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Kumaş Polisaj Tezgâhında Gürültü ve Titreşim Azaltım Çalışması

Hüseyin DAL[*,a], Murat BAKLACI[b]

[a,*] Sakarya Üniversitesi Mühendislik Fakültesi Makine Mühendisliği Bölümü, Sakarya, Türkiye
[b] Milli Savunma Üniversitesi Makine Mühendisliği Bölümü, Ankara, Türkiye

MAKALE BİLGİSİ

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ÖZ

Sanayileşme ile artan gürültü seviyeleri insan sağlığını olumsuz etkilemektedir. Özellikle yüksek gürültülü işyerlerinde çalışanların yüksek gürültüye maruz kalması işçi sağlığını olumsuz etkilemektedir. Bu çalışmada, bir tekstil firmasında dokuma tezgahı türü olarak kullanılan kumaş polisaj tezgahının gürültü ve titreşim problemini azaltmak için bir dizi çalışmalar yapılmıştır. Çalışanların gürültüye maruz kaldıkları çalışma alanında bulunan tezgahlardan kumaş polisaj makinesi, pilot çalışma tezgahı olarak seçildi. Polisaj tezgahı ve çevresinin bazı noktalarından gürültü ve titreşim ölçümleri alınmıştır. Alınan titreşim ve gürültü ölçümleri analiz edilerek polisaj tezgahının gürültü ve titreşim seviyeleri ve karakteristikleri belirlendi. Makinenin gürültü emisyonlarını azaltmak için çeşitli gürültü ve titreşim izolasyon uygulamaları yapılmıştır. Ofis çalışma alanına gürültü iletimini azaltmak için ofisler ile kumaş işleme alanı arasına gürültü duvarı kuruldu. Fan kanalları ise ses yalıtım malzemeleri ile kaplanmıştır. Titreşim kaynaklı gürültüyü azaltmak için tezgah ayaklarının altına titreşim izolasyonlu kauçuk takozlar yerleştirilmiştir. Aynı koşullarda tekrarlanan ölçüm ve analizler sonrasında, polisaj makinesinin gürültü ve titreşim seviyelerinin önemli ölçüde azaldığı görülmüştür.

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Noise and Vibration Abatement Study on a Fabric Polishing Machine

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ABSTRACT

Increasing noise levels with industrialization adversely affect human health. Especially in high noisy workplaces, the exposure of workers to high noise negatively affects worker health. In this study, a series of studies have been carried out to reduce the noise and vibration problem of a polishing bench, a weaving loom in a textile company. A fabric polishing bench in the working area where workers are exposed to its loud noise was chosen as the pilot fabric machine. Noise and vibration measurements were taken from some points of the polishing bench and its surroundings. By analyzing the vibration and noise measurements taken, the polishing bench noise and vibration characteristics were determined. Some noise and vibration isolation applications have been implemented to reduce the noise emission of the bench. In order to reduce noise transmission to the office workplace, a noise wall was set up between offices and the fabric processing area. The fan ducts were covered with sound insulation materials. For reducing vibration-induced noise, vibration isolation rubber pads are placed under the bench legs. After repeated measurements and analyzes under the same conditions, it was observed that the noise and vibration levels of the polishing bench were significantly reduced.

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*__Corresponding author__: hdal@sakarya.edu.tr

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1. INTRODUCTION *(GİRİŞ)*

The increase in high mechanization and heavy industry has brought the noise problem with it. Each country has its own laws to protect workers from exposure to noise. These laws require workplaces to take the necessary precautions to protect the health of employees from noise. Serious adverse effects of workplace noise are physical, physiological, psychological, performance loss, etc. It reveals effects such as [1]. Especially noise-based disturbances are common in iron and steel, printing and rolling workers in addition to textile workers. Many improvements have been made to regulate these adverse situations occurring in the working environments of industry employees around the world [2].

Due to all these negative effects, many studies have been carried out on the negative effects of noise caused by machinery and equipment. Noise-based hearing loss is seen as an occupational disease that occurs especially in textile workers. This situation occurs with prolonged exposure to high sound levels. In the industry, noise-based ailments are tackled by using protective equipment such as hearing protection equipment. In a study carried out by Jayawardana et al., the quality of the noise level existing in a textile factory and the distribution of the noise within the factory are examined. Then, a mathematical model was developed to estimate the noise distribution in the factory, and the mathematical model was verified with the noise data obtained in the factory by standard methods. Finally, suitable noise control panels were designed to prove the effectiveness of the noise control method experimentally, and a pilot application was carried out [3]. In another study, Noweır and Jamıl took noise measurements in different octave bands in textile, printing, and paper production industries and then identified the sectors with the highest noise pollution.

As a result, based on the experimental results obtained, recommendations for appropriate noise control and worker protection for the sectors are presented [4,5]. In another study, Talukdar conducted a study on noise pollution and control in textile factories in India [6,7]. Johnson proposed an analytical model for the noise generated by the vibrations of a weaving machine in his thesis. It has been observed that the proposed analytical model does not fully comply with experimental data obtained at low frequencies but gives good results for octave bands between 1000 Hz and 31500 Hz [8]. Alimohammadi and et al. researched the disturbances caused by noise in workers working in the textile industry. In the study under consideration, 162 textile workers who were exposed to excessive noise were selected. When the results obtained were evaluated, it showed that educational intervention could cause an increase in the noise problem by affecting their attitudes among workers [9]. Navarro et al. examined the acoustic performance of microcapsule reinforced woven textile products using the filling technique. Then, the sound absorption effects of 6 different woven textile products with the same microcapsule concentration were examined. The results obtained showed that the change of sound absorption coefficient of doped woven fabric was dependent on the experimental setup, microcapsule concentration, and fabric type [10]. In another study, Zaw et al. conducted an experimental study on 226 employees working in the weaving department of a textile company to determine their exposure to noise levels and their hearing loss. When the results obtained were evaluated, it was determined that 66.4% of the employees were exposed to noise above 85 dB and hearing loss occurred in 25.7% of the employees [11,12].

In addition to the textile industry, noise pollution occurs in iron and steel factories due to the vibration in machinery and equipment. As a result, workers working in iron and steel companies are exposed to this noise pollution. In a study conducted on employees exposed to noise in iron and steel companies, 468 employees who were exposed to noise were selected. When the results obtained are examined, 89% of the employees are exposed to noise above acceptable sound levels. At the same time, it is understood that 45% of these employees do not use any protective equipment [13,14]. In another study conducted in the iron and steel industry, Harmadji and Kabullah conducted an experimental study to prove that chronic exposure to high machine noise can lead to noise-induced hearing loss in the employee. They took sound measurements on randomly selected 50 workers (25 production employees, 25 management employees) in the environment where they worked for six months. When the results obtained are examined, the average sound level in the production section was measured as 102 dB and 60.4 dB in the control section. It was determined that 4% more noise-based hearing loss occurred in workers working in the production department compared to the workers in the management department [15,16,17].

Finally, Sriopas et al. conducted an experimental study on hearing loss occurring in workers working in the welding department of an automobile part manufacturing company. When the results are examined, it confirms that exposure to noise levels of 90 dB and above increases the risk of hearing loss in both ears. In addition to the results obtained, it has been revealed that people who have worked for ten years or more have a significant hearing loss in both ears [18]. It is an obligation to control workplace noise due to its stated negative effects on human health [2]. For this reason, legal regulations have been made in many countries in order to keep the noise level in the workplaces below the danger limits. Noise limit values have been determined in most inducstrial countries to control the noise and be protected from the negative effects of noise in the workplaces. The OSHA (Occupational Safety and Health Administration), which was implemented in the USA in 1970 and is constantly updated, is taken as a reference or applied by many countries. OSHA states that the noise level in the workplace must be known. At the same time, according to OSHA, if you feel the need to raise your voice to be heard in 3 steps in the workplace, the noise level of your environment may be above 85 dB [19,20]. In this arrangement, the periods that can be worked under the effect of different levels of noise are given in Table 1.

Table 1. Permissible noise exposures in workplaces
(İşyerlerinde izin verilen gürültü seviyesi)

Duration per day	Sound level dba slow response
8	90
6	92
4	95
3	97
2	100
1 or ½	102
1	105
½	110
¼ or less	115

According to CDC (The Center for Disease Control), the health of 22 million workers worldwide is affected by excessively noisy workplaces every year. Even the loudest noises are preventable [21]. In this study, noise and vibration analyzes of a loom used for fabric polishing in a fabric production facility were carried out. Various experimental setups have been prepared to reduce the noise and vibration of the counter. For this purpose, fans and air ducts are covered with sound-absorbing materials. A noise isolation wall was placed between the office and the polishing machine in order to reduce noise transmission. With the help of vibration measurement and analysis results, in parallel with theoretical calculations, antivibration rubber pad selection was made for machine feet, and vibration-based machine basic design was realized. According to the vibration and noise measurements taken again after the improvement works, it was determined that the noise and vibration levels of the bench decreased significantly.

2. MATERIAL AND METHOD *(MATERYAL VE METOD)*

2.1. Study Area and Definition of the Case *(Çalışma Alanı ve Problemin Tanımlanması)*

In this study, the noise and vibration of a textile polishing machine, which is an important source of noise in terms of occupational and worker health in an industrial textile factory, was selected as a research subject. There are a large number of looms and machines used for various purposes in the textile production industry. An average of 3 workers works at each workbench. The selected pilot worksite is the noisiest work area in the company. Most of the machines in the working area consist of benches such as shearing, brushing, finishing, polishing, which are used to give the fabrics a polished and shiny appearance. There is also a work office in an area close to the benches. Among these benches, the position of the polrotor polishing bench, which is close to the work office and where the most complaints are concerned, is shown in Figure 1.

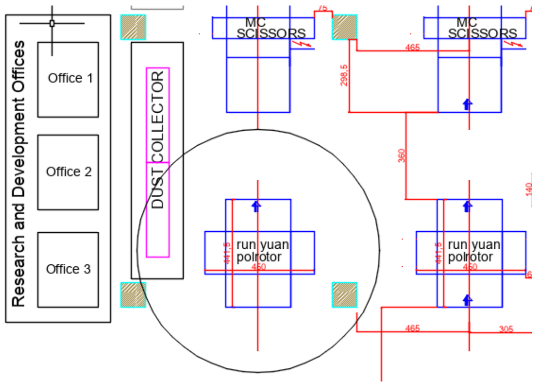

Figure 1. Location of polrotor polishing machine
(Polrotor polisaj makinesinin konumu)

The task of the Polrotor polishing machine is to make the pile (polishing) and lift (embossing) of the velvet-style pile (pile) fabrics. The machine under consideration is the RN420A model of the Runian company. The polishing bench is approximately 4150x4415 mm in size, with double polrotor cylinders (rotating channel cylinder (see Figure 2), a mass of approximately 6500 kg, and a power of 144 kW [22]. These polrotor cylinders can be rotated in both directions and can be operated independently or together.

Babyface velvet fabric has been chosen for the polishing process. R The fabric given to the loom in rolls enters the polrotor cylinders with polishing blades on it, rotating at 1000 rpm and heated up to 180-200 oC, and leaves the loom in the direction of the arrow shown in Figure 1 at a speed of 18 m / min. Moreover, the working parameters of the machine are given in Figure 3. Fabric particles coming out of dust from the polrotor roller and sanding rollers are transferred from the air ducts to the dust collecting units near the machine by means of fans (Figure 4).

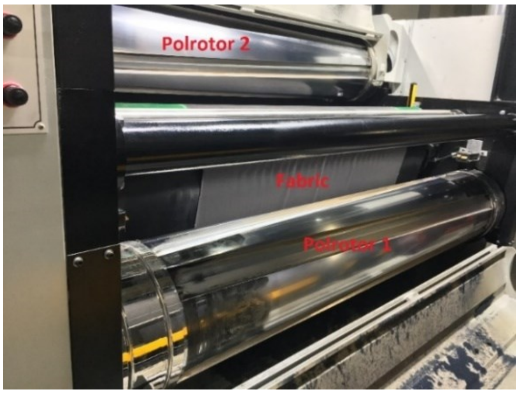

Figure 2. Fabric feeding input of the loom *(Tezgahın kumaş besleme girişi)*

Figure 3. Working parameters of the polishing machine *(Polisaj makinesinin çalışma parametreleri)*

Imbalances in the polrotor cylinder and other parts of the machine, vibrations that occur due to the machine being placed both directly and unevenly on the floor, vibrations transmitted by other machines to the floor, as well as the fan and air ducts are important noise sources.

In order to make a preliminary evaluation, the background noise levels of the work area and noise measurements were taken on all benches, and it was confirmed that the polrotor polishing machine was the dominant noise source. In addition to that, it is known from the literature that the most accurate noise reduction technique is to reduce the noise of the loudest machine. [23]. For this reason, noise reduction studies have been carried out on this polishing machine.

Figure 4. Polishing bench work area *(Polisaj tezgahının çalışma alanı)*

Bruel & Kjaer 2250 series sound level meters and hand-held analyzer were used for noise measurement and analysis on the bench. Bruel&Kjaer 2250 and its noise analysis software conforms with the relevant standards IEC 61672–1 (2013) Class 1 [24], ANSI/ASA S1.4–2014 Class 1 [25] and IEC 61260–1 (2014) 1/1-octave bands and 1/3-octave bands, Class 1 [26]. The microphone used for noise measurements is Bruel&Kjaer 4189, capable of measuring up to 140 dB. Before the noise measurement periods, the microphone used was calibrated with the Bruel & Kjaer 4231 microphone calibrator. The type of 4231 calibrator device is Class 1 according to EN/IEC 60942 (2003) [24] and ANSI S1.40–2006 [27].

As seen in Figure 5, noise analyzes were made by taking logarithmic averages of the noise measurements taken from each corner of the polishing machine three times for 60 seconds. The microphone was placed 120 cm above the ground and 1 m away from the corners of the polishing machine by means of a tripod. During all measurements, the measurement and environmental conditions were kept the same. A-weighted equivalent sound level (LAeq in dBA), which is closest to the sensitivity of the human ear, was used for noise measurements. For frequency analysis of machine noise, a 1/3 octave band filter was chosen.

The noise components of the Polrotor polishing machine were determined as the noise of the machine itself, the front and rear polrotor noise, the fan noise, the fabric noise, and the noise of the other machines.

In order to determine the noise characteristic of the machine, it is necessary to know the noise levels of all the mentioned noise sources. For this purpose, nine different measurement scenarios were applied to detect all noise components (Table 2). In stable working conditions of the machine, noise measurements were taken after each machine component operated for 5 minutes.

Figure 5. Noise and vibration measurement points of the polishing machine *(Polisaj makinesinin gürültü ve titreşim ölçüm noktaları)*

Accordingly, without operating any of the polrotors, fabric feeding rollers, fans, and other machines, only the machine itself was operated, and noise measurements were taken from A, B, C, and D corners of the machine (Figure 6). The noise level of the machine itself (motor+electrical noise) was determined by taking the logarithmic average of the noise levels taken from the four corners of the machine with the help of Equation 1. Similarly, only the fan group was operated, and the fan and noise levels of dust-air suction ducts were determined. Then, by operating the machine and polrotor one together, the total noise level of the machine and polrotor one was recorded. With Equation 2, the noise level of Polrotor one was determined by subtracting the machine's own noise from the total noise level. With similar measurement and calculation methods, individual noise levels of the total noise components (machine, polrotor 1, polrotor 2, fan, fabric, all machines) of the polishing machine were calculated separately.


Figure 6. Noise levels measurement at point B of polishing machine *(Polisaj makinesinin B noktasındaki gürültü seviyesi ölçümleri)*

$$LA_{eq_{machine}} = 10\log\left(\frac{10^{LA_{eq_i}/10}}{n}\right) \quad (1)$$

$$LA_{eq_{polrotor1}} = 10\log\left(10^{LA_{eq_t}/10} - 10^{LA_{eq_{machine}}/10}\right) \quad (2)$$

Table 2. Noise measurement scenarios *(Gürültü ölçüm senaryoları)*

	Machine (M)	Polrotor 1 (P1)	Polrotor 2 (P2)	Fan (F)	Fabric (T)	All machines
1.Meas.	✓					
2.Meas.				✓		
3.Meas.	✓	✓				
4.Meas.	✓		✓			
5.Meas.	✓	✓	✓			
6.Meas.	✓	✓	✓	✓		
7.Meas.	✓	✓	✓		✓	
8.Meas.	✓	✓	✓	✓	✓	
9.Meas.	✓	✓	✓	✓	✓	✓

2.1. Vibration Measurements *(Titreşim Ölçümleri)*

It is also important to determine the vibration-induced noise levels of the polishing machine. Vibration-induced noises generally occur in low-frequency regions. It is known that the human ear is more sensitive to low-frequency noise than to high-frequency noise. This shows that vibration-originated noise is important in terms of noise exposure of workers. In addition, machine vibrations are important for product quality.

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Bruel&Kjaer Photon+ vibration analysis device (DAQ), and RT Pro Photon vibration analysis software were used for vibration measurements (Figure 7). Bruel&Kjaer 4533-B-002 accelerometer with 482.7 mV/g sensitivity was used for acceleration measurements. When the machine reaches a stable operating period, vibration measurements were taken for 60 seconds at a frequency resolution of 0.1 Hz. The maximum sampling frequency is 1000 Hz.

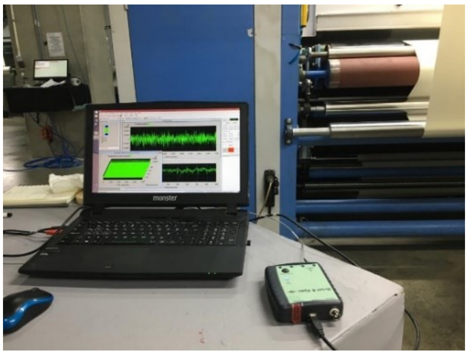


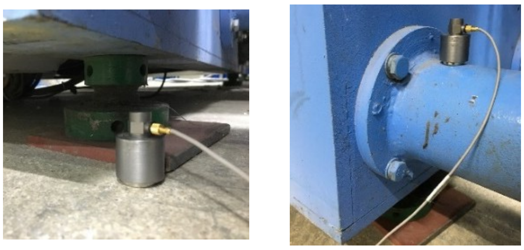
Figure 7. Vibration measurement setup *(Titreşim ölçüm düzeneği)*

The vibration measurement plan given in Table 3 was applied to determine the vibration components of the polishing machine. Unlike noise measurements, vibration measurements are taken, while other machines are constantly in operation because the factory is in the non-stop production phase. Nevertheless, unlike noise measurements, vibration levels and vibration isolation performances of each machine foot were evaluated separately.

In order to determine the vibration intensity of the polishing machine, vibration measurements were taken from the four legs of the machine and from the points where the feet touch the ground (Figure 8). The time and frequency responses of the vibration measurements taken were recorded. The vibration isolation performance between the machine and the ground was evaluated by examining the time and frequency responses. In order to evaluate the vibration intensity, RMS (Root Mean Square) acceleration values of the time responses of each measurement were calculated using Equation 3.

$$a_{RMS} = \frac{\sqrt{x_1^2 + x_2^2 + \cdots + x_n^2}}{n} \quad (3)$$

In Equation 3, $x_1, x_2, \ldots x_n$ are the acceleration amplitudes, and n is the total sampling number.



a. b.

Figure 8. (a) Machine foundation vibration measurement and (b) Machine foot vibration measurement *((a)Makine temelinin titreşim ölçümü ve (b)makine ayağın titreşim ölçümü)*

Using the relationship between the machine feet and the acceleration amplitudes a_{RMS} taken from the machine base, the vibration isolation performance of the machine can be calculated. For this purpose, how much of the machine vibrations are transferred to the ground or how much of the ground vibrations are transferred to the machine is calculated with the help of Equation 4.

$$T_r = \frac{\sqrt{1 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}}{\sqrt{\left(1 - \frac{\omega^2}{\omega_n^2}\right)^2 + \left(\frac{2\xi\omega}{\omega_n}\right)^2}} \quad (4)$$

In Equation 4, T_r is the vibration transmission amount, ξ is the damping ratio, ω machine polrotor cycle, and ω_n is the natural frequency of the machine. In the current situation, there is no vibration isolation as the machine is placed directly on the ground. For this reason, it has been observed that the amount of vibration insulation is very bad. This situation creates an extra source of the noise.

Table 3. Vibration measurement scenarios *(Titreşim ölçüm senaryoları)*

	Machine (M)	Polrotor 1 (P1)	Polrotor 2 (P2)	Fan (F)	Fabric (T)	All Machines
1.Meas.	✓	✓				✓
2.Meas.	✓		✓			✓
3.Meas.	✓	✓	✓			✓
4.Meas.	✓	✓	✓	✓		✓
5.Meas.	✓	✓	✓	✓	✓	✓

2.2. Noise and Vibration Abatement Studies *(Gürültü ve Titreşim Azaltım Çalışmaları)*

Three different insulation applications have been made to improve the noise and vibration performance of the polishing machine. Two of them are insulation applications for noise control and the other for vibration control. For noise control, first of all, fan suction ducts are covered with 19 mm thickness IzocamFlex acoustic insulation blanket.

The acoustic insulation materials used are elastomeric rubber-based, closed-pore, homogeneous sheet-shaped material with a cell structure. The insulation material was attached to the suction pipes by means of adhesive elastic bands, as shown in Figure 9.

The second acoustic insulation application is the noise wall application. For this, a trapezoidal sheet wall with a thickness of 0.7 mm was installed between the polishing machine and the working office. In order to increase the noise absorption of the wall, acoustic foams were placed between the trapezoidal profile plates, as shown in Figure 10.

Antivibration rubber pads were placed on the machine's feet, as shown in Figure 11, for the last application performed to improve the vibration and noise performance of the polishing machine. The stiffness of the vibration pads was calculated using Equation 4 for a 10% vibration isolation and a damping ratio of 0.1.

Figure 9. Dust suction ducts covered with IzocamFlex acoustic insulation material *(İzocamFlex akustik yalıtım malzemesi ile kaplanmış toz emiş kanalları)*

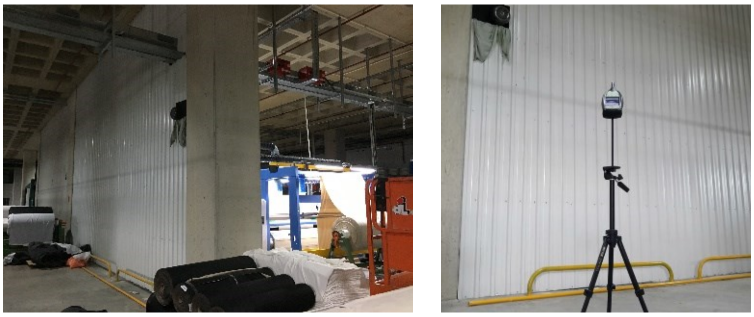


Figure 10. Noise wall application between machine and offices *(Makine ve ofis arasına gürültü duvarı uygulanması)*

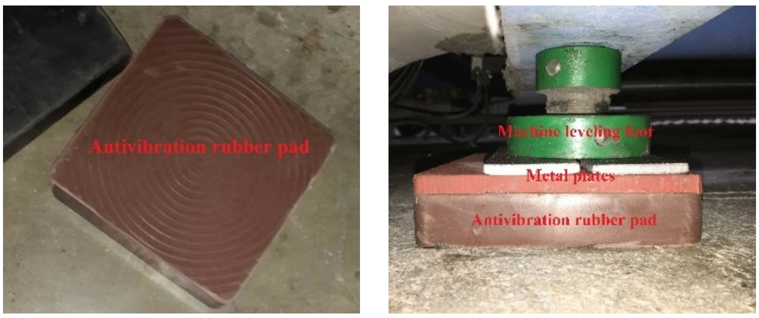


Figure 11. Antivibration rubber pad and its assembly *(Titreşim önleyici kauçuk takoz ve montajı)*

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3. RESULTS AND DISCUSSIONS *(SONUÇLAR ve TARTIŞMA)*

For reducing machine noise, noise measurements were taken before any insulation was applied. The noise levels of each noise component were obtained by taking the logarithmic average of the noise measurements taken three times from each corner of the machine. 1/3 octave band analysis results of the effect of each noise component on the total noise level are shown in Figure 12. According to Table 1, as the effect of new noise components is included in each measurement stage, the total noise level increases. In the first measurement, the noise level is lower than other measurements at all octave band center frequencies because only the machine is operating. In the last measurement, the total noise level is maximized as all noise components, and all other machines are working. According to 1/3 Octave band analysis, it is understood that the noise frequency range of the machine is between approximately 50-12500 Hz. The dominant frequency band is seen to be between 125-2500 Hz.

The vibration-induced noise level of the polishing machine should be determined. For this reason, the vibration isolation performance of the machine with the floor has also been examined. In this way, vibration levels from the machine to the ground and from the ground to the machine can be determined. For the vibration isolation performance, vibration measurements of all the feet of the machine as well as the ground where the feet of the machine touch were taken.

Vibration isolation performances of each foot were determined by using RMS values of floor and machine feet vibrations. According to the first vibration measurements, it was determined that there was no vibration isolation application and the vibration isolation of the machine was quite bad. Most of the machine vibrations are transmitted to the floor. However, ground vibrations originating from other machines are transmitted directly to the machine (Figure 13). In addition, it has been determined that the vibration levels of all machine feet are not equal and are very different from each other. This difference shows that different antivibration rubber is required for each machine foot.

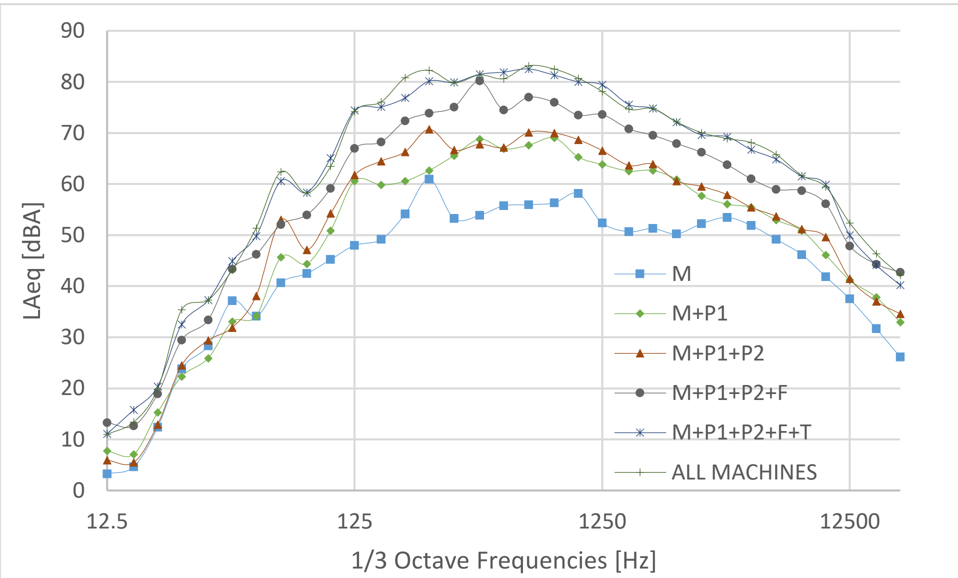

Figure 12. 1/3 Octave band frequency response of the polishing machine before insulation applications *(Yalıtım uygulamasından önce polisaj makinesinin 1/3 octave band frekans cevabı)*

The vibration-induced noise level of the polishing machine should be determined. For this reason, the vibration isolation performance of the machine with the floor has also been examined. In this way, vibration levels from the machine to the ground and from the ground to the machine can be determined. For the vibration isolation performance, vibration measurements of all the feet of the machine as well as the ground where the feet of the machine touch were taken. Vibration isolation performances of each foot were determined by using RMS values of floor and machine feet vibrations. According to

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Most of the machine vibrations are transmitted to the floor. However, ground vibrations originating from other machines are transmitted directly to the machine (Figure 13). In addition, it has been determined that the vibration levels of all machine feet are not equal and are very different from each other.

This difference shows that different antivibration rubber is required for each machine foot. Elastic coefficients of vibration isolation pads were calculated by using Equation 4 to improve the vibration isolation performance of the machine. Accordingly, the stiffness of the vibration rubber pad to be placed on each machine foot in order to provide 10% vibration isolation was calculated as in Figure 14.

After the antivibration rubbers, whose elastic rigidity was computed, were placed under the machine feet, significant vibration isolation for the machine was observed (Figure 15).

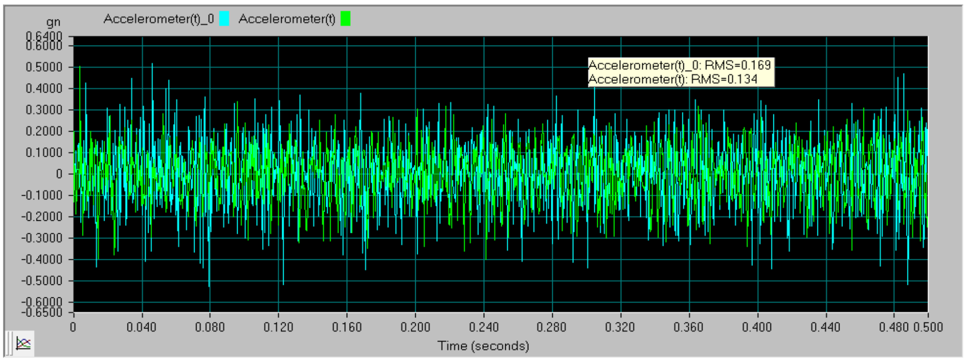

Figure 13. Vibration response of the machine for the A foot and the foundation before vibration isolation
(Titreşim izolasyonundan önce makinenin A ayağı ve temeli için titreşim cevabı)

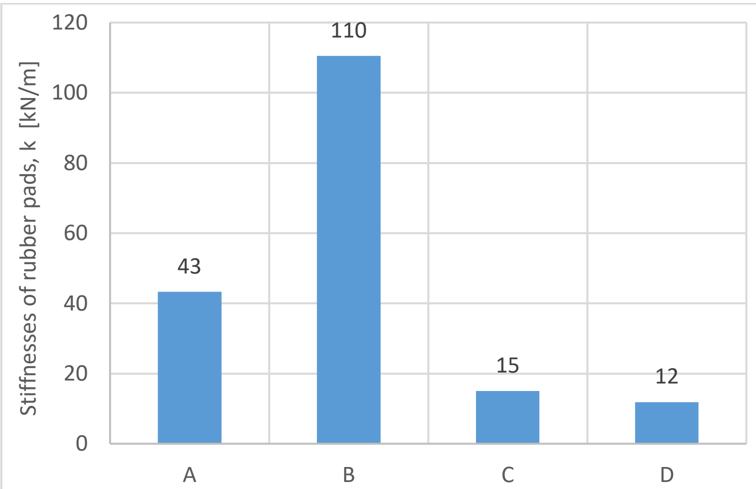

Figure 14. Stiffnesses of antivibration rubber pads placed under feet of the machine *(Makinenin ayaklarına yerleştirilen titreşim önleyici kauçuk takozların rijitliği)*

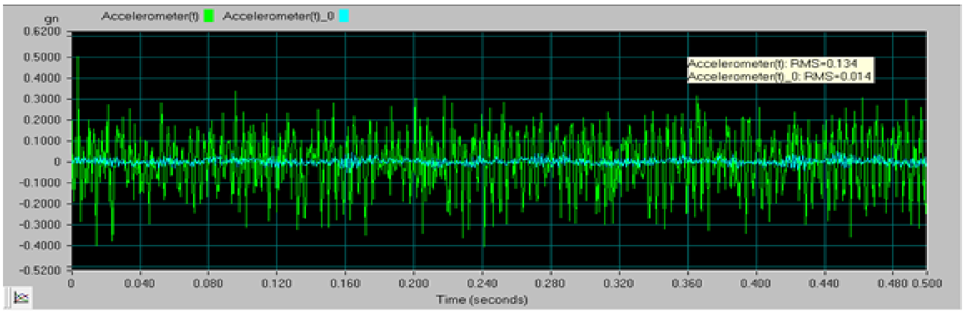

Figure 15. Vibration response of the machine for the A foot and the foundation after vibration isolation *(Titreşim izolasyonundan sonra makinenin A ayağı ve temeli için titreşim cevabı)*

In order to reduce the noise levels of the polishing machine, after the fan suction pipes were covered with acoustic insulation material and after the vibration rubber pad was placed on the machine's feet, all measurements were repeated under the same conditions. Thus, the effects of both noise and vibration insulation on the noise levels of the polishing machine were determined separately (Figure 16). Accordingly, it was determined that the component with the least impact was the idle noise of the machine. It is understood that the fan and fabric noise components are the dominant noise sources. For the polishing process, polishing polrotors apply pressure to the fabric fed to the loom and apply rapid shearing force at each turn. This causes low-frequency fabric cutting noise.

According to the measurement results, it is seen that fabric noise is the most dominant source of the noise. For this reason, it is understood that the fabric noise should be reduced first in order to reduce the total noise of the machine. However, the ability to reduce fabric cutting noise is related to the structural design of the machine. Since it is not effective to interfere with the structural design and manufacturing processes of the machine, no measures have been taken to reduce fabric noise. Nevertheless, it is clear that the measures are taken to reduce fan noise, and vibration-induced noise is quite beneficial. During the active operation of all the machines in the work area, a significant noise reduction of 7 dBA approximately has been achieved. This is an important level for workers exposed to noise.

Vibration-induced noises affect employees more because they are low frequency and high amplitude. The application of the vibration pads significantly reduced the vibrations caused by the polrotor cylinder. It is seen that vibration-induced high amplitude noise components decrease as vibration pads reduce machine vibrations.

There are working offices in the back of the fabric processing area where the polishing machine is located. Office workers, as well as production workers, are disturbed by the noise level of the fabric processing area. In order to reduce the transmission of the noise coming from the production line to the work area, a noise abatement wall was installed between the benches and the offices. In order to see the effect of the noise abatement wall, measurements were taken before and after the application of the wall, at a distance of 2 m from the wall, while all the machines were working actively. Results regarding the noise abatement of the wall are given in Figure 17. It was observed that the noise level on the fabric processing area was reduced up to 10 dBA approximately by the installed noise wall. The 10 dBA noise reduction is a significant improvement in terms of noise exposure of office workers.

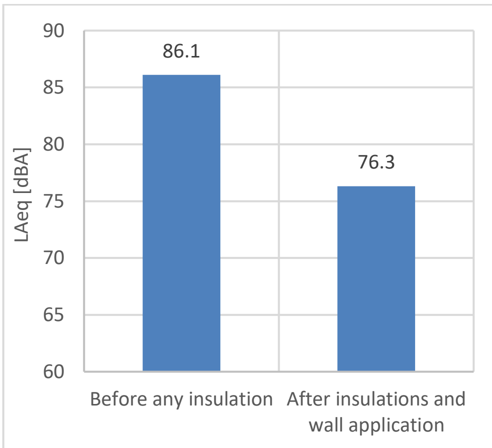

Figure 16. Comparisions of noise levels in the office area *(Ofis alanındaki gürültü seviyelerinin kıyaslanması)*

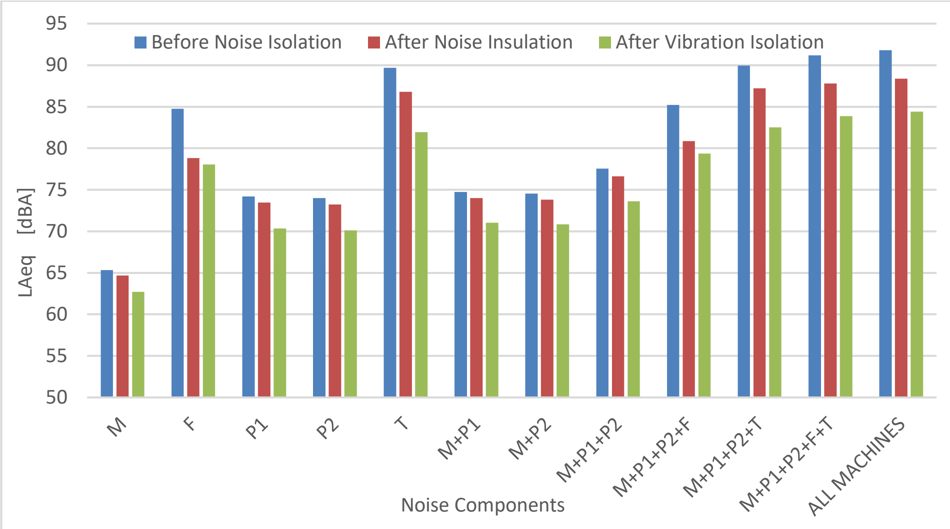

Figure 17. Comparisions of the noise levels after noise and vibration insulation application *(Gürültü ve titreşim izolasyon uygulamasından sonra gürültü seviyelerinin kıyaslanması)*

4. CONCLUSIONS *(SONUÇLAR)*

In the research study, noise and vibration reduction studies of the polishing machine, one of the loudest benches in a textile factory where the velvet fabric production is made, were carried out.

For noise and vibration abatements, the noise and vibration levels of each machine component contributing to the machine's total noise level were determined by experimental measurements and calculations. When the measurement data were examined, it was seen that each machine element contributed to the total noise level of the machine separately. The noise and vibration analysis determined that the dominant noise sources were fan noise, fabric polishing noise, and vibration originated noise. For reducing the noise effects of the dominant noise components, fan air inlet ducts are covered with special acoustic insulation material to reduce fan noise.

Interestingly, according to the vibration measurements, it was understood that each machine foot produced different vibration levels. Significant differences between the vibration levels of the machine feet were an indication of increased machine noise and the need for vibration isolation of the machine. In order to reduce the vibration of the machine and the noise level caused by vibration, firstly were calculated vibration insulatoın ratios of the machine feet. Next, the required rigidity and damping ratios of the vibration wedges placed on the machine feet were calculated for vibration isolation. Then suitable rubber pads were determined and applied to the machine's feet. According to the noise and vibration measurements before and after the insulation applications, approximately 7 dBA noise abatement was achieved. At the same time, an acoustic panel wall was built between the noisy production line and the working office. As a result, the noise transmission to the office areas has been reduced by approximately 10 dBA by noise cutting panel.

According to the results of the study, vibration and noise isolation applications of the machines must be made to protect the health of workers and employees. Work offices should be located as far away from noisy areas as possible. Various applications should be made to reduce noise transmission between noisy areas and work offices if this is not possible. Furthermore, this study will quickly guide the steps to be followed for noise and vibration reduction studies of noisy production machines in industrial areas.

CONFLICT OF INTEREST STATEMENT (ÇIKAR ÇATIŞMASI BİLDİRİMİ)

No potential conflict of interest was reported by the authors.

REFERENCES *(KAYNAKLAR)*

[1] E. Atmaca, I. Peker and A. Altın, "Industrial noise and its effects on humans," *Polish Journal of Environmental Studies*, vol. 14, no. 6, pp. 721-726, April 2005.

[2] World Health Organization (WHO), "Addressing the rising prevalence of hearing loss," *apps.who.int*, February 2018. [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/26

0336/9789241550260-eng.pdf?sequence=1&isAll [Accessed: Aug. 5, 2021].

[3] T. S. S. Jayawardana, M. Y. A. Perera and G. H. D. Wijesena, "Analysis and control of noise in a textile factory," *International Journal of Scientific and Research Publications*, vol. 4, no. 12, pp. 1-7, December 2014.

[4] M. H. Noweir and A. T. M. Jamil, "Noise Pollution in Textile, Printing and Publishing Industries in Saudi Arabia," *Environmental Monitoring and Assessment*, vol. 83, no. 1, pp. 103–111, March 2003.

[5] N. Parvin, M. Nabiollah and R. Negar, "Survey of noise pollution in weaving unit of parsabaft textile factory and providing some noise control ways," *International Research Journal of Applied and Basic Sciences,* vol. 10, no. 7, pp. 876-881, 2016.

[6] M. K. Talukdar, "Noise pollution and its control in textile industry," *Indian Journal of Fibre & Textile Research*, vol. 26, no.1-2, pp. 44-49, March 2001.

[7] Z. Duran, M. Genç, T. Doğan and B. Erdem, "Evaluation of noise emission in a textile plant," *NATURENGS, MTU Journal of Engineering and Natural Sciences*, vol. 1, no. 1, pp. 53-63, June 2020. doi:https://dx.doi.org/10.46572/nat.2020.6

[8] G. E. Johnson, "An investigation of picking noise in an automatic loom," M.Sc. thesis, Dept of Mec. Eng., Georgia Inst. of Tech., Atlanta, Georgia, United States, 1974.

[9] F. Shabani, I. Alimohammadi, J. Abolghasemi, T. Dehdari and R. Ghasemi, "The study of effect of educational intervention on noise annoyance among workers in a textile industry," Applied Acoustics, vol. 170, pp. 107515, December 2020. doi: 10.1016/ j.apacoust.2020.107515

[10] R. Atiénzar-Navarro, M. Bonet-Aracil, J. Gisbert-Payá, R. del Rey and R. Picó, "Sound absorption of textile fabrics doped with microcapsules," *Applied Acoustics*, vol. 164, pp. 107285, February 2020.

[11] K. Z. Aung, M. M. Aung, M. Thandar, Y. M. Htun, T. H. Aung, M. K. Tun and M. H. Zaw, "Assessment of noise exposure and hearing loss among workers in textile mill (Thamine), Myanmar: a cross-sectional study," *Safety and Health at Work*, vol. 11, no. 2, pp. 199-206, June 2020. doi: https://dx.doi.org/10.1016/j.shaw.2020.04.002

[12] A. Osibogun, I. Igweze and L. Adeniran, "Noise-induced hearing loss among textile workers in Lagos metropolis," *The Nigerian Postgraduate Medical Journal*, vol. 7, no. 3, pp. 104–111, Sep 2000.

[13] H. O. Ahmed. "Noise exposure, awareness, practice and noise annoyance among steel workers in United Arab Emirates," *The Open Public Health Journal*, vol. 5, no. 1, pp. 28-35, July 2012. doi:https://dx.doi.org/10.2174/1874944501205010028

[14] F. E. Ologe, T. M. Akande and T. G. Olajide, "Occupational noise exposure and sensorineural hearing loss among workers of a steel rolling mill," *Eur Arch Otorhinolaryngol*, vol. 263, no. 7, pp. 618-621, July 2006. doi: 10.1007/s00405-006-0043-9

[15] S. Harmadji and H. Kabullah, "Noise induced hearing loss in steel factory workers," *Folia Medica Indonesiana*, vol. 40, no.4, pp. 171-174, October-December 2004.

[16] G. Agarwal, P.S. Nagpure and S.V. Gadge, "Noise Induced Hearing Loss in Steel Factory Workers," *International Journal of Occupational Safety and Health*, vol. 4, no. 2, pp. 34-43, March 2015. doi:10.3126/ijosh.v4i2.12544

[17] T. N. Wu, F. S. Chou and P. Y. Chang, "A study of noise-induced hearing loss and blood pressure in steel mill workers," *International Archives of Occupational and Environmental Health*, vol. 59, no. 6, pp. 529-36, September 1987. doi: https://dx.doi.org/10.1007/BF00377915

[18] A. Sriopas, R. S. Chapman, S. Sutammasa and W. Siriwong, "Occupational noise-induced hearing loss in auto part factory workers in welding units in Thailand," *Journal of Occupational Health*, vol. 59, no. 1, pp. 55-62, January 2017. doi: https://dx.doi.org/10.1539/joh.15-0291-OA

[19] Occupational Safety and Health Administration (OSHA), "Hearing conservation," *osha.gov*, 2002. [Online]. Available: https://www.osha.gov/sites/default/files/publications/osha3074.pdf. [Accessed: Aug. 5, 2021].

[20] W. J. Murphy and John Franks, "Criteria for a recommended standard, occupational noise exposure, revised criteria," *The Journal of the Acoustical Society of America*, vol. 111, no. 5, pp. 2397, May 2002. doi:https://dx.doi.org/10.1121/1.4778162

[21] World Health Organization (WHO), "Situation review and update on deafness, hearning loss and

intervention programmes: Proposed Plans of Action for Prevention and Alleviation of Hearing Impairment in Countries of the South-East Asia Region," *apps.who.int*, December 2007. [Online]. Available: https://apps.who.int/iris/handle/10665/205895. [Accessed: Aug. 5, 2021].

[22] Runian Company, "Runian Machine: RN420A," *lygrn.com*, 2020. [Online], Accessed: April 07, 2021]. Available: http://www.lygrn.com/en/Products/POLISHING_MACHINE/2016111211.html. [Accessed: Aug. 5, 2021].

[23] H. N. Özgüven, *Gürültü Kontrolü: Endüstriyel ve Çevresel Gürültü.* Türk Akustik Derneği Yayınları, Ankara, Turkey, 2008.

[24] International Electrotechnical Commission (IEC), “IEC 61672-1:2013 - Electroacoustics - Sound level meters - Part 1: Specifications,” *webstore.iec.ch*, Sept. 30, 2013. [Online]. Available: https://webstore.iec.ch/publication/5708. [Accessed: Aug. 5, 2021].

[25] American National Standard (ANS), “ANSI/ASA S1.4-2014: Electroacoustics-Sound Level Meters - Part 1: Specifications (A Nationally Adopted International Standard),” *webstore.ansi.org*, 2014. [Online]. Available: https://webstore.ansi.org/standards/asa/ansiasas12014partiec616722013. [Accessed: Aug. 5, 2021].

[26] International Electrotechnical Commission (IEC), “IEC 61260-1:2014 - Electroacoustics - Octave-band and fractional-octave-band filters - Part 1: Specifications,” *webstore.iec.ch*, Feb 14, 2014. [Online]. Available: https://webstore.iec.ch/publication/5063#additionalinfo. [Accessed: Aug. 5, 2021].

[27] American National Standard (ANS), “ANSI/ASA S1.40-2006 (R2016): Electroacoustics-Specifications and Verification Procedures for Sound Calibrators,” *webstore.ansi.org*, 2016. [Online]. Available: https://webstore.ansi.org/standards/asa/ansiasas1402006r2016. [Accessed: Aug. 5, 2021].

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