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APPLICATION OF FORCE MEASURING PIN TO MEASURE WEIGHT ON THE Z10 CRANE

Abstract. The paper describes a force measuring pin (force transducer) mounted on a Z10 crane of an MS-40 bridge-laying vehicle. The design, main specifications and operating principle of the BROSA 0201 force measuring pin are presented. The paper focuses on measurement results obtained with the use of the force transducer.

Keywords: force measuring pin, BROSA 0201, Z10 crane, MS-40 support bridge, DAGLEZJA-S.

1. INTRODUCTION

The MS-40 support bridge, codename "DAGLEZJA-S", is designed for transporting and launching of bridge spans over water or other terrain obstacles up to 40 metres wide, enabling the crossing of obstacles by vehicles of MLC70/110 class according to STANAG 2021 [3][4]. The load suspended on the sheave of the Z10 crane of the MS-40 bridge laying vehicle is measured by means of a strain gauge pin-type transducer [1][2]. The use of this type of precision transducers in truck-mounted crane is unusual, because most of the measuring systems in cranes measure the force acting on the lifting cable. The use of a precision force transducer allows to determine the real value of the forces derived from the load suspended on the sheave and to determine and take into account the action of dynamic force components. The force measuring transducer was installed to act as a bolt in the upper sheave block at the tip of the crane boom (Fig. 1).

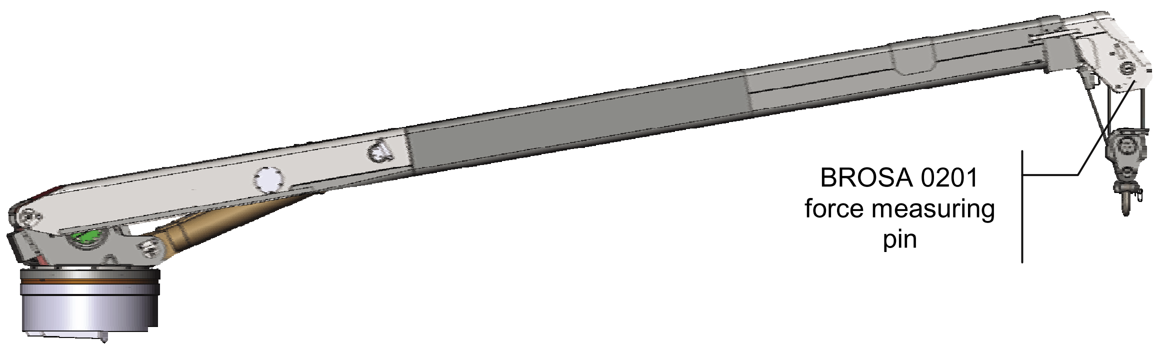

Fig. 1. Location of the transducer on the Z10 crane

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2. BROSA 0201 FORCE MEASURING PIN

The BROSA 0201 pin-type force transducer used (Fig. 2) enables precise measurement of force. The operating principle of the transducer is illustrated in Fig. 3.

BROSA 0201 is made of high-strength stainless steel with the option to define outer dimensions. It maintains its high measuring accuracy for a long time. It is resistant to overload and is equipped with a temperature compensated integrated amplifier. It is also resistant to electromagnetic field interference (EMC) [5][7].

Fig 2. BROSA 0201 force measuring pin [5]

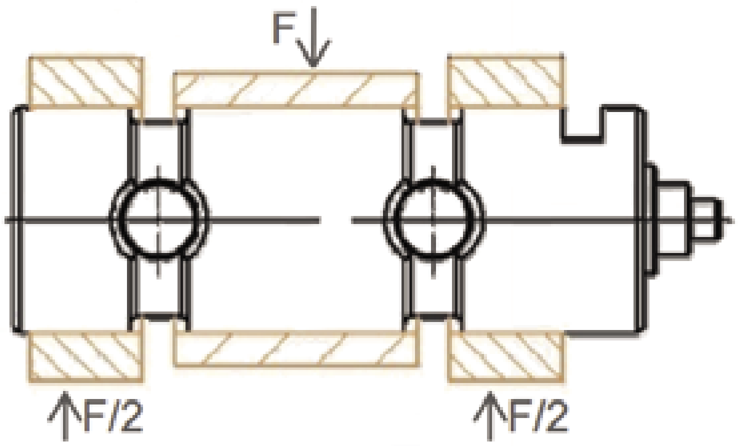

Fig. 3. Operating principle of the BROSA 0201 force measuring pin [6]

Some of the major specifications of BROSA 0201 are listed in Table 1. The most favourable option available with BROSA 0201 is for the design engineer to specify, for a particular application, the required outer dimensions and to propose other (than shown in Table 1) technical specifications of the transducer. In such case the force transducer is tailored for use on a specific device, rather than the other way round, when the entire measuring system has to be adapted to the transducer.

Table 1. Selected specifications of BROSA 0201 force measuring pin [5]

Parameter:	Value:
Measuring range	10 kN to 5000 kN (depending on the needs)
Accuracy	≤ 0.5% FS
Maximum overload	> 150 %, option: 300 %
Hysteresis	≤ 0.5% FS
Operating temperature	-40°C to +80°C
Temperature coefficient	≤ 0.0035%/K
Output signal	4-20 mA, options, e.g.: CANopen, PROFINET
Protection class	IP67, option: IP69K
Electrical protection	Reverse polarity protection, overvoltage and short-circuit protection

3. MEASUREMENT RESULTS

Tests were performed on a real physical object, the MS-40 bridge laying vehicle with the Z10 crane, onto which the force measuring pin was installed. The presented transducer features a measuring range of up to 500kN and overall measuring accuracy of 1%. The measuring device was made to order with the outer dimensions of the pin adapted to specified requirements.

Having an array of loads of known weight and an additional certified device for measuring force, it was possible to carry out a series of various experimental tests of the Z10 crane with the transducer installed onto it. The measurement results transmitted in the form of a data frame were read directly from the transducer by means of a signal converter, and the data were then processed (using Microsoft Excel) to plot graphs. Some of the measurement results are presented in this paper. It should be noted that tests were carried out under windless conditions.

The first test consisted in suspending a load of specified weight and manipulating the hoist – changing the elevation of the sheave with the suspended load. Along with the measurement results, the effect of crane inclination angle on the measuring accuracy is also presented.

Table 2. Measured results obtained from the BROSA 0201 force measuring pin installed on the Z10 crane

Weight (kg)	Angle (°)	During lifting	During lowering	Stabilized after lifting (under the upper sheave)	Stabilized after lowering (ca. 10 cm above ground)
5020	70	212	195	206	200
5020	62	210	196	206	198
5020	55	210	193	205	203
1190	70	55	50	53	51
1190	50	55	50	53	52
1190	30	55	50	54	51
1190	10	55	50	54	52

The results given in Table 2 are the direct readouts from the transducer (decimal value with no unit of measure). Table 2 specifies the weights and angles at which the results were read. The following columns show the values read during the movement of the load and after stopping it (after it becomes stable).

Visual comparison between test results is shown in graphs (Figs. 4 and 5) upon processing the data (Table 2) to obtain weight values from the indications of the force transducer. The graph in Fig. 4 shows differences in indications for a load of 5020 kg, whereas the one in Fig. 5 for a load of 1190 kg.

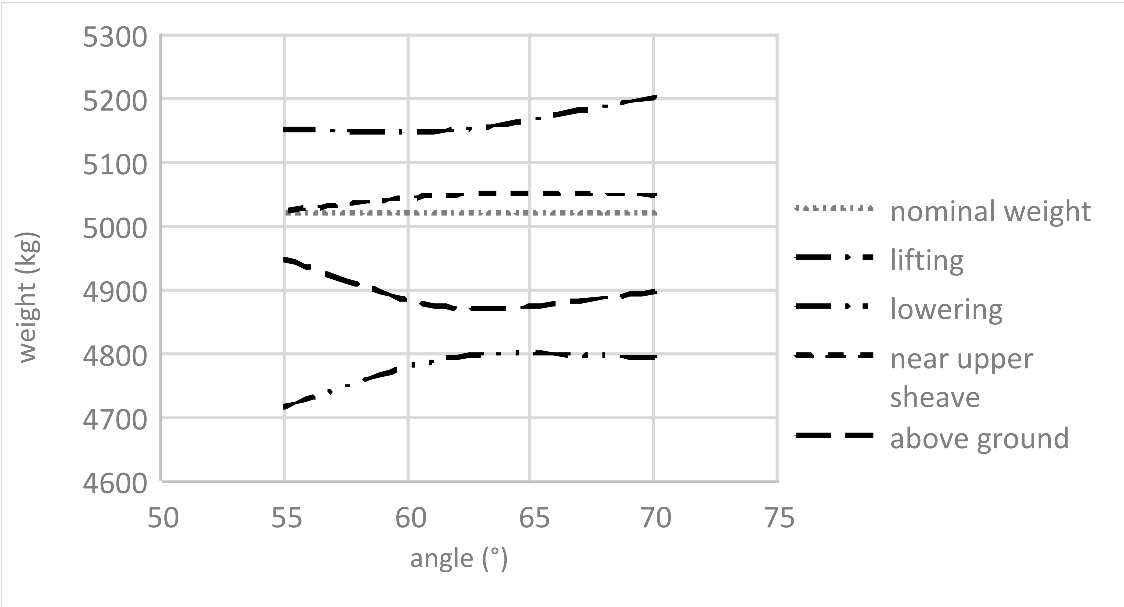

Fig 4. Differences in indications for a 5,020 kg load

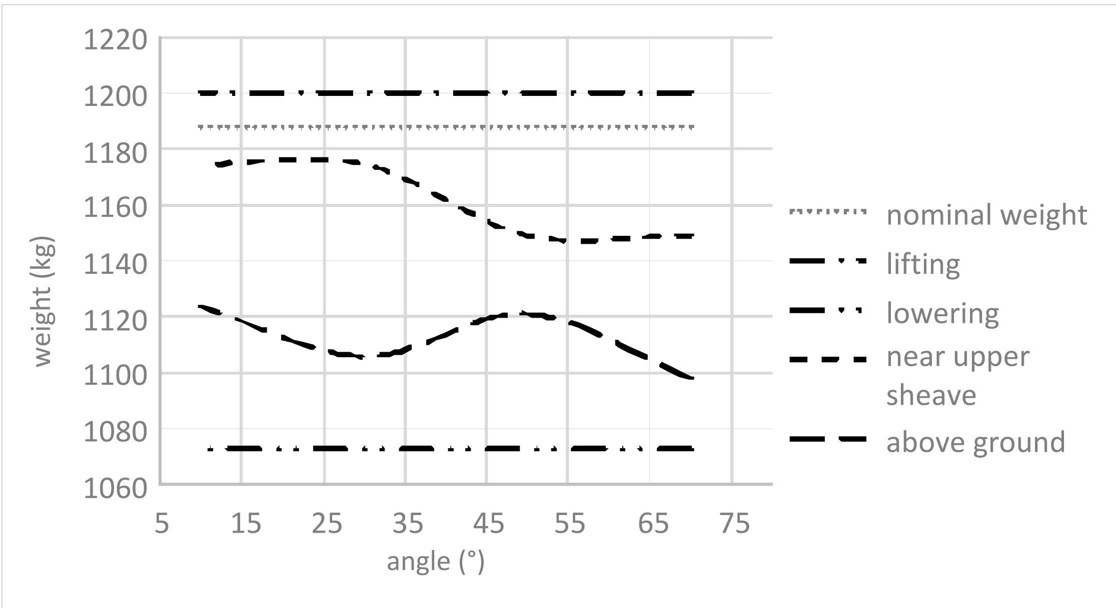

Fig 5. Differences in indications for a 1,190 kg load

In subsequent step tests were carried out to verify how the extension of the telescopic boom of the crane affects the measurement results. For better clarity, one selected case is illustrated (Fig. 6) where the suspended load is 1,190 kg and the angle of inclination is 40°.

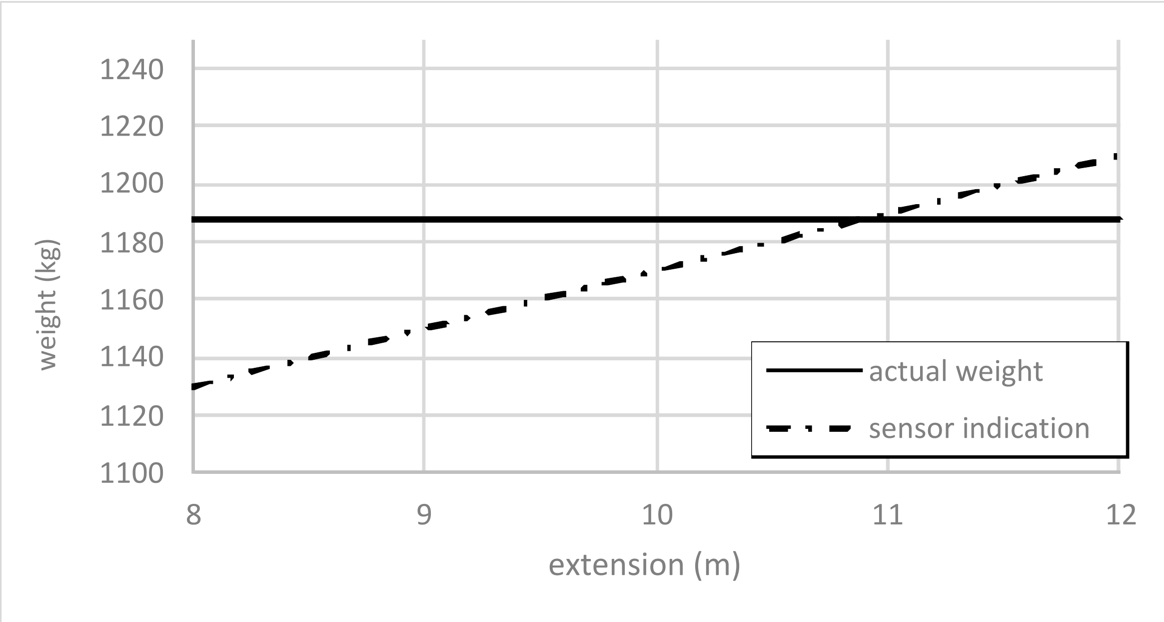

Fig 6. Differences in indications for a 1,190 kg load at various degrees of telescopic boom extension

The presented data show that the value indicated by the BROSA 0201 transducer mounted on the Z10 crane differs from the actual values depending on the operating parameters of the crane. Unfortunately, it was not possible to determine the effect of the installation method of the measuring pin on the measurement results. Such tests will possibly be performed in future.

After a series of different tests, including those not discussed in this article, it can be said that the measurement error is repeatable, so that the error value could be included as a certain constant in the crane controller program.

4. CONCLUSIONS

The use of strain gauge pin-type force transducer enables accurate measurement, it even detects interference from minor impacts of wind and movement controls of the Z10 crane. The collected measurement results indicate that the presented force transducer is better suited for accurate measurements in closed spaces, e.g. in a laboratory. In the case of the usual crane arrangement working in the open, a transducer for the measurement of forces acting in the cable seems to be a better solution, because in that case the cable acts as a damper and temporary (pulse) deviations of indications are much smaller.

The measurement deviations presented in this paper arise from the angle of contact between the cable and pulley because the results are reproducible when operating parameters are identical, but they change when the operating parameters change.

5. REFERENCES

[1] Makowski T., Pawłowski Sz., Płatek T.: Układ sterowania mostu przewoźnego wykorzystującego magistralę CAN. Szybkobieżne Pojazdy Gąsienicowe (37) No. 2, 2015, pp. 49-55). OBRUM Sp. z o.o. Gliwice, 2015.

[2] Makowski T., Pawłowski Sz.: Control system for Z10 crane on MS-40 support bridge. Szybkobieżne Pojazdy Gąsienicowe (40) No. 2, 2016, pp. 31-37). OBRUM Sp. z o.o. Gliwice, 2016.

[3] STANAG 2021 "Military Load Classification of Bridges, Ferries, Rafts And Vehicles", Edition 6, 7 September 2006.

[4] Ordinance No. 38 of the Minister of Infrastructure of 26 October 2010 on the procedure of MLC classification of new and reconstructed bridges of public roads (Dz.Urz.MI.2010.13.37).

[5] Specification Sheet. Force measuring pin type 0201. 2012

[6] Specification Sheet. Datasheet for inquiry – Load pin Type 0201. 2013

[7] Force measuring pin, http://www.brosa.net/en/products/force-measuring-pin.html, [retrieved: 15 April 2016]

[8] Żuraw Z10. (OBRUM documents – unpublished). Gliwice, 2015.