SYSTEMS PROPOSED FOR MEASURING, MONITORING AND ANALYSIS VIBRATION OF MACHINES FROM TEXTILE INDUSTRY

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Abstract: The purpose of this paper is to find various monitoring systems and vibration analysis of machines in the textile industry to improve their reliability. The need to reduce production costs has determined, over time, the evolution of different systems and maintenance concepts in the textile industry. Monitoring the equipment through periodic or continuous measurement of global vibrations indicates that the intervention on a machine will be made only when measurements show that this is necessary. According to the authors, the most obvious development directions of study are the following: a system for measuring, monitoring and vibration analysis with triaxial piezoelectric accelerometer mounted on each machine in the textile industry which will be connected to a data acquisition system with FFT spectrum analysis system, which will include a program for automatic calculation of the optimum operating modes; system for measuring, monitoring and FFT spectrum analysis with laser vibrometer for distance speed measurement, acceleration, displacement and vibration. This laser vibrometer which includes a PC program for automatic calculation of the optimum operating modes and modal analysis. On-line monitoring systems of vibration and other industrial parameters are designed for continuous monitoring of vibration amplitudes to equipment and industrial machinery and for study and analysis of vibration on laboratory stands. Also, the system can also be used for on-line monitoring of the other parameters in the textile industry.

Key words: measuring systems, vibrations, software, operating modes, regimuri de lucru, FFT spectral analysis.

ARTICLE INFO
Article history:
Received 04. avg 2015. Received in revised form 02. avg. 2015 Accepted 05. oct. 2015. Available online 10. jan. 2015.

1. INTRODUCTION

The development of consumer society has imposed development of industrial activity and determined some bigger productions, of better quality and at a low price. The price of any product, no matter the industry or the type of production, maintenance costs represents a significant percentage of the price of the products. [1]

The need to reduce production costs has resulted, over time, the evolution of different systems and maintenance concepts.

Monitoring the equipment through periodic or continuous measurement of global vibration indicates that intervention on a machine will be made only when measurements
show that this is necessary. [2] Vibration monitoring can be performed with a wide range of devices. Their goal is to accurately measure the vibrations amplitudes, vibration frequency and phase to allow effective diagnostic status of the machines. On the market there is a wide range of devices, each capable of a variety of performances. These can be classified as follows [3]:

- Vibrometers (devices for measuring global vibration)
- Analyzers swept filter
- Data collectors, including FFT spectrum (FFT Fast Fourier transform)
- Real-time Spectrum Analyzers
- On-line systems, acquisition boards (analog and digital).

In practice, the vibration signals are composed of a large amount of frequencies occurring simultaneously, so that they can not be analyzed, only by studying the characteristic amplitude – time (Figure 1) to determine the number of simultaneous components and frequencies of production of these vibration. [4]

**Fig. 1:** Oscillogram of vibration amplitude-time

These components can highlighted by tracing the characteristics amplitude-frequency (Figure 2.)

**Fig. 2:** Frequency spectrogram
Dividing the vibratory signals in individual frequency components is called frequency analysis, a technique which can be regarded as the fundamental stone of diagnosis based on vibration measurements. The curve which indicates the vibration level according to the frequency is called frequency spectrogram. In this way we can determine, using spectral analysis, the unwanted vibration source and types of faults that cause these vibrations. [5]

The use of modern methods of diagnosing these machines allow correct identification of the defect, by measuring the machines vibrations.

The vibrometers, analyzers and data collectors which are considered off-line systems are designed, in general, for implementing predictive maintenance, and on-line systems are considered tools needed to implement proactive maintenance [6].

Currently, many industrial companies have both monitoring systems on-line and off-line and hybrid systems.

With the help of off-line systems the data are collected at a predetermined time, then being transferred to a computer, where, with the help of maintenance programs they are analyzed.

In this case, monitoring of dynamic equipment shall be based on program tracking their operating status in terms of vibration measurements.

On-line monitoring systems of vibration and other industrial parameters are designed for continuous monitoring of vibration amplitudes for equipment and industrial machinery and also for vibration study and analysis and on laboratory stands. Also, the system can also be used for on-line monitoring of industrial or other parameters, such as temperature, pressure, flow, voltage, etc.

The systems can be used both as stationary equipment, laboratory and as portable equipment for field measurements.

These systems allow the performance of three categories of vibration measurements and monitoring of other industrial parameters by connecting the appropriate sensor.

Laser vibrometer system consists of the following parts:

- **laser sensor** ("laser head"), which emits laser beam on the sample measured
- **central unit (module controller)** that processes the signal from the sensor. [7]

In Figure 3 there is shown a laser vibrometer system of high-frequency Speed Vector OptoMet and in Figure 4 a laser-Vector Speed vibrometer system with optional modules.

**Fig. 3: Laser vibrometer system of high frequency – Vector Speed OptoMet**
The central unit contains a speed decoder D-VD-3 to extract the signal measured, the vibration speed of the sample in the point where it is illuminated by the laser beam.

Main technical characteristics

- Maximum frequency of the signal measured 2.5 MHz.
- Measuring the speed through the decoder, between limits 0 and 10 m/s to 2.5 MHz.
- The number of measurement domains of vibration velocity: 11 (0.01 / 0.02 / 0.05 / 0.1 / 0.2 / 0.5 / 1 / 2 / 5 / 8 / 10 m/s).
- Sensitivity: 10 nm / (s√Hz).
- Measurement domain 500 mm – 100 m. Other measurement domains can be chosen optionally.
- Resolution of vibration speed: 0.01 µm/s.
- Power of laser sensor: < 1 mW for eye protection, 633 nm, visible red beam.
- The laser sensor does not weigh more than 4 Kg. The sensor with the central unit can be easily mounted on positioning devices - tripod.
- Central unit (Module controller), can be controlled from an external computer through the RS232 or USB interface.
- Central unit weight together with laser sensor is 11 kg.
- Output signal: analog, BNC connector.
- Interfaces: touch screen 3.5 " + 20 LED bargraph segments, menu buttons, key switch type (power) laser switch ON / OFF.
- Dimensions: length 370 mm x width 120 mm x height 100 mm.
- The decoder D, DD-3 for measuring the displacement amplitude in the range 1 µm - 100 mm.

Fig. 4: The laser vibrometer Vector Speed with optional modules
Composition of delivery

a. Laser vibrometer of high frequency Vector-Speed - 1 piece
   - D-VD-3 decoder for measuring the vibration velocity - 1 piece
b. Lens objective for long distance 500 mm - 100 m, bayonet lens - 1 piece
c. Digital oscilloscope with software for data acquisition and analysis on laptop or PC: -1 piece
   - Oscilloscope Picoscope, USB of high resolution, resolution of 16 bits bandwidth
     5 MHz, low noise, dual channel sampling 10 MS/s
   - Arbitrary waveform generator
   - Connection to PC: USB 2.0 Hi-Speed
   - Software PicoScope, SDK compatible with Windows XP, Windows Vista and
     Windows 7
   - FFT spectral analysis program included. [7]

2. THE EXPERIMENTAL PART

It is well known that recorded increased vibration of textile industry machines can cause a series of significant defects affecting the production process such as:

- thread breakage,
- needle wear,
- excessive wear of mechanisms and parts that make up the powertrain.

To this end, in order to reduce vibrations and diagnosing the cause of accidental shutdowns on Happy embroidery machine have been performed a set of measurement vibrations in order to determine the optimum operating regimes. [8]

Before performing the vibration measurements were established the following technical requirements: type of vibration measurements; establishing the measurement points and directions; vibration parameters and their values; setting the operating modes.

Considering that embroidery machine manufacturer does not specify the allowable vibration level of the machine nor the optimum operating modes leading to increased reliability, we determined that these can be determined by measuring the vibrations. [9]

The experimental part conducted on Happy embroidery machine consisted in determining the optimum operating modes to which the quality and productivity is increased and embroidery machine reliability will be maintained at a high level.

The operating modes of may change depending on the wear of machine parts (components of the driveline, needle, engine drive etc.) and highlight the weaknesses or non-compliances that may occur during the manufacturing process. These can be influenced by the type of needle, the density of the material, etc. and can be considered after analysing the vibration levels and a complex process, this operating method can be expanded to other machines in the textile industry. These operating modes were established and published by the authors in an earlier paper. [9]
Determining operating modes by measuring vibrations can be considered as a personal contribution to increasing the reliability of the machines used in the textile industry. For the Z measurement direction (the direction on which the sensor is installed) and fabric advance on the X direction, the optimal operating mode is at 700 sinking/min. Operating modes can change based on the wear of machine parts (components of the kinematic chain, needle, motor drive etc.) and highlight the weaknesses or nonconformities that may occur in the production process.

The results obtained in this study will allow a number of potential directions to be sketched out and followed in order to continue this research. The most obvious ulterior development directions for the study are, in the author's opinion:

1. A system for measuring, monitoring and analyzing vibrations with triaxial piezoelectric accelerometers installed on every machine in the textile industry which will be connected to a retrieval system with FFT spectral analysis, a system which will include an application to automatically calculate the optimal operating modes (Figure 5). The vibration measurement system consists of:
   - piezoelectric accelerometers: n pieces
   - ICP modules: n channels
   - AMDT retrieval module: - n analog inputs, 8 digital inputs, 8 digital outputs, 4 analog outputs
The data retrieval system consists of:
   - 2 base devices with 16 GB of memory
   - 2 retrieval modules for AMDT vibrations

**Fig. 5: System for measuring, monitoring and analyzing vibrations with triaxial piezoelectric accelerometers**
2. System for measuring, monitoring and FFT spectral analysis with laser vibrometer for non-contact measurements of vibration velocity, displacement and acceleration. This laser vibrometer will include a computer program to automatically calculate the optimal operating modes and perform modal analysis (Figure 6.). The laser vibrometer system consists of:

- Laser sensor (“laser head”), emitting the laser beam towards the measurement sample
- The central unit (modulated controller), which processes the signal from the sensor.

The central unit contains a D-VD-3 decoder to extract from the measured signed the vibration velocity of the sample in the section illuminated by the laser beam.

![Diagram of Diagnosis System with Laser Vibrometer](image)

**Fig. 6. System for measuring, monitoring and FFT spectral analysis with laser vibrometer**

3. CONCLUSIONS

In conclusion the authors propose:

A system for measuring, monitoring and vibration analysis with triaxial piezoelectric accelerometer mounted on each machine in the textile industry which will be connected to a data acquisition system with FFT spectrum analysis system that will include a program for automatic calculation of the optimum operating modes of the embroidery machines.

A system for measuring, monitoring and FFT spectrum analysis with laser vibrometer for remote measurements of speed, acceleration, displacement and vibration. This laser vibrometer which includes a PC program for automatic calculation of the optimum modes and modal analysis of the embroidery machines.
All these proposals were foreseen and can be subject to possible future research that would lead to the automatic monitoring with the help of the computer of the sewing process and the implementation of significant reliability of the machines from the textile industry.

4. REFERENCES