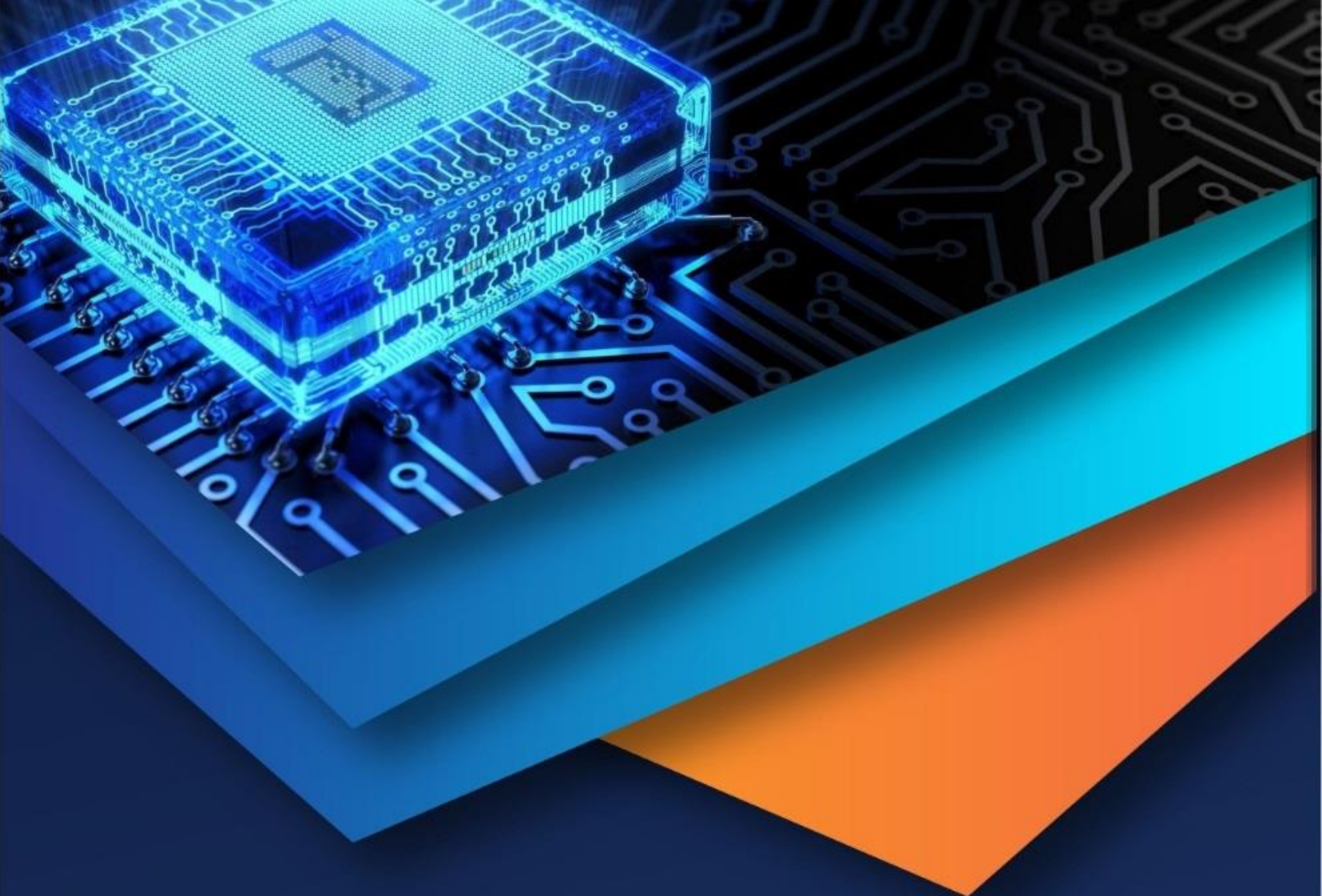
IX. CONCLUSION AND FUTURE DIRECTIONS

In conclusion, shot peening is an effective method for enhancing the fatigue life and residual stress of compressor reeds, thereby boosting the reliability and performance of compressor systems. Future research could focus on developing new shot peening techniques, optimizing process parameters for specific compressor applications, and exploring the combined effects of shot peening with other surface treatment methods.

REFERENCES

[1] "Impact", Fall 1989, Metal Improvement Company, Bloomfield, Connecticut.
[2] "John S. Eckersley, ushing shot peening to multiply the life of compressor components"
[3] https://istsurface.com/resources/abrasive-blasting-equipment/shot-peening/
[4] https://img.antpedia.com/standard/pdf/T06/1612/SAE%20J2441-2000_317.pdf
[5] "SAE J2441, Issued 2000-08, Surface Vehicle standard.
[6] "SAE AMS2430, Issued 1948-09, AEROSPACE MATERIAL SPCIFICATION
[7] SHOT PEENING A N D ITS I M P A C T O N FATIGUE LIFE OF ENGINEERING COMPONENTS R . K . Pandey M. N. Deshmukh, Department of Applied Mechanics, Indian Institute of Technology, Delhi, India
[8] ARAI -Automotive Research Association of Indi, Research Institute of the automotive industry with Ministry of Heavy Industries, Govt. of India

This research paper provides valuable insights into the application of shot peening for enhancing the performance of compressor reeds, contributing to the advancement of surface engineering technologies in the field of compressor systems.



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