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SYSTEM FOR REGISTRATION RADIAL FORCES FOR METAL SPINNING PROCESES

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Abstract. *For experimental metal spinning processes on turning machines we need measure radial forces of forming tool. This forces we need known for safe turning machine from overloading, and also we can increase lifetime of machine parts and forming tools.*
Keywords: *spinning processes, radial forces, strain gauge, Wheatstone measurement bridge, Arduino Uno.*

We have designed the special system for measuring radial forces of metal spinning process. Fig. 1 shows the scheme of this system.

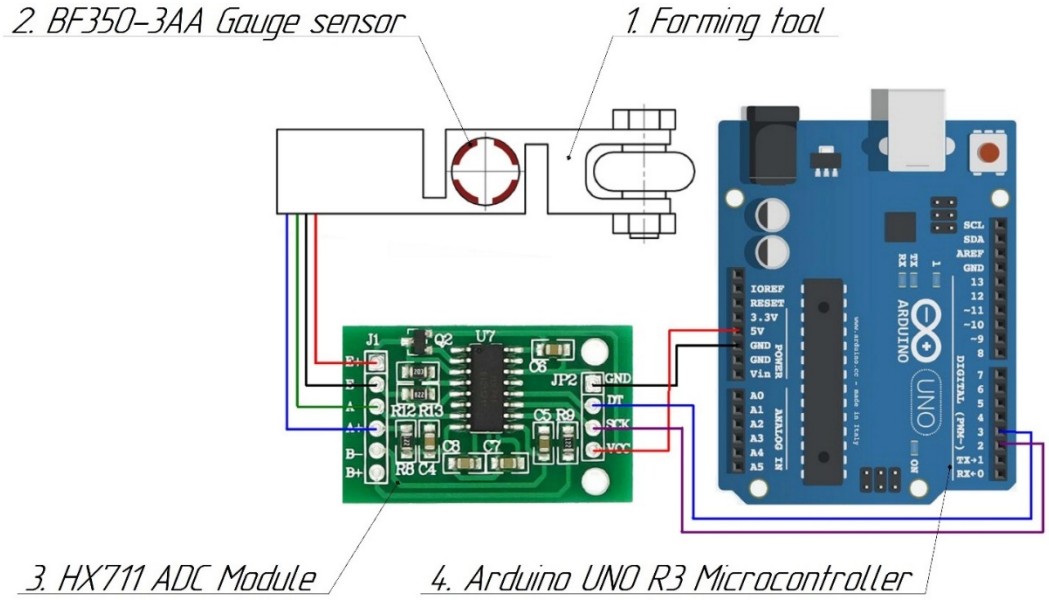

Fig. 1. Scheme of system for registration radial forces for metal spinning processes

Registration system consist of next parts:

1. Forming tool – includes the tool body and the forming roll which connected with the axis pin. Body of forming tool have stress concentration slots, which allows increase body strain of metal spinning process forces on the place where mounted strain gauges.

Approximate force of forming tool during metal spinning process we have calculated in the simulation software system – DEFORM-3D [1]. This calculated force was used for design tool body geometry during static structural analysis in the software complex – SolidWorks, which include CAE add-on for the finite element analysis – SolidWorks Simulation.

The goal of this analysis is design optimal tool body geometry and get biggest strain of tool body in places for strain gauges during work process. Also this force must don't exceed strain limit of strain gauges (2%) and proportionality limit of tool body material.

2. Four strain gauges BF350-3AA are installed on special place of forming tool. This strain gauges are film resistors deposited on a thin, flexible carrier material. The film is very thin, so it can

easily be stressed (strain is limited to about 10^{-3}). Fig. 2 shows general layout of a thin film strain gauge. [2]

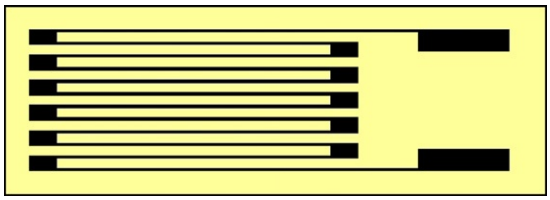

Fig. 2 General layout of a thin film strain gauge

Wheatstone measurement bridge consists of four strain gauges which are connected to HX711 ADC Module.

Table 1

Technical characteristics of strain gauges BF350-3AA.

Nominal resistance	350 Ohm
Tolerance of resistance	< ±0,1%.
Gauge factor	2,0 – 2,20
Dimensions	7.1 mm x 4.5 mm

3. Amplifier HX711 – is a precision 24-bit analogue to-digital converter. This chip works directly with a bridge sensor. By connecting the amplifier to Arduino microcontroller we will be able to read the changes in the resistance of strain gauges.

Table 2

Technical characteristics of Amplifier HX711.

Operation Voltage	5 V
Output data rate	80 Hz
Output of data	24 bit
Operation Current	< 10 mA
Differential input voltage	~ 40 mV
Selectable gain	2; 64; 128
Selectable output data rate	10 Hz or 80 Hz

4. Arduino UNO R3 – is a microcontroller board based on the ATmega328 [3]. The USB port of the Arduino Uno can be connected to a desktop/laptop.

Table 3

Technical characteristics of microcontroller Arduino UNO R3.

Input voltage	5-20 V
Flash Memory	32 kb
SRAM	2 kb
EEPROM	1 kb
Digital I/O Pins	14 (6 PWM outputs)
Analog Inputs	6
Clock Speed	16 MHz
Interfaces	UART TTL, I2C (TWI), SPI

References:

1. Deform-3D – http://www.tesis.com.ru/software/deform
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3. Seyed Reza Larimi, Hojatollah Rezaei Nejadb, Michael Oyatsi, Allen O'Briena, Mina Hoorfar, Homayoun Najjaran – Low-cost ultra-stretchable strain sensors for monitoring human motion and bio-signals; Elsevier 2018.