Measurement and Evaluation of Spatial Motion of Washer Extractor

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Abstract: This paper describes the measurement stand for the determination of the spatial motion of the rigid structure. As the example, the drum of the washing unit can be given. The measurement system uses 2D laser sensors to obtain the instantaneous position of the point at the device investigated. The motion of any point can be then calculated on the base of known body stiffness. The measurement method is sufficiently accurate and makes possible the cheap and simple evaluation of the motion or vibrations of the construction.

Keywords: measurement; spatial motion; washer extractor; laser distance sensor.

1 Introduction

This paper builds on contributions [1, 2] which deal with the measurement of the motion of the washing unit using six one-component position sensors. The newly designed system is based on 2D laser sensors. The measurement is primarily focused on the determination of the drum motion of the washing unit. However, this method can be used for measurement of any other rigid object.

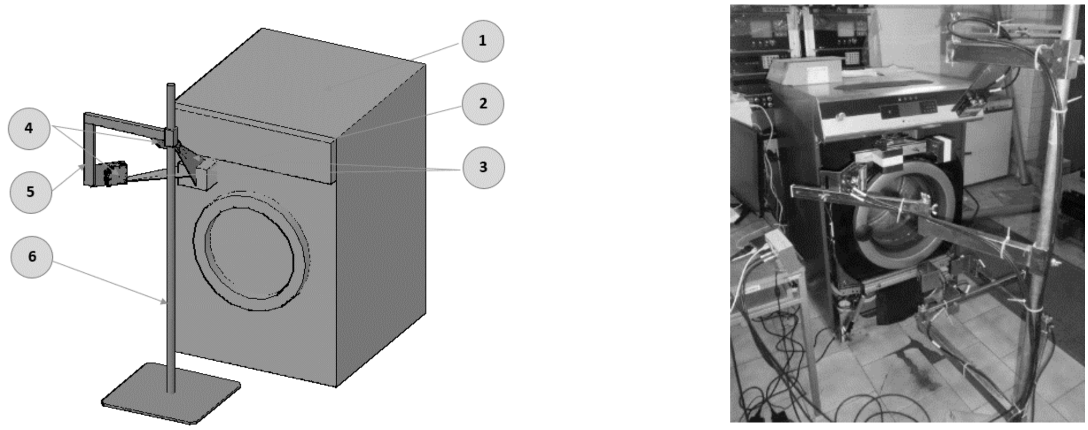
2 Description of the Measurement System

The measurement and evaluation is realized based on two main components - hardware and software.

The first one utilizes two 2D laser distance sensors (Position 4, Fig. 1) placed at a specific angle and distance toward the auxiliary measurement jig (Position 2, Fig. 1), which is attached by magnets to the object being investigated (Position 1, Fig. 1). The proper placement of laser distance sensors is guaranteed through the auxiliary bracket with the fixed space for these sensors (Position 5, Fig. 1). The auxiliary bracket also provides the possibility to adjust the height (Position 6, Fig. 1). The whole scheme allows fast installation and start of the measurement process. The hardware equipment provides the power for sensors and realizes the transfer of data collected during the measurement to a service PC.

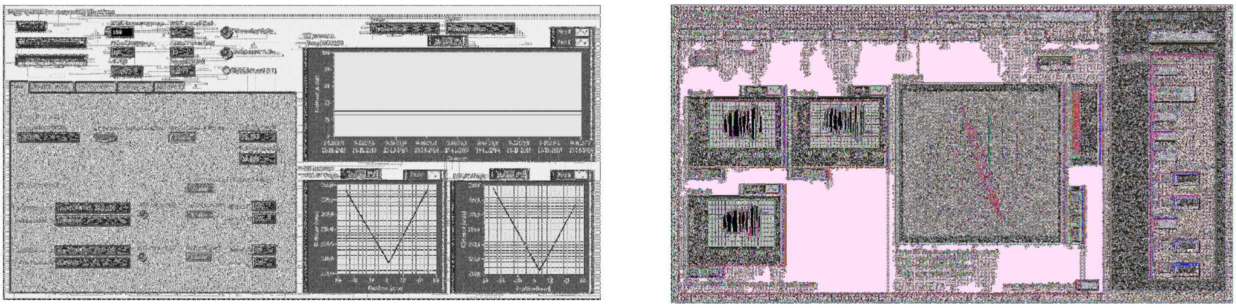
The second part contains the measurement and evaluation software. The measurement software (Fig. 2a) provides information at the connection of laser sensors and allows the user to adjust precisely the mode of their operation, filtering and smoothing of profile data in every image. Furthermore, it includes a function to control and input the measured data into a file, including runtime control with information about the iterative processing of individual images from the measurement.

The evaluation software (Fig. 2b) analyses and displays the spatial motion of the body based on the data acquired and stored via the measurement software. With this program, the user can directly see the basic data and individual images from the measurement or perform the complete analysis of the motion of the body in both 2D and 3D visualizations.



a) Stand scheme b) Real configuration

Fig. 1: Measurement stand for evaluation of spatial motion.



a) Measurement software b) Evaluation software

Fig. 2: Software for measurement and evaluation of spatial motion.

3 Measurement

The measurement system was developed and tested in laboratory conditions where very good results were achieved. In order to verify the functionality, the stand was equipped with a series of additional laser one-dimensional sensors. Subsequently, the calculated results were compared with those from auxiliary sensors.

In addition to laboratory measurements, the measurements in practical conditions in the factory was realized.

In order to design the chassis of the washing unit, it is necessary to know the motion of individual points of the washing drum. The inner space of the washing machine is filled with other members such as driving unit, mechanical members (for example vibration and impact dampers), electrical wiring, control systems and emergency members. Thus, the motion of the washing drum is limited. The shape of the chassis is fully influenced by exterior design of the washing machine given by the appearance. Thus, it is obvious that knowledge of the motion of individual drum points in all modes of the washing cycle is essential.

The following table (Tab. 1) summarizes results obtained from measurements in practical conditions on two types of washing units. The evaluation software makes possible to approximate the trajectory of any point at the washing drum. In Table 1, amplitudes of the point (located at the front of the washing unit at its upper left corner) in individual directions are recorded.

The column "Mode" in Table 1 represents the washing program (short 13 min., long 40 min.). The column "Filling" represents the contain of the washing drum (jeans – washing machine was filled by jeans cloths, rubber – washing machine was filled by rubber segments simulating the 15% imbalance, stop in the column "Notice" indicates the emergency state – see bellow).

Tab. 1: Measurement results.

Measurement	Washing machine	Mode	Filling	Δx [mm]	Δy [mm]	Δz [mm]	Notice
1	1	short	jeans	13,5	4,9	9,9	
2	1	short	jeans	48,3	8,7	17,36	stop
3	1	short	jeans	17,3	4,7	12,37	
4	1	short	jeans	6,9	4,7	8,96	
5	1	short	jeans	25,3	4,7	16,55	stop
6	1	long	jeans	28,2	6,2	15,52	
7	2	short	rubber	23,9	4,9	14,6	
8	2	short	rubber	24,1	4,9	14,4	
9	2	short	rubber	24,1	5,0	14,5	

Records of the measurement 3 on the washing unit 1 is depicted in following figures. Again, the results correspond to the front of the washing unit at its upper left corner. The motion depicted in 3D visualization is obvious in Fig. 3. Individual graphs represent the motion in individual axes x, y, z with respect to the main coordinate system of the measuring stand. Motions can be easily converted to any coordinate system chosen.

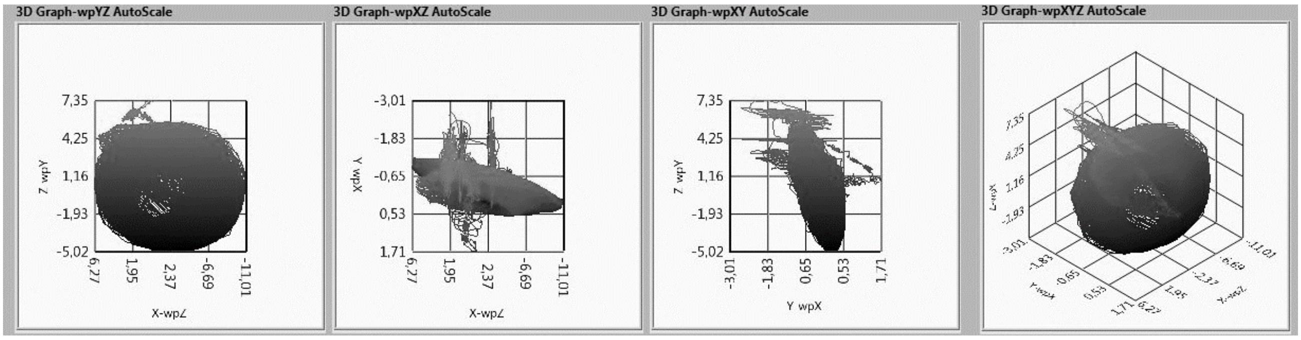


Fig. 3: Motion during the whole washing cycle in 3D visualization (measurement nr. 3).

Figure 4 represents the motion during the whole washing cycle. The significant shift of the washing drum can be seen at the beginning of the record. This shift is related to the filling of the drum and needs to be taken into the account. Then, the washing process proceeds. At the end of the washing process it is obvious that the washing unit does not return to its initial position. The initial sag does not appear during testing with the rubber imbalance. It is necessary to realize that simulation with clothes (in our case with jeans at 50% of maximal load) gives truer image than an experiment with mere imbalance. On the other hand, there are uncertain inputs concerning the repeatability and potential numerical simulation. Further, also other types of filling need to be used for more complex description of the behavior.

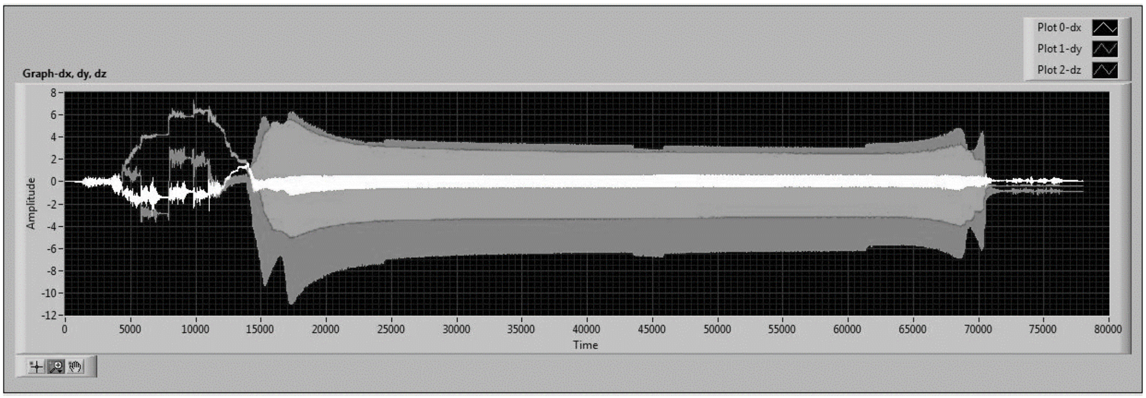


Fig. 4: Motion during the whole washing cycle (measurement nr. 3).

The emergency switch was activated during the measurement nr. 2. This switch guards the deflection of the washing drum so that both the damage of the devices located in the inside of the washing unit frame and collision between the drum and housing of the washing unit is avoided. After the guarding sensor is activated, the chosen washing program is interrupted, speed of the drum is reduced so that the cloth adopts more uniform position and after approx. four minutes the original washing program proceeds. Such case represents the emergency state which is not desirable. The emergency state was activated also during measurement nr. 5 – see Fig. 5. Results obtained by measurement make possible a better understanding of the motion parameters of the washing unit and allow to optimize the inner arrangement of the washing unit. The information obtained can also help during setting up the simulation models. The software for evaluation was positively accepted by the company designers and is being tested at present time.

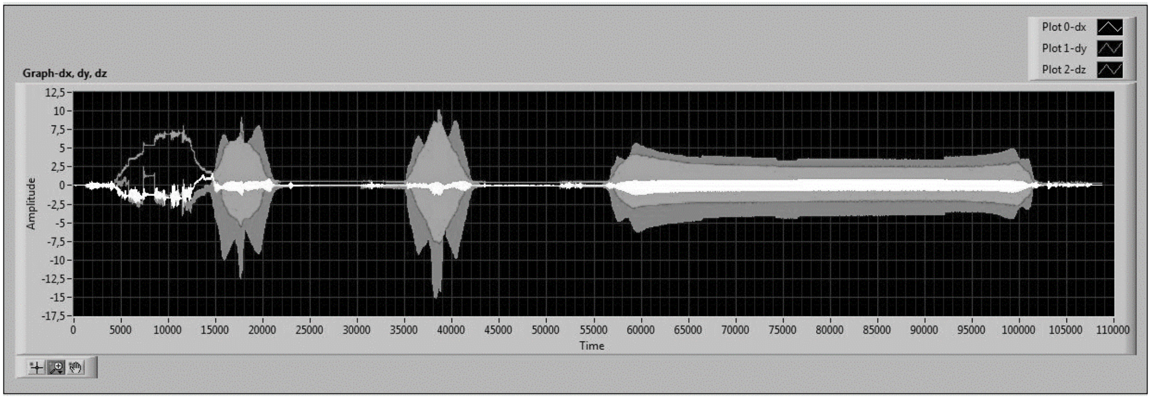


Fig. 5: Motion during the whole washing cycle with emergency switch (measurement nr. 5).

4 Conclusion

This contribution describes the laser system designed for the measurement of the spatial motion of (sufficiently) rigid object, for instance the drum of washing unit. It is the improved stand related to the original measurement system which is consisting of six one-component sensors of motion – see [1, 2]. The great benefit of the new measuring stand is significantly faster manipulation and measurement preparation. The contribution deals with the measurement performed in the factory designing and producing washing units. However, the method developed is not limited only to the measurements of washing drums. It can be used for measurement of any object engaging the spatial motion.

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