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Studying the Jeans Fabric Sewability using Piezoelectric Sensor and Acoustic Signal (Part I: Vibration)

دراسة قابلية الحياكة لأقمشة الجينز باستخدام حساس كهربي ضغطي و اشارة صوتية (الجزء الاول – الاهتزازات)

Ihab M El_Sayed[1,2,3]

[1]Suez Canal University, [2]Taibah University, [3]OMTC Chair

خلاصة: هذا البحث يهتم بقياس اشارات الاهتزازات في الزمن الحقيقي أثناء عمليات الحياكة والتي فيه الحساس الكهربي ضغطي مثبت لأقرب مايكون على عامود ابرة ماكينة الحياكة وكذلك تم تركيب ميكروفون حساس بجوار عمود الابرة. الهدف من البحث تطوير جهاز يُعتمد عليه لقياس قابلية الحياكة ويضاهي جهاز L &M Sewability Tester تم اختيار نوع من أقمشة الجينز و تم اجراء عدة عمليات تجهيز و معالجات مائية عليه.كل عملية مائية تؤثر على الخواص الفيزيائيةو الميكانيكية للاقمشة و بالتالي على قابليته للحياكة. حساس كهربي ضغطي (حساس قياس التعاجل) مثبت على ماكينة الحياكة و متصل بالحاسب عن طريق كارت تحويل اشارات تناظرية الى رقمية مجهز خصيصا للاشارات ذات الديناميكية العالية مثل النبذبات في هذه الحالة.تم تركيب برنامج خاص على الحاسب لتجميع و تسجيل البيانات على القرص الصلب حيث يتم تحليلها احصائيا و استخراج الملامح المهمة المرتبطة بعمليات قابلية الحياكة. وتمت مقارنة البيانات المستخرجة من الجهاز المطور في هذا البحث مع النتائج التي تم الحصول عليها من الجهاز المعملي المعتمد المذكور سالفا و أعطت النتائج معامل ارتباط قوي وصل الى 0.93 في الاتجاه الموجب

Abstract: - This research paper is concentrating on measuring the vibration signal online during the sewing process of some Denim fabric. A selected type of Jeans fabric was going under several wet treatment. Each type of those wet treatment process has its own impact on the fabric. These wet treatment affected the physical properties of the fabric and hence its Sewability. A Piezoelectric sensor (Accelerometer) was installed as near as possible from the needle bar on a sewing machine. The sensor were connected to a special Data Acquisition card with high dynamic range for such purposes. The data were collected and analyzed. Some important statistics feature were extracted. Those extracted features were compared to those resulted from the L & M Sewability Tester. The results gave a good correlation with the new applied technique up to 0.92. The Author preferred to divide the work into two separate paper namely vibration –Part I- and acoustic-Part II- in order to elaborate more on sound pressure signal in the textile field.

Key-Words: Sewability, L & M Sewability Tester, Denim Fabric, Wet Process

1 Introduction

Chemical Finishing Processes affects fabric physical properties. Sewability of Denim Fabric are much affected by its wet process treatment. Some of them improve the Sewability, while other put negative impacts. Sewing process is one of the critical processes in Garment and Apparel manufacturing. it is well known that vibration analysis is widely used in the field of rotating machine condition monitoring. The researchers have used many analysis techniques in order to be able to predict machine faults as early as possible. Many of them used to apply the time-averaging of vibrating signal method. In this research paper the author will apply the same technology. The author will utilize the Piezoelectric sensor in sensing the vibration of the sewing machine during the sewing process of certain fabric. The fabric type and construction will be the same , but the finishing and wet process will be different .Therefore the results will be much affected

2.1 Selection of Sensors

2.1.1 Selection of Accelerometer

IMI Accelerometer IEPE was selected. A low cost industrial Piezoelectric sensor was chosen and installed in the rig to monitor the vibration of the rotating parts in the machine. Model 603C01 - Industrial ICP® Accelerometer, Typical ICP® Sensor System (Source:IMI Sensors Operating Manual). Piezoelectric Sensor Specifications:
Low-cost Industrial ICP® Accelerometer
Model 603C01
General purpose, industrial, ceramic shear ICP® acceleration, 100 mV/g, 0.5 to 10k Hz, top exit, 2-pin connection..

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Sensitivity: (±10%) 100 mV/g (10.2 mV/(m/s²))
Frequency Range: (±3dB) 30 to 600000 cpm (0.5 to 10000 Hz)
Measurement Range: ±50 g (±490 m/s²)
Electrical Connector: 2-Pin MIL-C-5015

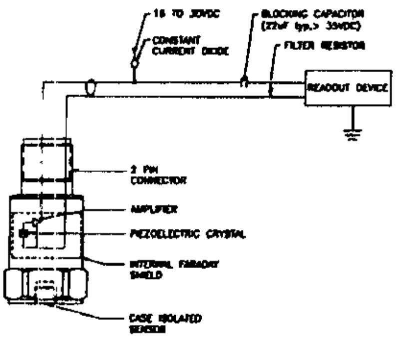
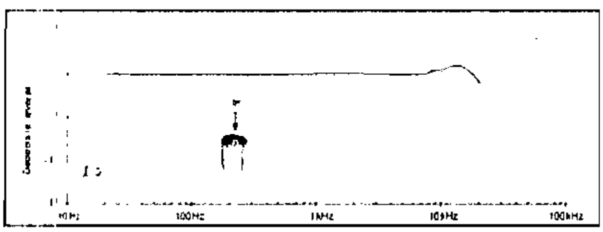


Fig2 Piezoelectric sensor
Fig. 1 Connection of Piezoelectric Sensor

2.1.2 Selection of Microphone

Type 46AE: A combination of ½-inch Prepolarized Free-field Microphone Type 40AE and ½-inch CCP Preamplifier Type 26CA with BNC co-axial connector.
For CCP transducers, the signal wire is used for reading the TEDS information directly from the preamplifier.



Fig, 3 Free Field Pre polarized Microphone
Typical frequency response of Type 46AE. Upper curve shows free-field response for 0°, lower curve shows pressure response lower curve shows pressure response. Specifications Type 46AE
Frequency response:
3.15 Hz - 20 kHz:...... ....± 2.0 dB
5 Hz - 10 kHz:.......................± 1.0 dB
Nominal sensitivity: 50 mV/Pa, Polarization voltage: 0 V, Dynamic range: , Upper limit: 135 dB re. 20 μ Pa Lower limit (thermal noise):17 dBA re. 20 μ Pa, Output impedance: Typical: < 50 Ω

Power-supply: 2 m A to 20 m A (typically 4 m A)
Maximum signal-output voltage (peak): ± 8.0 V
Temperature: Operation: -30 oC to + 70 oC
Storage: - 40 oC to + 85 oC
Coefficient (250 Hz): - 0.007 dB / °C

Relative humidity: Operation: 0 to 95 % Storage: 0 to 95 %
Influence (250 Hz): ....< 0.1 dB
Static-pressure coefficient: - 0.01 dB / k Pa
Influence of axial vibration, 1 m/s2: 63 dB re. 20 μ Pa
Connector: BNC: Co-axial
Dimensions and weight: Diameter: 13.2 mm Length: 84 mm Weight: 33 g

2.2. Selection of Hardware

2.2.1.Sewing Machine Specifications

Type: Household Sewing Machine, Stitch Formation: Lock Stitch, Mechanical Configuration: Flat-Bed, Max. Sewing Speed: 1000SPM, (Stitch per minute) Max. Sewing Thickness: 7mm Stitch Length: 6mm, Power: 150W, Overall Dimensions: 42x20x29cm, Weight: 11kgs Specifications
It is equipped with cam motion take up lever, Oscillating Shuttle and Straight lockstitch it is with electric motor installation. Suitable for garment factories in sewing cotton, woolen, Silk Fabrics and sewing for Embroidery and also can do heavy Material specially Jeans fabric .other Specification: includes Height of Presser Foot: 7mm, Stitch length: 6mm, Needle: HAx1 #14 , Packing: 42x20x29cm G.W./N.W.: 11/10 kgs

2.2.2 Selection of Data Acquisition Hardware

National Instruments offers two different modules namely NI9233 and NI 9234. The team selected to have an USB module to be operated easily on a Laptop and to be utilized in customer visits whenever it is necessary.

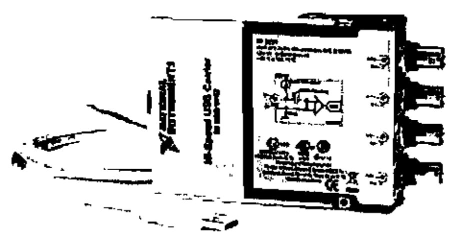


Fig 4 NI 9234,
4-Channel, ±5 V, 24-Bit Software-Selectable, IEPE and AC/DC Analog Input Module. Hi-Speed USB data transfer and USB bus-powered
The 9234 has better phase linearity than the 9233
The phase non-linearity of the 9233 means signal components at different frequencies will appear

slightly out of phase (by as much as a couple of degrees) relative to each other. Although this is not significant for most machine monitoring applications, it might be a problem for testing professional audio equipment.

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2.2.3. Selecting Software

National instruments offer s LABVIEW 8.6 LABVIEW 2009, LABVIEW 2010, LABVIEW Signal Express, LABVIEW Sound and Vibration Measurement Assistant. The later was chosen for its flexibility and ease of handling.

3 System Description - Experimental Setup

The author designed a rig for on-line real time vibration monitoring. of the sewing machine under test (see Fig. 2) A commercial sewing machine was used to simulate the industrial machine. A vibration sensor 2-Pin IMI Accelerometer 100 mV/g was fixed near the needle shaft of the sewing machine. A BNC cable was connected to a National Instrument Module. NI USB-9234 which is a high-accuracy data acquisition (DAQ) module specifically designed for high-dynamic range of sound and vibration applications. This was connected to a Laptop where NI Sound and Vibration Assistant Software were installed.

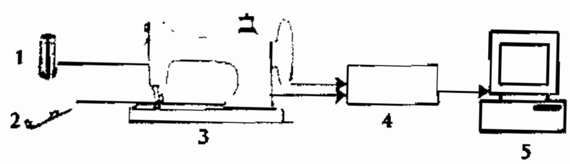

Fig 5 Block diagram of the experiment

1-Pizoelectric Sensor 2-Sensitive Microphone
3-Sewing Machine 4-Data Acquisition Card
5-Computer

Figure 6 represents a block diagram to the experiment which have a photograph in figure 3and figure 4 respectively.

The Module used for Accelerometer Measurement had 4-channels. One channel was allocated to Accelerometer. The second channel was allocated to

G.R.A.S Microphone – Free Field Pre Polarized Microphone as in Figure 1. An Electronic. The Software was set up to run continuously and measure vibration during sewing process..

Fig.6 NI 9234 USB module (Data Acquisition Card) and Computer used in the experiment

The data were acquired with rate of 50 K S/s at 24-bit resolution Analog Digital converter with 102db Dynamic range. The input voltage range was ± 5 Volt. The AC Coupling and IEPE condition always enabled. The Dynamic Signal Acquisition was equipped with variable antialiasing filters.

The system has a Hi-Speed USB Data transfer and USB bus powered. The data were acquired from the two channels simultaneously, Acceleration, Sound Pressure in Channels AI0, AI1 (Analogue Input) respectively. Then computer was instructed to log the stream of the data to the hard disk. The system was running during the sewing process of the samples shown in table 2.

3.1. Material and Method

3.1.1.Material

The author used in their experiment and research the fabric specifications shown in table 1. All fabrics were cut to 30x5 cm strips in the warp direction. Single layer fabric were used for this experiment. A strip of paper with same dimension were used for reference and calibration purpose.

Fabric Property	Fabric Wt
Fabric Weight (Wt) g/m2	302.7
Yarn Count Ne – Warp	40/1
Yarn Count Ne – Weft	36/1
No. Warp ends / cm	28
No. Weft ends / cm	21
Fabric Structure	Twill 2/1
Material	100% Cotton

Table1

3.1.2.Methods

The samples were treated with several wetting processes. These processes were mainly applied as follows: washing , washing and fashion, washing and stone wash, washing and balanced enzyme - washing and acid enzyme, washing and balanced enzyme and chlorine, washing and acid enzyme and chlorine, washing and balanced enzyme and potassium permanganate, washing and acid enzyme and potassium permanganate. All the above mentioned wet treatments were applied only to simulate the industrial processes, but the author must emphasize here that they are disagree completely with the treatments which doesn't conform with international environmental agreements (Oeko-Tex®). The author applied those treatment for the purpose of the research and to prove and indicate the difference and impact of each treatment on the sewability of the fabric. In other words to tell the garment manufacturer that some treatment are not necessary and doesn't help in improving the sewability. The permanganate samples were completely removed from the research since it has a negative impact on the environment and does not conform with Oeko-Tex standards.

3.1.3. Wet Process

The fabric washed using 1g/l Amylase Enzyme and 1g/l Detergent for 15 minutes at 60°C. The fabric were washed with water for 5 minutes at ambient temperature. Before going to sewing process the fabric were immersed in a softener solution with concentration 100g/l softener and 0.5 g/l acetic acid. The rest of wet processes were carried out according to the recommendation of some traditional garment manufacturer in order to simulate the effect of wet treatment in the research laboratory.

Sample Nr	Finishing Treatment
1	Raw Material
4	Wash
7	Wash + Neutral Enzyme
10	Wash + Acidic Enzyme
13	Wash + Neutral Enzyme + Chlorine
16	Wash + Acidic Enzyme + Chlorine
19	Wash + Fashion
22	Wash + Stone

Table 2

3.2. Vibration and Acoustic Signal Acquisition

The acquisition of the vibration signal during the sewing process was done using a moderate speed. The author adjusted a certain screw in the accelerating pedal to control the maximum speed of the machine and to hold it on an equal speed for all samples approximately 700 SPM (stitch per minute) for the research purpose. The acquisition was started before running the machine.

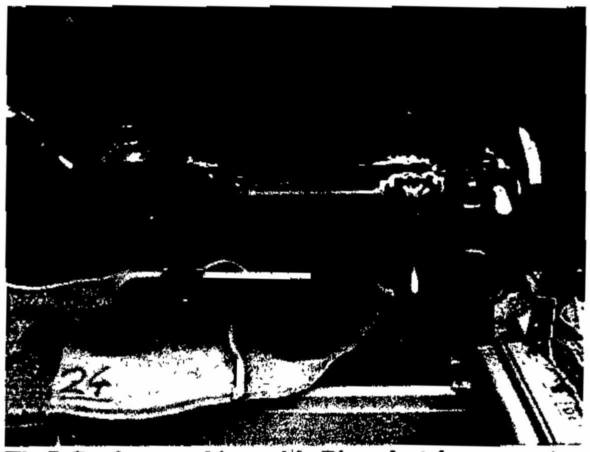

Fig.7 Sewing machine with Piezoelectric sensor top right and sensitive microphone, sample Nr. 24

The author tried to investigate the possibility of using one of those conventional parameters in diagnostic and machine condition monitoring and applying it to the prediction of sewability of Denim Fabric. The waveforms from the Vibration signal were utilized to get some parameters and statistics. Also sound pressure signal (Acoustic signal) will be also utilized and discussed in the Part II of these research. These were programmatically examined including the mean of the signal, the maximum, the minimum, the standard deviation, the variance and the root mean square. In addition to Skewness , Kurtosis and Quantile. Many literatures and researcher said that the Kurtosis is the most extracted parameter which can detect failure in rotating elements of any machine. Based on this information, the author utilized it in detecting sewabilty of Denim Fabric treated with different finishing processes.

3.3 Displaying Vibration and Acoustic Signal

The author utilized all features of the LABVIEW NI Sound and Vibration Assistant. On the Other hand the Acoustic Emission signals (AE) were utilized to get Octave Analysis, Sound Quality. Both Vibration and Acoustic Emission were expressed to Peak Search in the Frequency – Domain Measurement But as mentioned before Acoustic will be in Part II. With the ease of productivity and powerful Graphic Display of LABVIEW products. The author managed to display both signal vibration and acoustic in one screen as per figure 8. In this figure 25 groups of signals represent the response of the piezoelectric sensor form paper strip and 24 fabric samples.

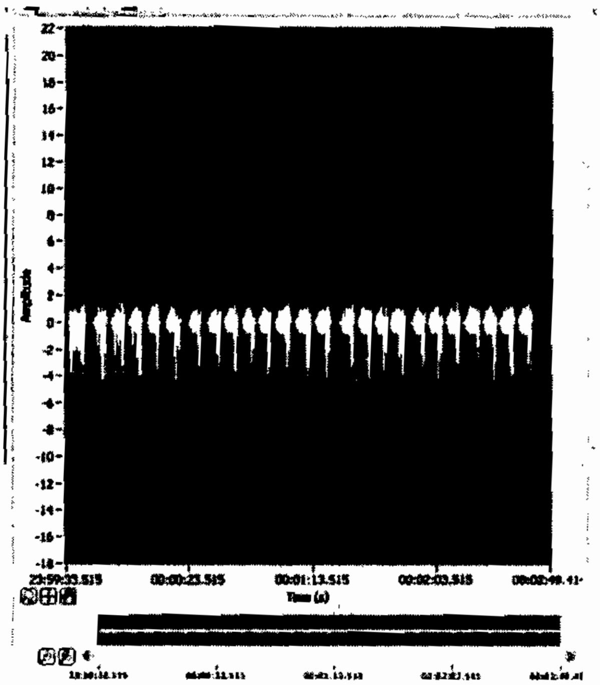

Fig. 8 – A Paper Strip and 24 Denim Samples vibration and acoustic signals

4 Analyses of the Acquired Vibration Data

The author concentrate here on the analysis of the needle bar of the sewing machine. In other word the author fixed the vibration sensor on the needle bar itself as seen in figure 9. By placing the sensor on this position, the author managed to run the machine with almost constant speed and logged the vibration data resulted from all the samples.

Fig. 9 – Vibration sensor fixed near needle bar

The software was configured to acquire and log the data automatically on the hard disk. The logged data were then treated and analyzed with DIADEM software from National Instruments. The DIADEM was configured to extract all possible statistical feature.

4.1. Signal Processing Methodology

4.2. Parameter-features extraction

The author extracted all possible features from acquired signal in order to identify the best and most suitable one to monitor the condition of the sewing machine during sewing of the fabric sample. The author managed to measure several samples several time and compare their data with each other.

Fig. 10 Enlarged Signal group for one strip of Denim Fabric

Figure 10 shows the vibration signal of sample number 24 . The white part of the signal is the vibration surrounded by the Acoustic Signal of course in Time Domain Wave Form.

The following statistics parameters were extracted from data. For all samples.

1. Summation of data values
2. Sum Of Squares
3. Minimum
4. Maximum
5. Arithmetic Mean
6. Square Mean
7. Geometric Mean
8. Harmonic Mean
9. Lower Quantile
10. Median
11. Upper Quantile
12. Range
13. Standard Deviation
14. Variance
15. Variation Coefficient
16. Quartile Distance
17. Relative Variation Coefficient
18. Average Abs Deviation From Mean
19. Average Abs Deviation From Median
20. Skewness
21. Kurtosis
22. Standard Error

These parameters were compared to the sewability results of the Denim fabric measured by the L & M Tester. Then using Microsoft Excel the Correlation Coefficients were calculated. The results are shown in Table 3..

5. Results

Table 3 shows the correlation coefficient between Fabric Sewability measured using L & M

Sewability Tester and the researcher proposed method of measurement using Piezoelectric sensor. All descriptive statistics features were extracted from the collected data. The selected features show in table 2 were found to be relative and highly correlated

Sample	LnM	StdDev	Max	Skewn	Kurtos
A1	83.0	0.0920	1.6633	-1.6819	89.4344
G1	52.5	0.1076	1.3491	-0.9433	48.7985
B1	46.5	0.1043	1.4250	-0.6594	48.0527
H1	50.0	0.1046	1.4270	-0.3946	39.1705
F1	40.5	0.1000	1.4672	-0.5090	44.2037
E1	32.0	0.1072	1.4287	-0.5351	36.5927
D1	40.5	0.0998	1.4647	-0.4318	48.3944
C1	45.5	0.1043	1.3615	-0.4904	47.3001
Correlation		-0.7038	0.7114	-0.9045	0.9294

Table3

6. Conclusion

The industrial Piezoelectric sensor was capable to measure and differentiate between fabric finishes. The denim fabric was treated as shown Table 2. It was found that sewability of the samples measured with L & M Tester were highly correlated. With the Kurtosis of the Vibration Signal with a correlation coefficient .reaches 0.93. While the correlation coefficient between vibration Signal Skewness and results of L &M Tester was -0.90 (negative). The correlation coefficient between L & M Tester and the maximum of the vibration signal was 0.7. While the correlation coefficient with standard deviation of the vibration signal was -0.70 (negative). The rest of statistics extracted feature including sum of vibrations signal, Sum, Sum Of Squares, Minimum, Arithmetic Mean, Square Mean are all have no significant relation like the rest mentioned above.

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