Vol. 5, No. 1, April 2024, page 1-13
JTTM: Jurnal Terapan Teknik Mesin
p ISSN 2721-5377| e ISSN 2721-7825
http://jurnal.sttmcileungsi.ac.id/index.php/jttm

Using a frequency vibration approach, examine the impact of screw rotor clearance on the screw housing in an 11kW compressor

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Article Submit: 16/12/2022 Article Revision: 12/01/2023 Article Accepted: 26/03/2023

Abstract: One of the industrial devices required for today's production and productivity is a screw compressor. Pneumatic systems are typically used in industrial machinery with the assistance of compressed air provided by a compressor unit. The functioning system of the compressor needs to be given careful consideration. It is imperative to perform maintenance and prevent damage to air screw compressor machines, particularly to rotary screw air compressors. Shaft issues can lead to decreased air supply flow or unstable air pressure, which interrupts the production line. This study used the frequency analysis method to measure vibration values at the screw compressor housing point using an accelerometer sensor and a Fast Fourier Transform (FFT) tool. The vibration values were then discussed against the rotor clearance from the ideal output on male and female screw compressor rotors. At each predefined point, the analyzer rotates in the X, Y, and Z axes at 1500 rpm. According to research, the clearance is determined to be 0.03, 0.05, and 0.08. In this study, the vibration data of 0.03 and 0.05 frequently show the high frequency sample values of 1x 25 Hz, 2x 50 Hz, and 3x 75 Hz; at the vibration frequency range value of 0.08, none exist. Because the screw rotor compressor's end housing lacks a frequency graph with 1x, 2x, and 3x rpm at each point and axis, the results indicate that the optimal rotor clearance value is at a distance of 0.08.

Keywords: Vibration analysis; screw compressors; rotors clearances; Fast Fourier Transform (FFT)

1. INTRODUCTION

The compressor is a crucial piece of equipment in today's completely automated industry for accelerating the production process. The male and female rotor sections of the Airend, which both revolve on the screw housing axis and have a very important clearance between the rotor and the screw housing wall, are the main source of issues with screw type compressors [1].

Frequent usage of the compressor engine will cause the clearance on the male and female rotors to alter; if the rotor clearance is not accomplished correctly, friction will occur, leading to overheating and wear [2] to the two rotors, stretching the rotor clearance (rotary gap) and causing the rotors to collide, preventing them from rotating. This noise is produced inside the screw housing. Torsional resonance, imbalance, failure, and other factors are the causes of the vibrations produced by the revolving airend screw compressor [3].

The screw type compressor has two rotors in one chamber that are shaped like intertwined helical lobes and rotate in the direction of one another at a precise distance from the casing [4]. Every rotating machine produces vibrations as a result of the dynamics of the machine, including the balance and alignment of the rotating parts [5]. Because there is a space between the male and female rotors in screw compressors, high vibrations should be taken seriously when there is low or high axial movement. In actuality, a variety of mechanisms as well as potentially additional elements like vibration, errors in torque transmission, or other sporadic operational irregularities, have an impact on clearances [5] . When the vibration is too high, the compressor does not recommend excessive axial movement or a rotation speed faster than critical when there is little clearance between the rotors [6].

The primary method of studying rotary compressors, which are contemporary industrial devices, is by optimizing both theoretical and real rotor profiles [7]. The working distance must be changed for optimization. Since the high pressure fluid in the screw compressor shell raises the temperature at the discharge end, there is a chance that the interlocking rotor surfaces will be disrupted and leaks may occur [8]. Lubricants are crucial for keeping the compressor maintained and in good working order. The user's manual and the working period schedule for each kind of spare part are typically consulted when performing routine maintenance on screw compressors. Always replace consumable parts, according to the standard screw compressor user's manual. periodically by modifying the work schedule for every component.

A machine maintenance policy is crucial since regular maintenance and performance monitoring of the compressor are necessary. Because predictive maintenance is so much more cost-effective than reactive maintenance, it is the preferred approach when dealing with unexpected damage that renders a machine inoperable during production [9]. The vibration frequency generated by the screw's rotation can be used in tests to assess the screw compressor's condition. At Mercu Buana Meruya University, vibration research has long been conducted with a Fast Fourier Transform (FFT) analyzer [10], such as the Frequency Response Function (FRF) method for identifying nonlinearity, followed by wavelet packet decomposition analysis.

Screw compressor vibration characteristics under different rotational conditions [11] Can there be an imbalance with the screw compressor? [12],The amplitude manifests at 1x revolutions per minute (RPM), which explains why. In addition, it is misaligned because the vibrations it generates are higher than the typical 2x revolutions per minute (RPM) situation [13]. Studying the Fast Fourier Transform (FFT) technique was done by [14] with the title Energy audit analysis on the 11KW screw compressor machine as a preventative maintenance effort, vibration analysis on the screw compressor, needle bearing and the impact of belt tension on the rotor rotation of the screw compressor, and bump tests on bearings, screws, and compressor pulleys with and without base. This study focused on the air end screw on the compressor at rotor clearances of 0.03 mm, 0.05 mm, and 0.08 mm with a motor rotation of 1500 rpm. It was conducted using a screw type compressor machine and employed time domain, frequency domain, signal statistics, and wavelet transformation techniques.

2. METHOD

The literature review, interviews, and observation research methods are used to gather the required data and information. Nevertheless, the test flowchart in Figure 1 below provides a brief explanation of how to obtain the data results.

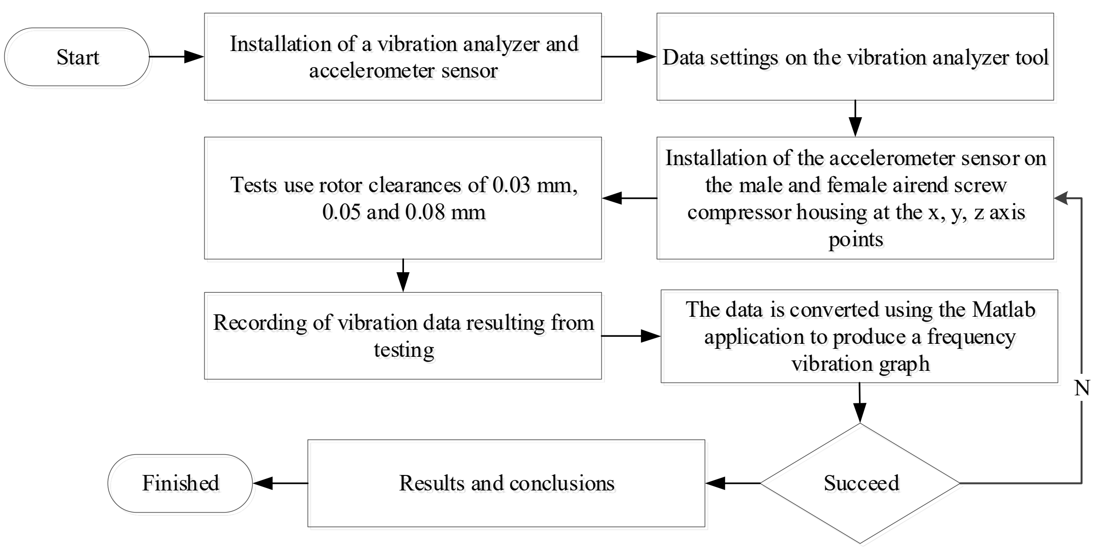

Figure 1. Research flow

The preparation of the measuring instruments and the screw compressor machine test apparatus is the first step in the research methodology. The rotation speed control device is then tested in order to complete this. The mechanical engineering vibration laboratory at Mercu Buana University's Meruya Campus served as the testing site. Meruya Sel., kec. Kembangan, Jl. Raya, RT.4/RW.1, Jakarta, Special Capital Region of Jakarta 11650. A screw type compressor with an 11 kW power output was used in this study, as depicted in Figure 2. Table 1 lists the screw compressor's specifications. As seen in Figure 3, data is collected using an accelerometer coupled to an Ono Sokki FFT analyzer as a vibration sensor [15].

Figure 2. 11 kW screw compressor.

Table 1. Screw compressor specifications.

NAME	DIMENSION	UNIT
Working Pressure Workplace	7,5	Bar(e)
	109	Pound per square inch gauge (psig)
Capacity FAD	30,7	Liter per second (l/s)
	110,5	Cubic meter per hour (m^3/h)
	64,8	Cubic feet per minute (cfm)
Motor Power	11	Kilowatt (kW)
	15	Horse Power (HP)
Noise Level	62	Decibel Adjusted (dbA)
Weight	293	Kilogram (kg)

Figure 3. ONO SOKKI FFT ANALYZER and accelerometer sensor.

The following are the details of the instrument from Figure 3 that was utilized for the measurements:

- Accelerometer sensor to measure vibration response
- Type: piezoelectric accelerometer
- Conversion sensitivity ratio:
- Frequency range: 2 – 10,000 Hz
- Resonance frequency: >20 khz
- Transverse sensitivity: <5%

- Accelerometer cable: 1.5 m
- CF-3600A (4-ch) portable FFT type analyzer with touch panel computer that utilizes simultaneous analysis and recording. Range [16] the maximum frequency that can be analyzed is 40 khz.
- FFT is used as a spectrum analyzer and data acquisition.

Before gathering vibration data, the FFT Analyzer tool is set up. It is configured to use channel 3 and the "time domain" data type, which will later yield txt data of amplitude versus time that will be converted into frequency using the Matlab 2018 application; the span used is up to 20KHz. In order to gather vibration data, we first identify the bearing housing point from which the data will be collected. We also identify the direction of the X, Y, and Z axes (horizontal, axial, and vertical, respectively), as shown in Figure 4.

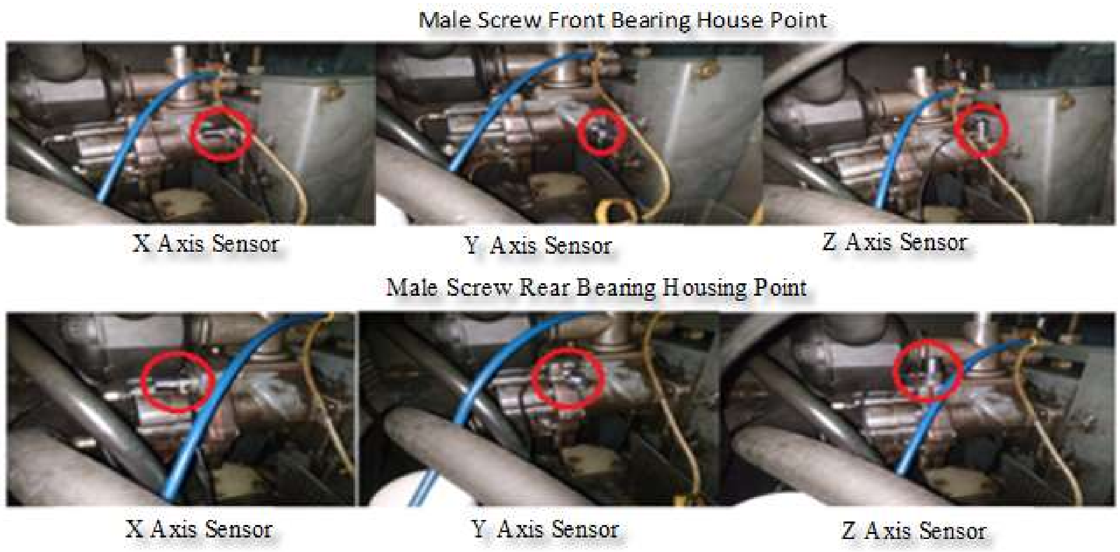

Figure 4. Accelerometer Sensor Points for X, Y & Z data collection

Figure 5 screw compressor machine was running at the motor speed with a fixed rotation of 1500 rpm when the vibration data was collected. Four points on the bearing housing are where the screw compressor rotor data is taken on the three axes (X, Y, and Z). The GAP Clearance distance is set at 0.03, 0.05, and 0.08 mm.

Figure 5. GAP Clearance distance settings 0.03, 0.05, 0.08 mm

p ISSN 2721-5377 | e ISSN 2721-7825
DOI 10.37373/jttm.v5i1.405

Using the three axes of the bearing housing, the vibration data is obtained in txt format at each point. The txt data type is then converted using the Matlab 2018 application to produce a frequency data graph, as shown in Figure 6.

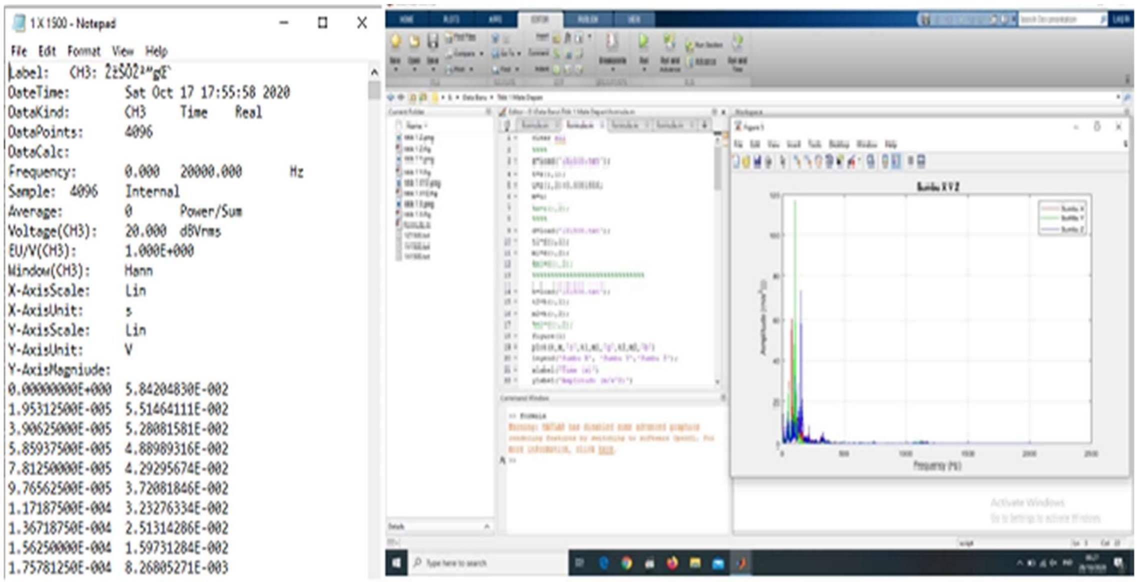

Figure 6. Data conversion from TXT to the Matlab 2018 application.

3. RESULT AND DISCUSSION

The frequency graph results are obtained by processing the text data (txt) from the FFT analyzer measurements using the MATLAB application software. Next, we obtain visual information.

3.1 Vibration data at point 1 (Front Rotor Male)

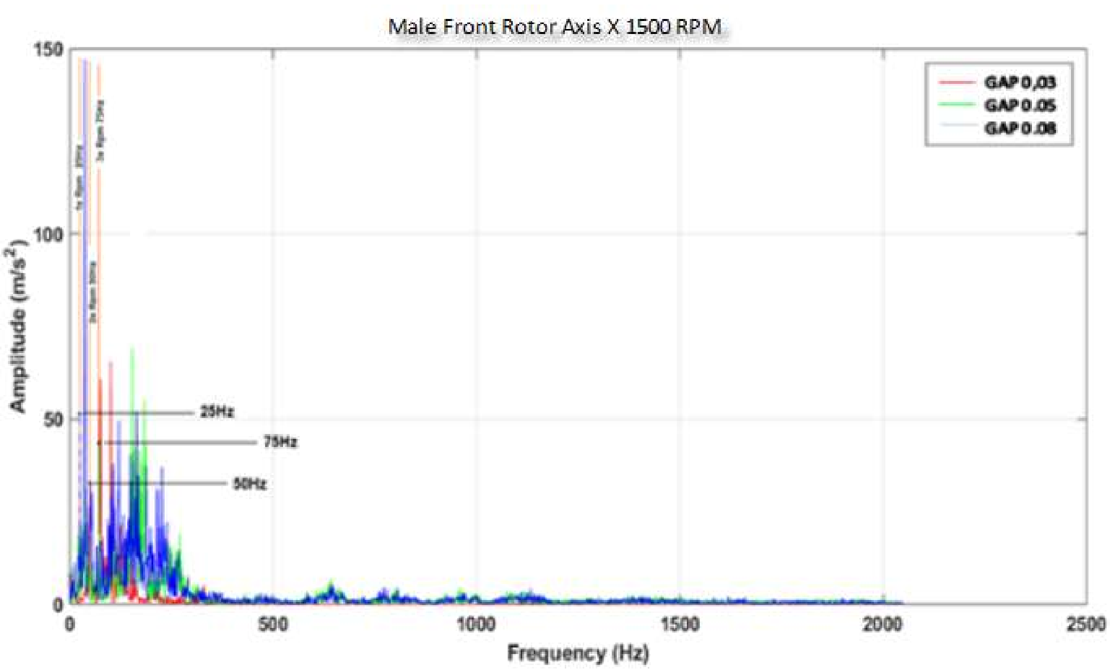

Figure 7. Third front rotor X-axis data for GAP Clearance distance.

Figure 7 front rotor male vibration data at point 1 on the in the meantime, it appears at a frequency of 3x rpm 75 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

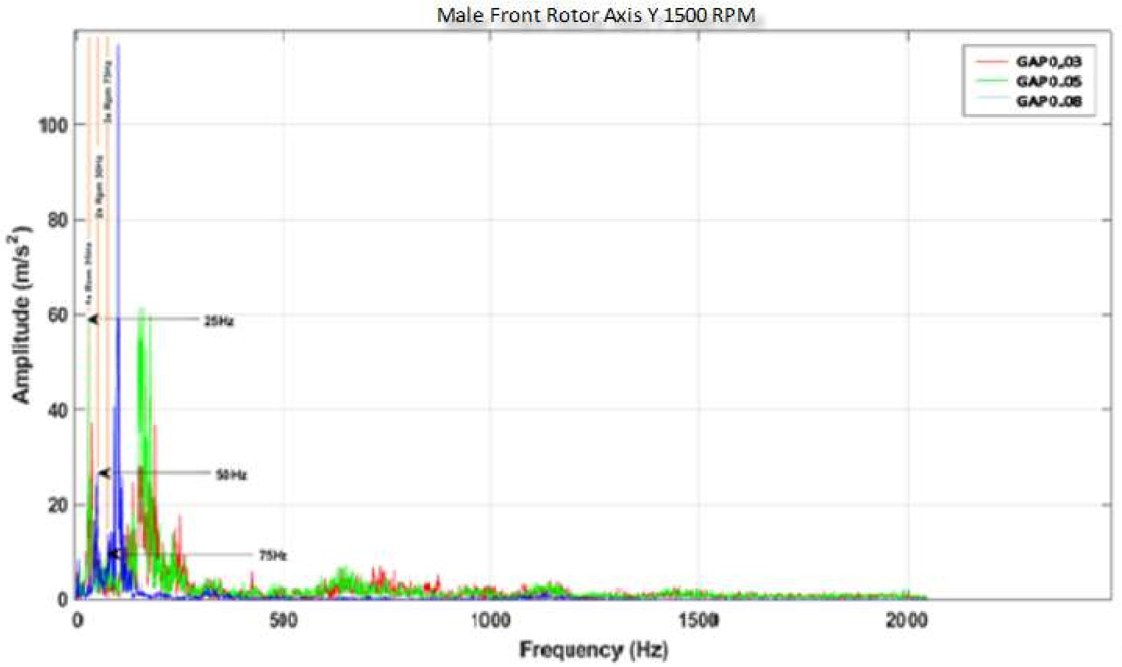

Figure 8. Y-axis data for the third front rotor male GAP Clearance distance.

Figure 8 vibration data at point 1 (the front rotor male on the Y axis) reveals that GAP Clearance occurs at two times the frequency of 50 Hz and 75 Hz, with a distance of 0.03. In the meantime, it appears at a frequency of 1x rpm 25 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

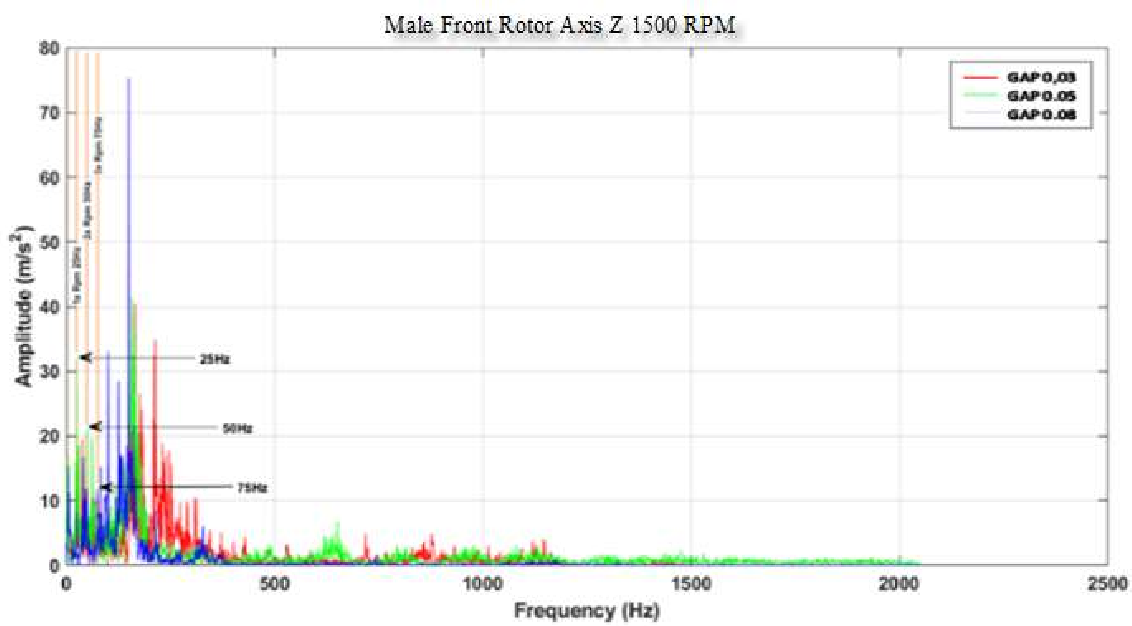

Figure 9. Third front rotor male Z axis data GAP Clearance distance.

Figure 9 vibration data at point 1, or the front rotor male on the Z axis, reveals the presence of GAP Clearance at a frequency of 1x rpm 25 Hz and a distance of 0.03. In the meantime, it appears at a frequency of 2x rpm 50 Hz and 3x rpm 75 Hz at a distance of 0.05 GAP Clearance, and it does not appear at a distance of 0.08 GAP Clearance.

3.2 Vibration data at point 2 (rear rotor male)

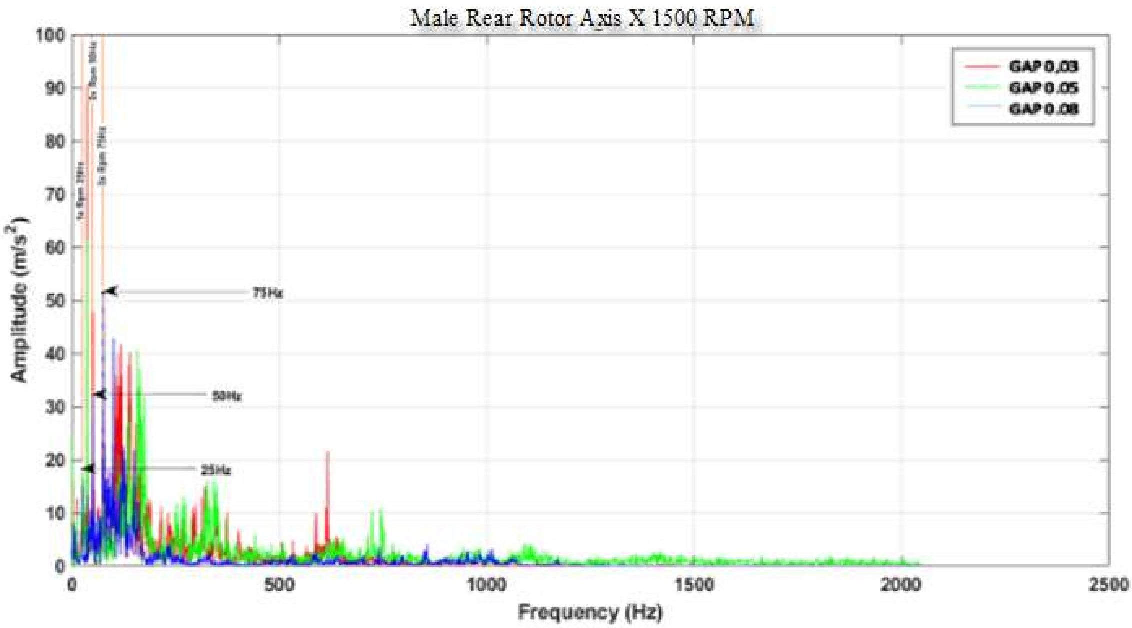

Figure 10. Third rear rotor male X axis data GAP Clearance distance

The vibration data at point 2 (the rear rotor male on the X axis) in Figure 10 indicates that GAP Clearance occurs at a frequency of 2x rpm 50 Hz and 3x rpm 75 Hz, with a distance of 0.03. In the meantime, it appears at a frequency of 1x rpm 25 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

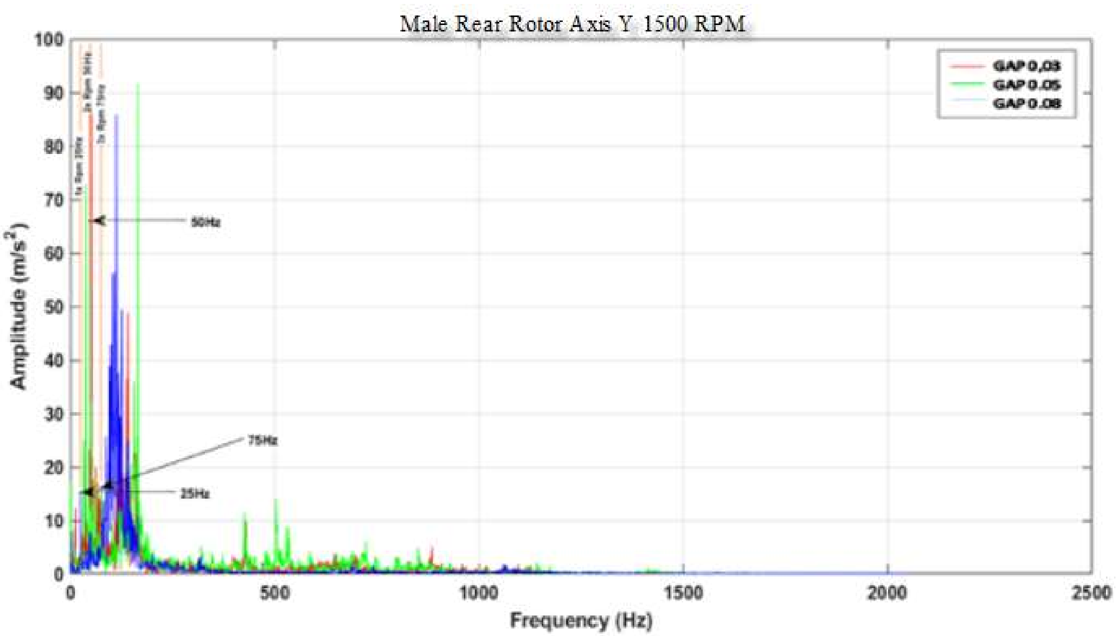

Figure 11. Third rear rotor male Y axis data GAP Clearance distance

Figure 11, vibration data at point 2 (rear male rotor on Y axis) reveals that GAP Clearance occurs at a frequency of 1x rpm 25 Hz and 3x rpm 75 Hz, with a distance of 0.03. In the meantime, it manifests at a frequency of 2x rpm 50 Hz at a GAP Clearance distance of 0.05, and it is absent at a GAP Clearance distance of 0.08.

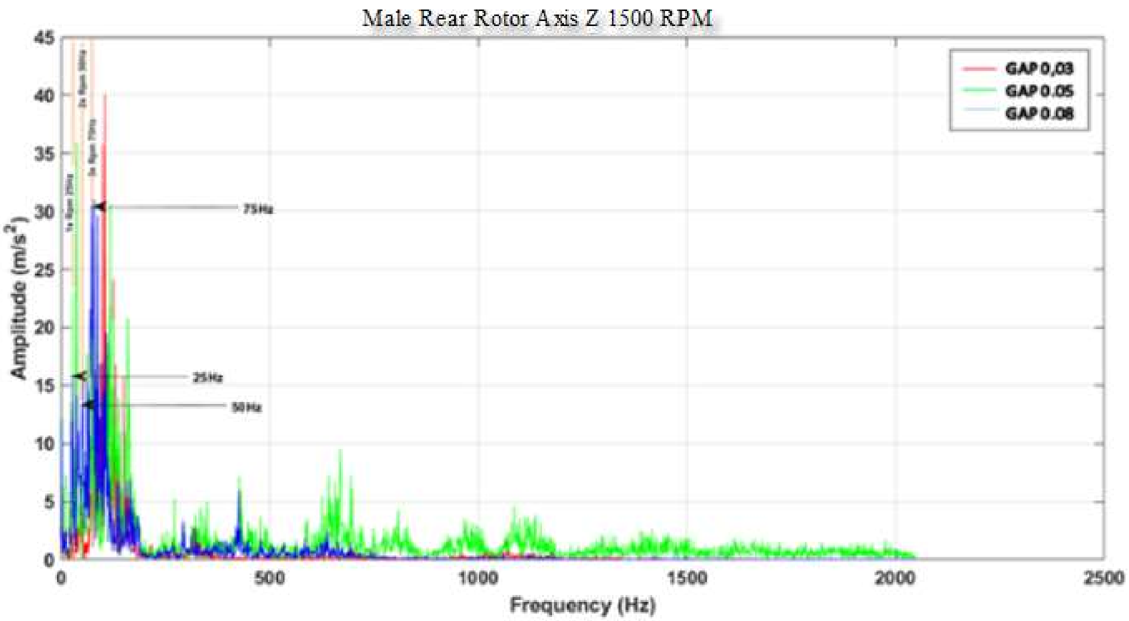

Figure 12. Third rear rotor male Z axis data GAP Clearance distance

GAP Clearance appears at frequencies of 1x rpm 25 Hz, 2x rpm 50 Hz, and 3x rpm 75 Hz, with a distance of 0.03 (rear rotor male on the Z axis) as shown in Figure 12 vibration data at point 2. In the meantime, no frequency is visible at GAP Clearance distances of 0.05 and 0.08

3.3 Vibration data at point 3 (female rear rotor)

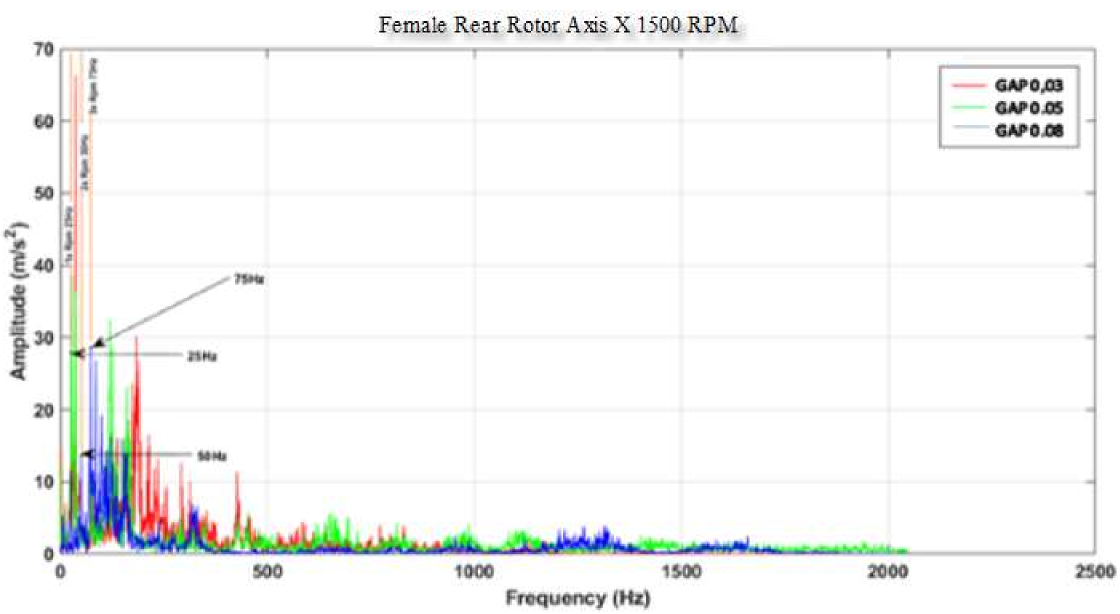

Figure 13. Third rear rotor female X-axis data GAP Clearance distance

The vibration data at point 3 (the rear female rotor on the X axis) in Figure 13 indicates that GAP Clearance occurs at a frequency of 2x rpm 50 Hz and 3x rpm 75 Hz, with a distance of 0.03. In the meantime, it appears at a frequency of 1x rpm 25 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

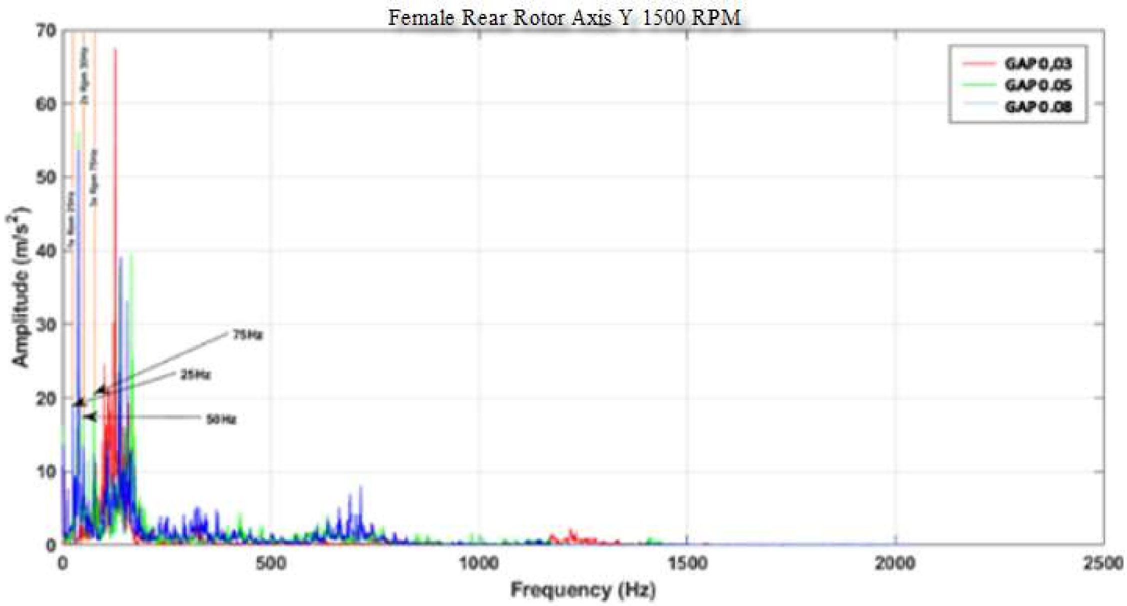

Figure 14. Third rear rotor female Y axis data GAP Clearance distance.

The vibration data at point 3 (the rear female rotor on the Y axis) in Figure 14 indicates that GAP Clearance occurs at a frequency of 1x rpm 25 Hz and 2x rpm 50 Hz, with a distance of 0.03. In the meantime, it appears at a frequency of 3x rpm 75 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

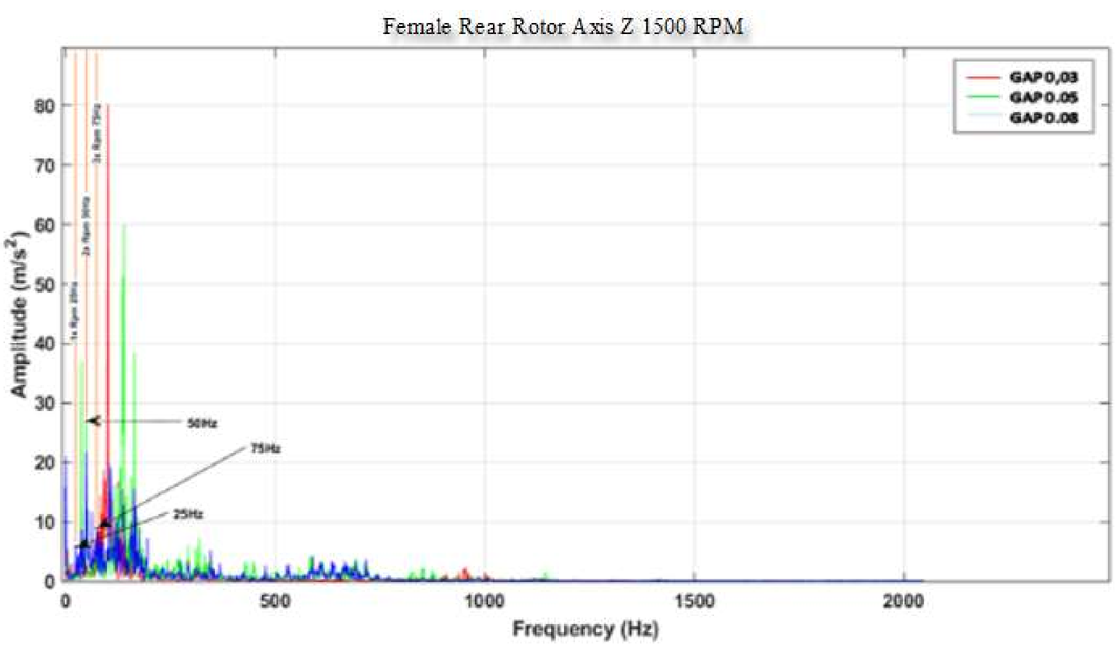

Figure 15. Third rear rotor female Z axis data GAP Clearance distance

Figure 15 vibration data at point 3 (the rear female rotor on the Z axis) reveals that GAP Clearance occurs at 1.x rpm 25 Hz and 3.x rpm 75 Hz, with a distance of 0.03. In the meantime, it manifests at a frequency of 2x rpm 50 Hz at a GAP Clearance distance of 0.05, and it is absent at a GAP Clearance distance of 0.08

3.4 Vibration Data at Point 4 (female front rotor)

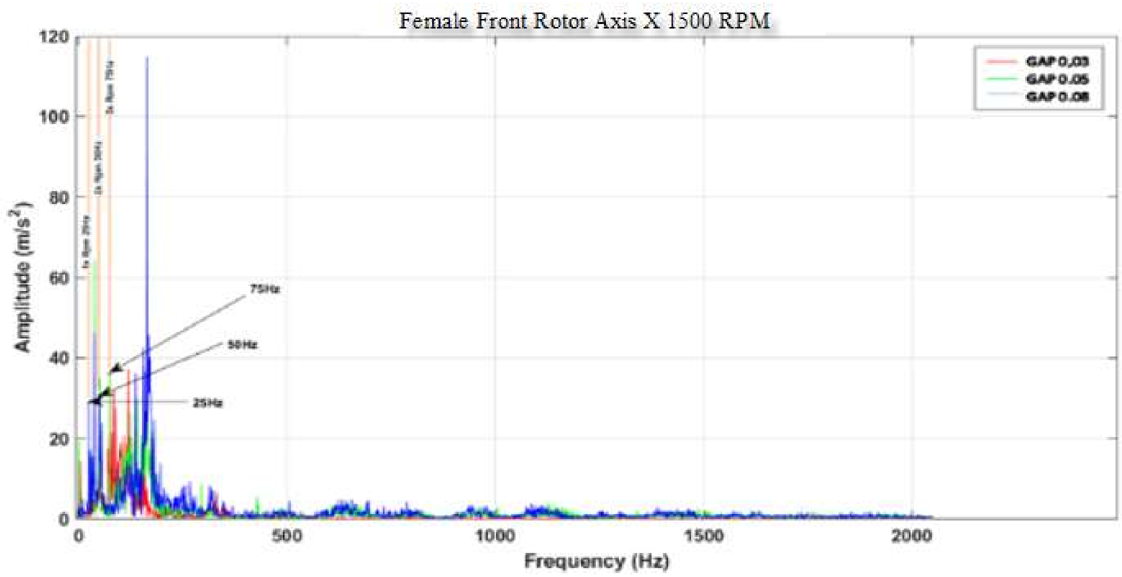

Figure 16. Third front rotor female X-axis data GAP clearance distance

Figure 16 vibration data at point 4 (the front female rotor on the X axis) reveals that GAP Clearance occurs at a frequency of 1x rpm 25 Hz and 2x rpm 50 Hz, with a distance of 0.03. In the meantime, it appears at a frequency of 3x rpm 75 Hz at a GAP Clearance distance of 0.05, and it does not appear at a GAP Clearance distance of 0.08.

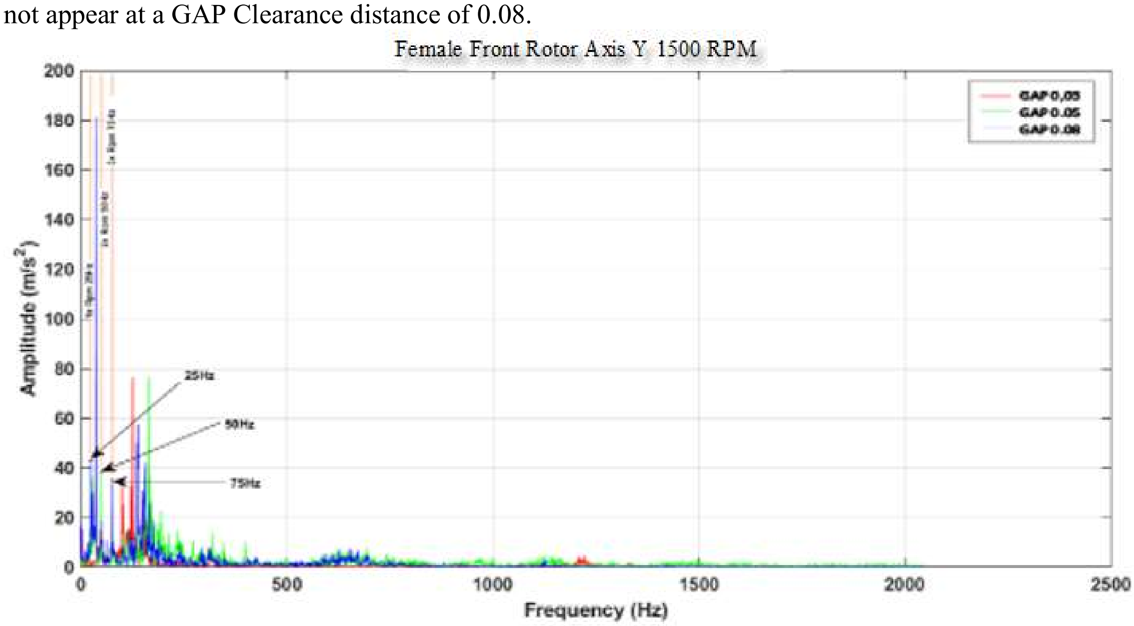

Figure 17. Third front rotor female Y-axis data GAP Clearance distance

Figure 17 vibration data at point 4 (the female front rotor on the Y axis) reveals that GAP Clearance occurs at a frequency of 1x rpm 25 Hz and 3x rpm 75 Hz, with a distance of 0.03. In the meantime, it manifests at a frequency of 2x rpm 50 Hz at a GAP Clearance distance of 0.05, and it is absent at a GAP Clearance distance of 0.08.

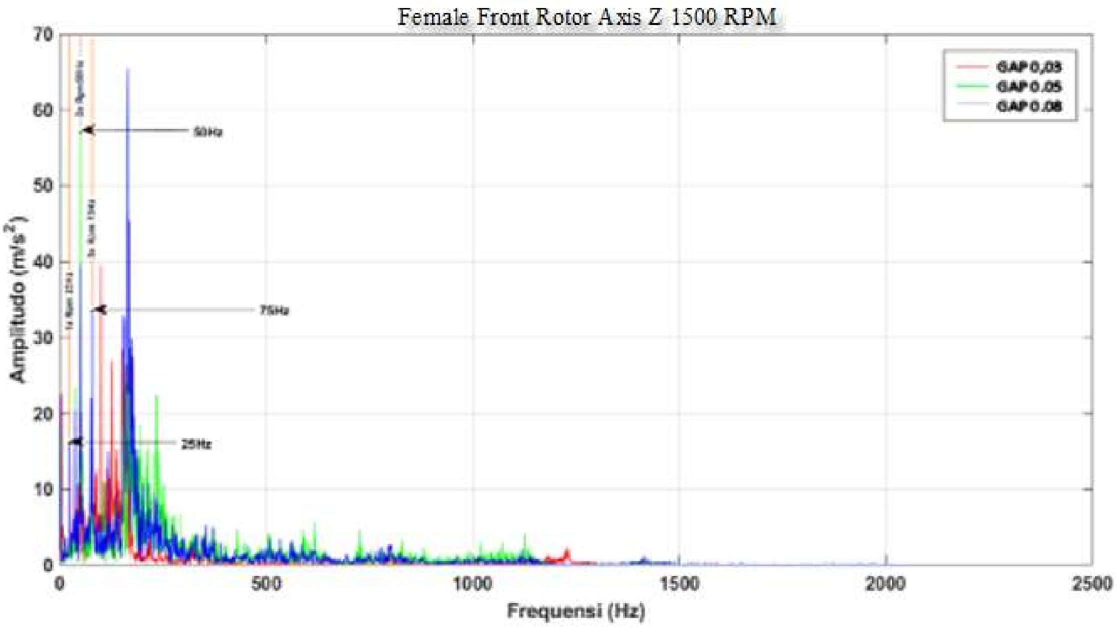

Figure 18. Third front rotor female Z axis data GAP Clearance distance

At point 4, the female front rotor on the Z axis in Figure 18 vibration data, Table 2 GAP Clearance is visible at a distance of 0.03 and appears at two different frequencies: 1x rpm 25 Hz and 3x rpm 75 Hz. In the meantime, it manifests at a frequency of 2x rpm 50 Hz at a GAP Clearance distance of 0.05, and it is absent at a GAP Clearance distance of 0.08.

Table 2. Research results

SAMPLE DESCRIPTION				
1x		25 Hz		
2x		50 Hz		
3x		75 Hz		
ROTOR HOUSE POINT	AXIS	GAP CLEARANCE		
		0,03 (mm)	0,05 (mm)	0,08 (mm)
Front male rotor screw	X	1x, 2x	3x	-
	Y	1x	2x, 3x	-
	Z	3x	1x, 2x	-
Rear male rotor screw	X	2x, 3x	1x	-
	Y	1x	2x, 3x	-
	Z	1x, 2x, 3x	-	-
Rear female rotor Screw	X	2x, 3x	1x	-
	Y	1x	2x, 3x	-
	Z	1x, 3x	2x	-
Front female rotor Screw	X	1x, 2x	3x	-
	Y	1x, 3x	2x	-
	Z	1x, 3x	2x	-

4. CONCLUSION

The vibration data results graph indicates that, at a distance of 0.03 and 0.05, there is a sample graph of 1x 25 Hz, 2x 50 Hz, and 3x 75 Hz on the X, Y, and Z axes, but at 0.08, there is not a sample graph of 1x 25 Hz, 2x 50 Hz, or 3x 75 Hz. The gap clearance value of 0.08 is the optimal distance, according to the graphic data results, as no frequency graph samples were shown in the vibration results. The recommended ideal clearance gap for rotor rotation in the airend screw compressor will be produced by overcoming damage by determining the clearance gap and investigating each clearance gap using vibration frequency.

ACKNOWLEDGEMENT

I am incredibly grateful to God Almighty and my parents for their unwavering support throughout my journey. We also thank the supervisors, Deni Arif Budiman team friends, and all other parties involved in the research and preparation of this paper to produce results that provide valuable insights. We thank the head of the mechanical engineering study program and the head of the mechanical engineering laboratory, who always provide support for this research in the form of morals and facilities.

REFERENCE

[1] M. Engineering, U. M. Buana, M. Selatan, and J. Barat, "STUDYING THE DYNAMIC CHARACTERISTICS TO LENGTHEN THE OPERATING LIFE FOR A DIESEL ENGINE USING FREQUENCY RESPONSE FUNCTION (FRF) MEASUREMENT," vol. 22, no. 3, pp. 161–168, 2018.

[2] M. A. Pratiwi, M. Ikhsan, R. D. Octavianto, A. Hamid, and S. Subekti, "DYNAMIC CHARACTERIZATION OF BALL BEARING IN TURBINE PROPELLER USING BUMP TEST METHOD," *SINERGI*, vol. 25, no. 2, 2021, doi: 10.22441/sinergi.2021.2.004.

[3] R. Rahmana, K. Eberle, and M. Maculo, "Case study of solving screw compressor package vibrations," *Gas Mach. Conf.*, pp. 1–4, 2017.

[4] A. Anggriawan and F. Huda, "Deteksi Kerusakan Motor Induksi Dengan Menggunakan Sinyal Suara," *Jom FTEKNIK*, vol. 5, no. 1, pp. 1–7, 2018.

[5] X. Wu *et al.*, "Stress analysis of reciprocating pump pipeline system in oil station," vol. 6, no. 7, pp. 2026–2032, 2014.

[6] M. Cerpinska and M. Irbe, "Vibration of foundation for rotary screw compressors installed on skid mounting," no. October, 2020, doi: 10.22616/ERDev2018.17.N094.

[7] A. S. Subekti, Subekti, Harus Laksana Guntur, Vivien S. Djanali, "Simulation and Dynamic System Modeling in an Elastically Supported Rigid Cylinder for Vibration Energy Harvesting," *Recent Adv. Renew. Energy Syst.*, pp. 61–68, 2022.

[8] J. Lu, Z. Cai, S. Cai, B. Yao, and B. Chen, "A Novel Engagement-Pixel Tracking Method for Meshing Clearance Layout of Twin-Screw Rotors," vol. 2019, 2019.

[9] Susilo and D. Djoko, "Pemantauan kondisi mesin berdasarkan sinyal getaran," *Mekanika*, vol. 8, no. October, pp. 804–811, 2019.

[10] M. Saidiman, M. Satya Nugroho, Subekti, and A. Hamid, "KARAKTERISTIK DINAMIK COMPUTER NUMERICAL CONTROL MILLING ROUTER 4 AXIS," *Sist. J. Ilm. Nas. Bid. Ilmu Tek.*, vol. 9, no. 2, 2021, doi: 10.53580/sistemik.v9i02.62.

[11] E. S. Eko Saputra, Subekti Subekti, and Tulus Supriyanto, "Analysis of the vibration caused by porting on the intake and exhaust channels of a 150 cc Kawasaki Ninja driver," *JTTM J. Terap. Tek. Mesin*, vol. 4, no. 1, pp. 1–10, 2023, doi: 10.37373/jttm.v4i1.359.

[12] F. R. Adi and S. Suwarmin, "Identifikasi Keausan Bantalan Tirus (Tapered Bearing) Berbasis Analisis Vibrasi dengan Metode Support Vector Machine (SVM)," *J. Tek. ITS*, vol. 6, no. 2, pp. 768–771, 2017, doi: 10.12962/j23373539.v6i2.27527.

[13] H. Sangian, D. A. Rahman, R. Rudiwanto, S. Subekti, and A. Hamid, "Analisis Getaran pada Screw Compressor Akibat Pengaruh Putaran Rotor," *J. Rekayasa Mesin*, vol. 11, no. 2, pp. 267–275, 2020, doi: 10.21776/ub.jrm.2020.011.02.13.

[14] M. Heideman, D. Johnson, and C. S. Burrus, "Gauss and the history of the {{}FFT{}}," *IEEE Signal Process. Mag.*, vol. 1, no. 3, pp. 14–21, 1984.

[15] K. Muhamad and Subekti Subekti, "Analysis of material incision in milling machine against

workpiece by vibration method," *JTTM J. Terap. Tek. Mesin*, vol. 4, no. 2, pp. 127–136, 2023, doi: 10.37373/jttm.v4i2.552.

[16] D. Andryas Saputra, Subekti Subekti, and Erlangga Yorda Agustin, "Identification of ignition system coil damage on MPV 1000 CC vehicle using fast fourier transform," *JTTM J. Terap. Tek. Mesin*, vol. 4, no. 2, pp. 156–162, 2023, doi: 10.37373/jttm.v4i2.554.