Impact Factor:

ISRA (India)	= 6.317	SIS (USA)	= 0.912	ICV (Poland)	= 6.630
ISI (Dubai, UAE)	= 1.582	РИНЦ (Russia)	= 0.191	PIF (India)	= 1.940
GIF (Australia)	= 0.564	ESJI (KZ)	= 8.100	IBI (India)	= 4.260
JIF	= 1.500	SJIF (Morocco)	= 7.184	OAJI (USA)	= 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online)

Year: 2024 Issue: 12 Volume: 140

Published: 22.12.2024 http://T-Science.org

Issue Article

Denis Chemezov
Vladimir Polytechnic College
MEng, Honorary Worker of the Education Field of the Russian Federation, Academician of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
vpk-science@yandex.ru

Aleksandr Tsygankov
Vladimir Polytechnic College
Student, Russian Federation

Danil Ilyushin
Vladimir Polytechnic College
Student, Russian Federation

Danil Bubnov
Vladimir Polytechnic College
Student, Russian Federation

Vladislav Markin
Vladimir Polytechnic College
Student, Russian Federation

Dmitriy Ishanov
Vladimir Polytechnic College
Student, Russian Federation

Andrey Stepanov
Vladimir Polytechnic College
Student, Russian Federation

Matvey Alekseev
Vladimir Polytechnic College
Student, Russian Federation

Kirill Gerasimov
Vladimir Polytechnic College
Student, Russian Federation

NATURAL VIBRATIONS OF THE IMPELLER AND THEIR EFFECT ON THE PRESSURE DISTRIBUTION OVER THE BLADE AREA

Abstract: *The pressure change on the surface of the impeller blade at different values of its natural vibrations is considered in the article. It is noted that with high natural vibrations of the impeller, the pressure on the surface of the blade can only be positive or negative. At the same time, natural vibrations at a frequency of 1300 Hz cause a change in pressure along the blade length from negative to positive values.*

Key words: *impeller blade, natural vibrations, pressure.*
Language: *English*
Citation: Chemezov, D., et al. (2024). Natural vibrations of the impeller and their effect on the pressure distribution over the blade area. *ISJ Theoretical & Applied Science, 12 (140)*, 267-269.
Soi: http://s-o-i.org/1.1/TAS-12-140-31 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2024.12.140.31
Scopus ASCC: *2201.*

Introduction

The impeller is a rotating component of a centrifugal pump that accelerates the fluid away from the center of rotation, thereby transferring energy from the motor that drives the pump to the fluid that the pump moves [1-2]. The impeller has several blades that provide fluid movement.

During operation of the pump, the impeller may be subject to natural vibrations [3-4]. The magnitude of natural vibrations of the impeller depends on the speed of rotation of the impeller and the number of blades on it. Natural vibrations are an undesirable phenomenon, because they can cause destabilization of the operating mode and damage to the device [5-10]. The calculation of natural vibrations and their subsequent analysis to determine the possible resonance are performed in special engineering applications.

Using the example of a computer model of an eight-blade impeller, a modal analysis of the change in pressure on the blade surface at different natural vibration frequencies was performed.

Materials and methods

The eight-blade impeller was subjected to frequency analysis. The electronic model of the impeller was given the properties of an aluminum alloy. This alloy reduced the weight and provided sufficient strength of the impeller. The theta angle was assumed to be 0.7854 degrees. A constant force of 5 kN was applied to the surface of the impeller blades. The configuration of the impeller blade is shown in the Fig. 1.

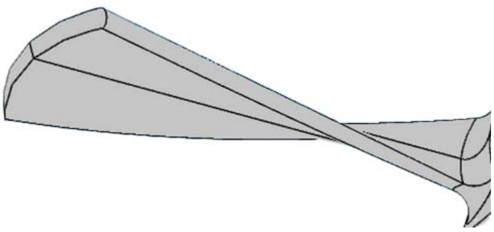

Figure 1. The configuration of the impeller blade.

Natural vibrations of the impeller were calculated at various frequencies from 220 to 3900 Hz. The calculated pressure values were fixed along the length of the impeller blade at each natural vibration frequency.

Results and discussion

The pressure change along the length of the impeller blade with various natural vibrations is shown in the Fig. 2.

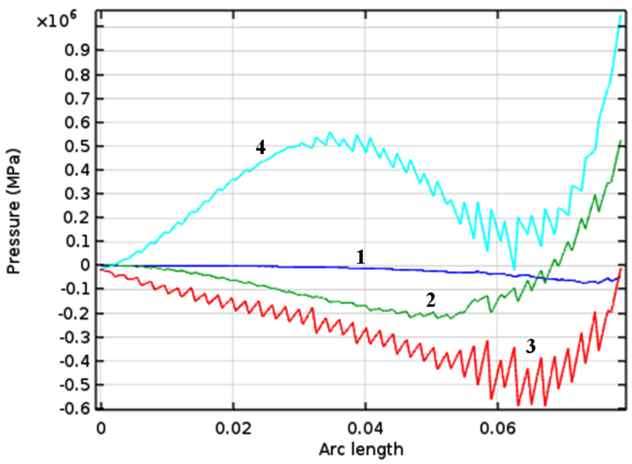

Figure 2. Pressure change along the length of the impeller blade with various natural vibrations: 1 – 220 Hz, 2 – 1300 Hz, 3 – 1500 Hz, 4 – 3900 Hz.

It is noted that the effective pressure on the length of the impeller blade can be positive and negative, depending on the magnitude of the natural vibration frequency. At a natural vibration frequency of 220 Hz, the pressure change occurs smoothly from a positive value to a negative value on the pump hub side. The difference in pressure change at this frequency is no more than 100 GPa. Natural vibrations of the impeller at a frequency of 1300 Hz lead to an increase in the effective pressure along the blade length. There is a significant change in pressure, both in value and in the nature of the impact (negative and positive values). The maximum positive pressure is fixed from the hub side. Only negative pressure occurs at a natural vibration frequency of 1500 Hz. At the same time, the maximum pressure is noted not at the hub, but at some length of the blade (about ¼ of the blade length) from it. Natural vibrations of the impeller at a frequency of 3900 Hz cause only positive pressure along the blade length. The maximum pressures were determined at the middle of the blade length and at the hub.

Conclusion

Thus, based on the analysis of the results of the study, the following conclusions can be drawn:

1. Along the length of the impeller blade, both positive and negative pressure acts, which varies in increasing and decreasing function.

2. The nature of the pressure action on the impeller blades depends on the magnitude of the natural vibration frequency. It is noted that at a natural vibration frequency of 1500 Hz, only negative pressure acts on the impeller blade, and at a frequency of 3900 Hz, only positive pressure acts.

References:

1. (2024). *Impeller*. Retrieved 09.12.2024 from https://en.wikipedia.org/wiki/Impeller
2. Trulev, A. V., & Trulev, Y. V. (1998). Theoretical fundamentals of the operation of impeller machines on multicomponent mixtures. *Chem. Petrol. Eng*., 34, 270-276.
3. (2024). *Natural frequency*. Retrieved 09.12.2024 from https://en.wikipedia.org/wiki/Natural_frequency
4. Hvatov, A. (2019). The symmetrical cell eigenfrequency method for periodic structure stop-band definition. *Vibroengineering PROCEDIA*, Vol. 25, 100-105.
5. Bogrekci, I., et al. (2024). Enhancing Steel Wheel Ventilation Efficiency Through Multi-Objective Optimization. *Arabian Journal for Science and Engineering*, 49 (8), 11661.
6. Píštěk, V., Kučera, P., Fomin, O., Lovska, A., & Prokop, A. (2020). Acoustic Identification of Turbocharger Impeller Mistuning-A New Tool for Low Emission Engine Development. *Applied Sciences*, 10(18), 6394.
7. Al-Obaidi, A. R. (2021). Analysis of the Effect of Various Impeller Blade Angles on Characteristic of the Axial Pump with Pressure Fluctuations Based on Time- and Frequency-Domain Investigations. *Iran. J. Sci. Technol. Trans. Mech. Eng.*, 45, 441-459.
8. Chemezov, D., et al. (2024). Pressure distribution curves on the surfaces of the impeller blades and the performance of the centrifugal pump. *ISJ Theoretical & Applied Science*, 02 (130), 236-242.
9. Cui, B., et al. (2020). Influence of Cutting Angle of Blade Trailing Edge on Unsteady Flow in a Centrifugal Pump under Off-Design Conditions. *MDPI Applied Sciences*, 10 (2020), 2, 580.
10. Abood, M. H., et al. (2012). Stress Analysis of Centrifugal Fan Impellers. *Al-Rafidain Engineering Journal (AREJ)*, 20, 6, 60-69.