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CALIBRATION OF THE PRESSURE SENSOR WITH A CERAMIC MEMBRANE

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Abstract: For the correct estimation of the energy consumption of mixing of a bulk material, it is necessary to know the stress in the particulate matter in front of the mixing elements. Despite the theoretical knowledge of the stress in front of a blade, in the world there isn´t a experimental verification yet. The problem is to find a suitable measurement system. At the Institute of Chemical and Hydraulic Machines and Equipment, Faculty on Mechanical Engineering of the Slovak University of Technology in Bratislava, there was such the measurement system designed. However, it should be calibrated for the proper use. This article deals with the measurement of pressure using a pressure sensor with a ceramic membrane and with calibration of this sensor for liquid and for a point load on the ceramic membrane simulating a point load of particular matter.
Keywords: energy consumption, mixing, bulk material, pressure sensor, ceramic membrane

1. INTRODUCTION
In the present time research works about particulate matter are dealing mainly with computer simulations. However, for the correct deal of the mixing process and its energy consumption are experiments are necessary, too. The measurement system has to be design and properly calibrate so that experiments could be considered relevant.

2. EXPERIMENT
For the experiments, there are used components like the pressure sensor with a ceramic membrane TSZ S 1003G 40X0KQSQ0 from the company MERET, s.r.o., the measuring card SPIDER 8 and a special preparation for these measurements.

The actual calibration consisted of two sets of measurements. In the first group of measurements, the calibration curve was determined using the pressure sensor and an electrical output of the measuring card to transfer pressure. In the second group of measurements, it was necessary to load the sensor with a point force to simulate a touch particle of particulate matter with a ceramic membrane in different locations of the membrane. This experiment determined the active zone of the surface of the sensor, where there is a real pressure measurement.

3. MEASUREMENTS
3.1. Calibration of the pressure sensor with a liquid
The aim of these measurements was to determine the constant of the pressure sensor that would convert the measuring from the card directly to units of pressure. In the beginning, the pressure sensor was consolidated in a vertical position with the preparation. The preparation consisted of a tube with an internal diameter of 24 mm and the piston of the same diameter. Between the piston and the ceramic membrane, a layer of a vaseline was applied. The vaseline was the medium for the transmission of pressure induced by the piston with weights.

Eight weights were used for induction of pressure in the vaseline. These weights which caused the pressure in the vaseline are shown in the Table 1. Each measurement was repeated seven times

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with each weight. The results are the seven dependences on the measured electric current on the card for measuring the pressure exerted weights (Figure 1). Statistical analysis of these measurements was found a linear relationship and resulting in a constant sensor 13695,8. Multiplying the output of the measuring card (mA) by this constant, we can directly obtain the pressure (Pa) based on the ceramic membrane.

Table 1. The weights, force and pressure induced weights

Weight	Mass of loading weight, (kg)	Force induced weight, (N)	Pressure induced weight, (Pa)
1.	13,615	133,56	295 389
2.	27,305	267,86	592 405
3.	41,025	402,46	890 073
4.	54,685	536,46	1 186 438
5.	68,330	670,32	1 482 478
6.	81,945	803,88	1 777 867
7.	95,640	938,23	2 074 992
8.	109,475	1 073,95	2 375 154

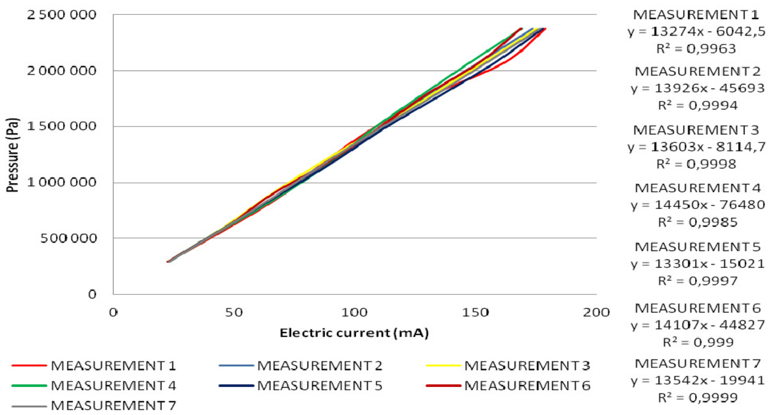

Figure 1. The dependence of the measured electric current on the sensor and pressure induced weights

3.2. Calibration of the pressure sensor with the tip representing a point load

In these measurements, we proceeded as follows. The pressure sensor together and the preparation in the form of tube were consolidated in a vertical position. The piston that caused pressure on the sensor of the ceramic membrane had four holes. These holes were used to position the tip, which consisted of a roller of a roller bearing with diameter of 2 mm with a hemispherical tip. Moving the tip, we simulated a point load on various locations of the ceramic membrane of the pressure sensor. To induce more weight we used several loads. All measurements were carried out on four positions of the tip location (A, B, C, D) (Figure 2), with nine mass of weights (Table 2) and every measurement was repeated seven times for each weight and each position of the tip. A graphical representation of the pressure dependent on the force which was induced by weights is in Figure 3 and a graphical representation of the pressure dependent on the position of the tip is shown in Figure 4.

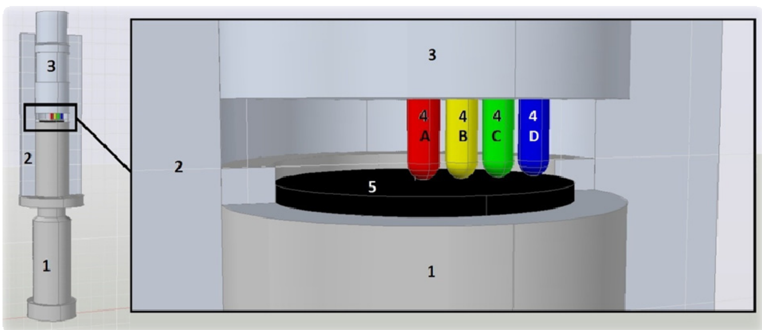

Figure 2 . Model of the calibration station. 1) pressure sensor TSZ 1003G S 40X0KQSQ0 made by the company MERET, s.r.o., 2) calibration preparation in the cut, 3) calibration piston, 4) tips in positions A-B-C-D, 5) ceramic membrane of pressure sensor.

Table 2. The weights, force and pressure induced weights

Weight	Mass of loading weight, (kg)	Force induced weight, (N)	Average pressure induced weight, (Pa)			
			Tip A	Tip B	Tip C	Tip D
1.	0,202	1,99	104800	34800	500	-167
2.	0,403	3,95	204400	66800	333	-500
3.	0,702	6,89	356600	117200	500	-1167
4.	0,899	8,82	455400	149200	833	-1667
5.	1,202	11,79	608600	200000	1333	-2000
6.	1,703	16,70	861200	282000	1333	-3500
7.	2,202	21,60	1115600	366200	1667	-4500
8.	2,702	26,51	1368400	453600	10800	-6833
9.	3,201	31,41	1605000	541600	19800	-8000

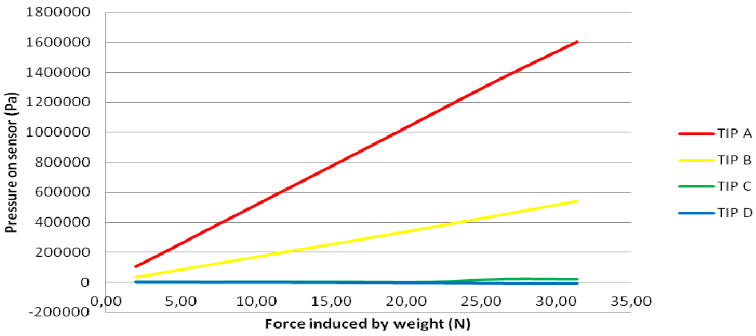

Figure 3. Graphical representation of the pressure dependent on the force induced by weights

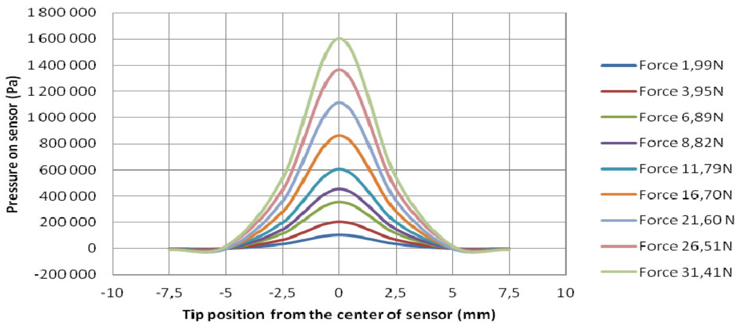

Figure 4. Graphical representation of the pressure dependent on the position of the tip

4. RESULTS OF THE EXPERIMENT

In the first group of measurements, the conversion constant of sensor 13695,8 was found. This was used later for direct reading of the pressure exerted on the ceramic membrane of the pressure sensor.

In the second group, the goal was to map the measurements of pressure at different weights which acted on point on the ceramic membrane of the sensor. The initial measurements showed that the pressure at the same radius stayed unchanged and the problem could be addressed as the 2-dimensional task. From the Figure 3, it is observed that the increase in pressure was almost linearly dependent with increasing mass of weights and each tip position. On the Figure 4, it is observed the process of the pressure dependent on the tip location and the size of the force induced by weights. The ceramic membrane was centered on 0 mm (tip position A) and the tip positions were 2,5 mm (B), 5 mm (C) and 7,5 mm (D) from the center. Taking these measurements into consideration, it can be concluded that in spite of the ceramic membrane with diameter of 18 mm, the active zone of the sensor has the diameter of 10 mm.

5. CONCLUSION

The aim of these measurements was to observe the behaviour of the pressure sensor with ceramic membrane and its subsequent application of the stress field in particulate matter in front of the mixing elements. To apply these assumptions to the mixing of bulk material, it was necessary to determine the behaviour of the ceramic membrane and point load and to simulate the load of particulate matter. Before the measurement of the mixing station with the blade equipped by such sensors, it is necessary to perform further measurements with different layers of material in a variety of particle sizes of particulate matter. Pressure sensors with ceramic membrane which are calibrated like this can be used to measure correctly the stress field on the blade of homogenizer of bulk material.

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