

3D Experimental Vibration Analysis of Washer Extractor Using Planar Laser Sensors

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Abstract: This paper deal with measuring and evaluating the spatial motion of industrial washer extractor in two working modes. The article also describes 3D motion measurement device, which is unique by using 2D laser sensors. Washer extractor, on which the measurement was performed, is produced by Alliance Laundry Systems in Příbor. The patented measuring equipment, including software, is characterized by speed and simplicity of the measured data evaluation as well as easy application to the measurement device. This paper is primary focused on measuring the spatial movement of the rotating part of the industrial washer extractor. However, the presented method can be used to measure any object with a known stiffness.

Introduction

Following long-term development of the measuring system, which is evident in contributions [1, 2], the spatial movement analysis of the FX135 washer extractor drum was performed. Measurements were performed for two different wash cycles - rinsing and spinning. For both wash cycles, ordinary textile filling of the drum was used. The measurement aim was to determine the spatial movement of the four selected points of the analyzed body. In the context of the washer extractor manufacturer requirements, the 3D motion analysis of the washing unit drum is necessary especially in case of engineering design. The advantage is the possibility of further use the measured data for example to determine the critical speed, optimize the flexible placing or as the input data of the MPK software.

Since the method of measurement is the content of the patent, only the basic information about the measuring device will be given in subsequent chapters. With respect to paper scope, the evaluation software will not be discussed

Measurement apparatus description

The measurement equipment has undergone several modifications during its development. Current hardware version includes two 2D laser displacement sensors and one axis displacement sensor. Measurement can be complemented by a speed sensor of the washing unit drum. All the sensors used are synchronized together using a separate measuring card. For easy and fast measurement preparation, displacement sensors are mounted on an adjustable measurement stand. This stand allows precise adjustment of the distance and angle of the laser sensors relative to the auxiliary jig. The auxiliary jig is firmly attached by magnets on the movable part of the measured device. The hardware also includes other features that provide power to the sensors and transfer the measured data to the computer.

The above measuring device configuration allows measurement of the spatial movement of any vibrating object. Any complicated preparation or modification of the measured object is not required for the measurement realization.

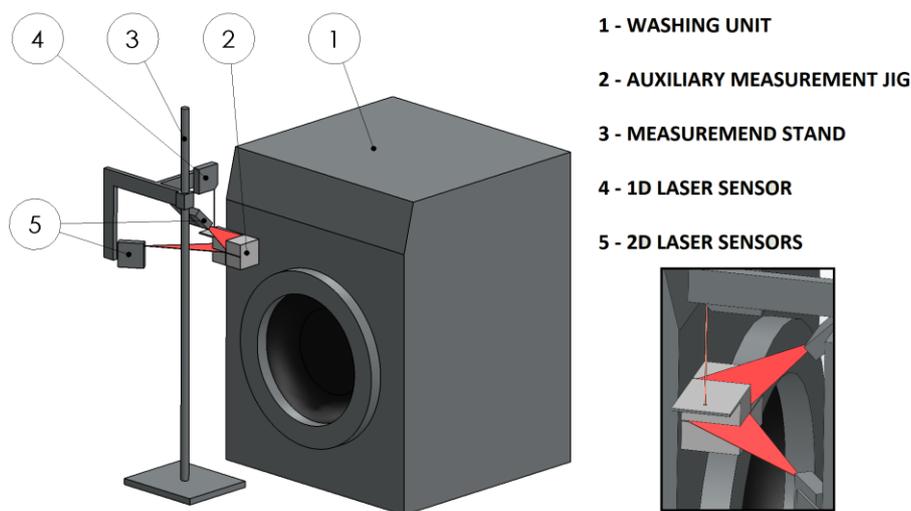


Fig. 13 Measurement apparatus for spatial motion evaluation

The second major part of the apparatus is software, including a measurement module and a data evaluation module. The measurement software allows precise adjustment of individual laser sensors. Another feature of measurement software is the possibility to store measured data to a file. The evaluation part of the software analyzes the measured data and converts it into graphical form. The software allows direct monitoring of measured data over time. It also provides a complete spatial motion analysis in both 2D and 3D visualizations. The spatial motion can be analyzed for any number of points of the measured object.

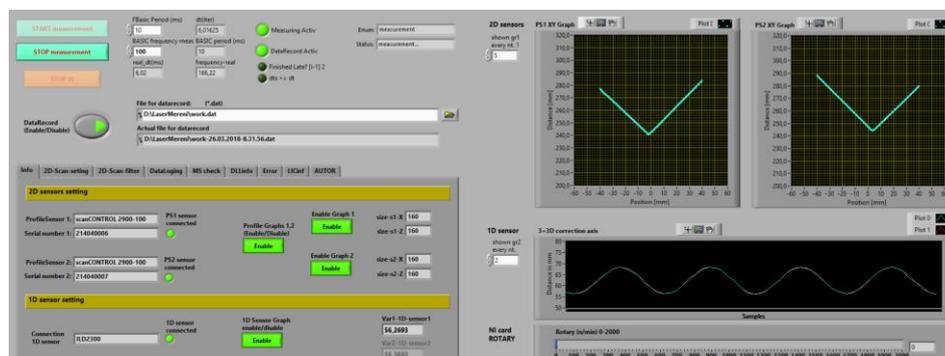


Fig. 14 Measurement software

Measurement analysis

Besides the drum, there are many other members inside the industrial washer extractor, such as control systems, driving unit, water and detergent inlets or drainages. It is necessary to take care to avoid a collision with those members in the design of the washer extractor unit. For the development of industrial washing machines, it is necessary to measure the spatial motion of the washing drum in testing laboratories.

Four points were selected for the washing machine spatial motion analysis. The first point (labeled 0) is also the reference point of the auxiliary measurement jig. The second point (labeled 1) corresponds to the washing drum center at the front of the washing unit. The next two points (labeled 2 and 3) are located at the top and bottom right corners of the industrial washing machine. The layout diagram is shown in figure 3 (b) below. Figure 3 (a) shows photo of practical measurement.

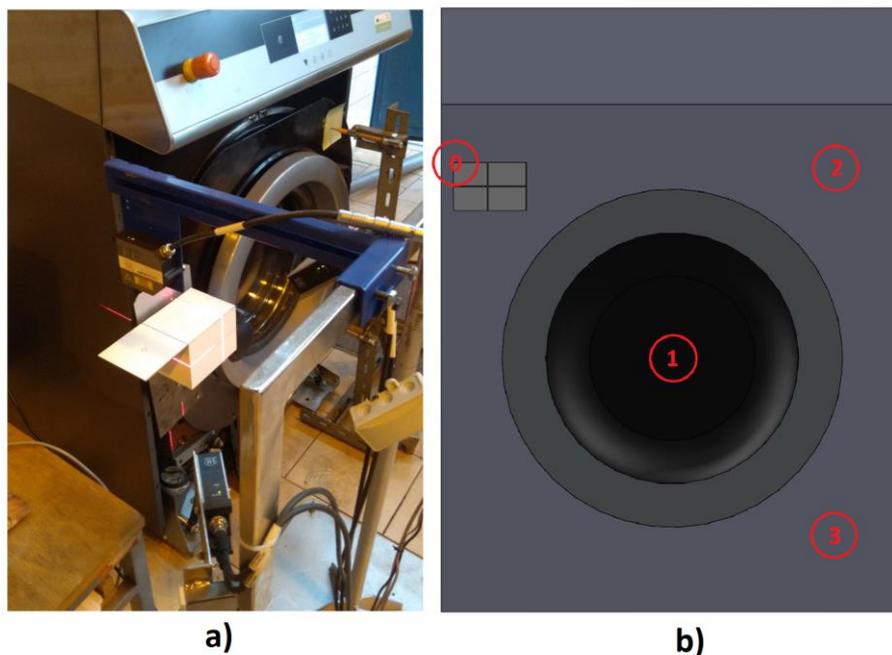


Fig. 15 a) real measurement photo, b) measurement points placement scheme

Spatial movement in the rinse program was measured first. The length of this program is 13 minutes. The speed of the washing drum is relatively low in the rinsing mode. During the rinsing cycle, the washing drum is filled by water, which causes drum weight increase and the reference point static displacement. Second, the washing with spinning was measured. The drum speed reaches maximum values during spinning.

The movement in 3D and in XY, ZY, ZX planes was evaluated for individual measurement points. The XY plane corresponds the side view, the ZY plane corresponds the top view, and the ZX plane corresponds the view from the front. The individual measured displacements were also plotted in time for each point.

Table 3 - Measurement results

Washing cycle	Measurement point	0	1	2	3
Rinsing	Δx [mm]	7,4	5,5	15,6	13,9
	Δy [mm]	19,8	53,9	78,8	84,0
	Δz [mm]	15,4	13,1	34,2	49,7
Spinning	Δx [mm]	17,5	46,3	76,3	71,1
	Δy [mm]	15,4	24,7	34,6	35,0
	Δz [mm]	19,9	12,7	20,2	19,2

Graphical results will be presented here only for reference point 0. The following figures show the deflections of point 0 for both measured cycles. The top part of figure 4 shows deviations in the individual planes including the 3D image for the rinsing cycle. The lower part of figure 4 shows the time record of spatial motion in individual coordinate components.

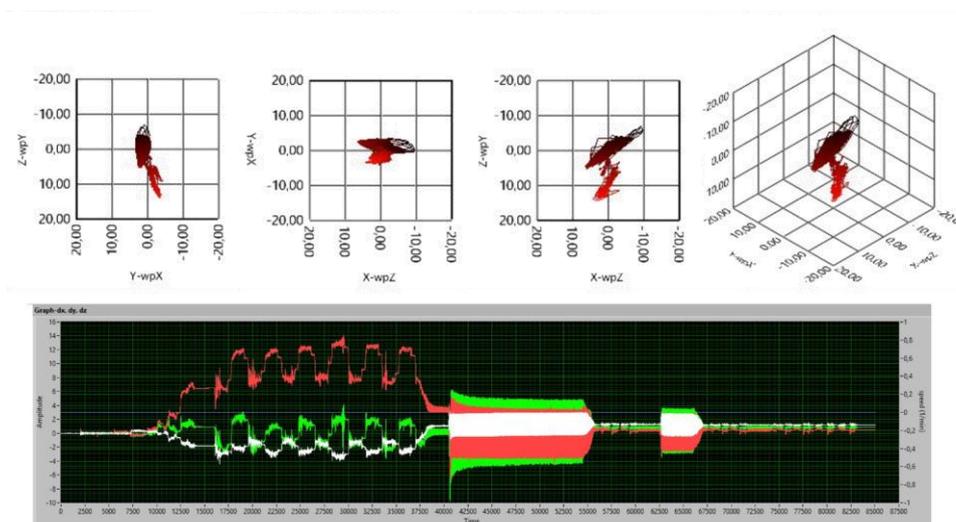


Fig. 16 Motion during the whole rinsing cycle (point 0)

Figure 5 shows the spatial motion of the reference point 0 for the spinning cycle. In its bottom part, the time record of individual deviations throughout the measurement is again shown.

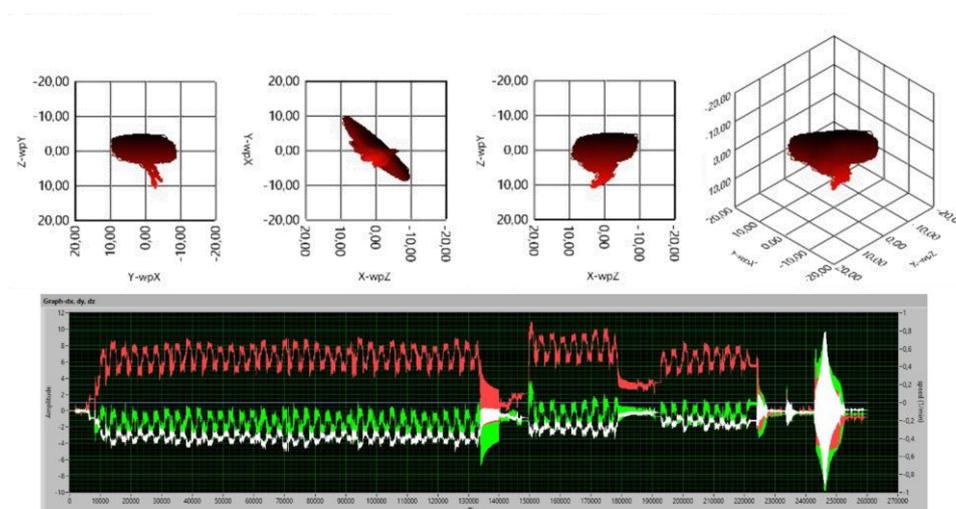


Fig. 17 Motion during the whole spinning cycle (point 0)

Conclusion

This contribution presents a device for accurate measurement and evaluation of spatial movement of rigid structures. The subject of the measurement is the industrial washer FX135. Two washing cycles - rinsing and spinning were selected to measure spatial motion. The data were evaluated at four points in each of the wash cycles. The resulting displacements in individual points are shown in table 1 above.

The washer extractor drum was filled with conventional textile filling during the measurement. It can be assumed considerable variability of the imbalance distribution of the drum in case of repeated measurements. In the case of evaluating a higher number of measurements, it is recommended to use stochastic approaches for evaluating the results.

The measurement result is important statement used by the washer extractor manufacturer to design and develop new equipment.

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