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# LOW – COST CNC DIMENSIONAL INSPECTION GAUGES IMPROVING

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***Abstract (TNR 9 pt Bold):*** *The paper describes the way in which a low cost and efficient measuring and scanning system was obtained, starting from existing equipment in the Faculty of Product Design from Transilvania University of Brasov. It refers to a YAMAHA robotic 1-D axis, for translation entraining, which was disposed to another 1-D entraining axis (which was manufactured with recycled components and controlled by an Arduino microcontroller). For dimensional inspection and scanning, a portable and flexible support as third axis was adapted, may include any type of measuring device. In this way, a low - cost three axes ordering system the coordinate measuring was possible to be obtained. The advantages of the proposed solution are: simplicity, low-cost, high accuracy and precision. The main disadvantage is that it does not allow a quick displaying and processing of the results. This is the subject of future research on improving the proposed solution.*
***Keywords (TNR 9 pt Bold):*** *entraining axis, microcontroller, measuring, scanning*

## 1. COORDINATE MEASURING SYSTEMS – KEY ROLE FOR QUALITY INSURANCE

Due to the fact that allow very accurate and efficient dimensional measurement and scans of parts components with applications in all fields, in the last years the use of the coordinate measuring machines has experienced unprecedented development. Equipped with complex software environment, these are very user friendly, allowing access without the need for excessive baggage of knowledge on their use. The only disadvantage on their widespread use is the high purchase price.
Therefore, one of the main goals of our research is to create and develop a low-cost and effective type CNC coordinate machine for testing and scanning of small complex components with applications in industry.

## 2. TWO AXES COORDINATE MEASURING SYSTEM – STEPS TO ACHIEVE

The starting point for manufacturing and implementing the system consisted into a 1-D robotic entraining axis, manufactured by YAMAHA (figure 1), which technical characteristics are presented in the table below [1], [2]:

**Table 1:** First robotic entraining axis, technical characteristics

| | |
|---|---|
| Range | 600 mm |
| Ordering | DC motor coupled with ball screw |
| Accuracy | 0.005 mm |

a) b) c)

**Figure 1:** The first 1-D entraining axis: a) axis arrangement; b) power supply module; c) hardware interface for PC connecting

The axis is equipped with a conveyor for different components transport, technological processing or manufacturing quality inspection.
To increase the applications field in terms of quality inspection, the research aim was to extend the possibilities to measure and to scan different type of components. For this reason, it was took the question to dispose a second axis, which orientation is at 90° to the first one. In this way a 2D translation coordinate system could be obtained.
Mechanical standpoint, the second entraining axis (figure 2) was composed by several recycled components, providing from a scrapped printer. Over the conveyor was then ordered first axis.

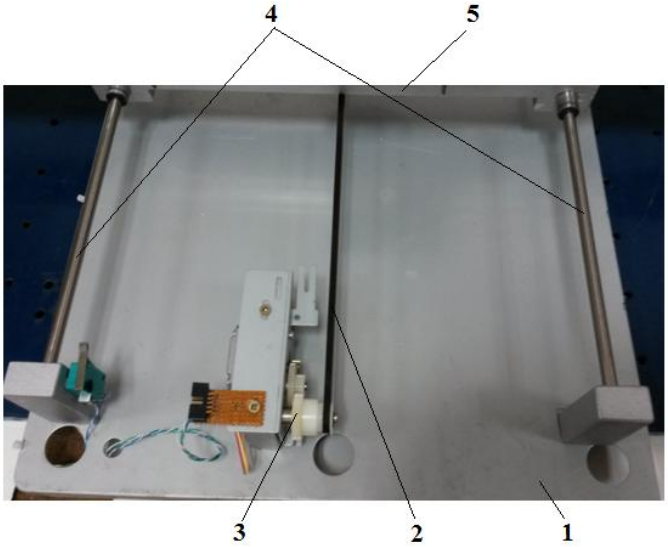


**Figure 2:** The second entraining axis: 1 – support plate, 2 – toothed belt; 3 – engine with reduction; 4 – guide bars; 5 - conveyor

Hardware standpoint, a base plate was used, on which some electronic components were fixed (figure 3) (an *Arduino* microcontroller, a display, connection sockets etc.) [3]. Another plate serve (figure 3) as support for some command buttons [4].

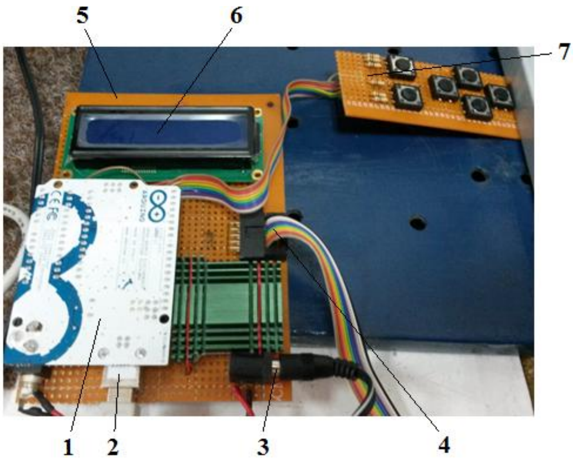


**Figure 3:** Hardware system to command the second entraining axis: 1 – Arduino microcontroller; 2 – USB plug-in connection; 3 – supply cable socket; 4 – plug-in connection for the engine; 5 – base support; 6 – display; 7 – second plate with push buttons for command

Composing both axes, a two axes drive system was obtained, as can be seen in figure 4. Besides, a measuring and scanning system was disposed to complete the 3-D CNC dimensional inspection system (figure 6). The measuring system, as the third axis was obtained using a magnetic flexible support and a measuring device (figure 5). The system allows disposing the measuring support in any position, the latter one could be in contact or non-contact principle. Thus means that different type of measuring devices can be used, including also optical non contact displacement transducer with LASER ray.

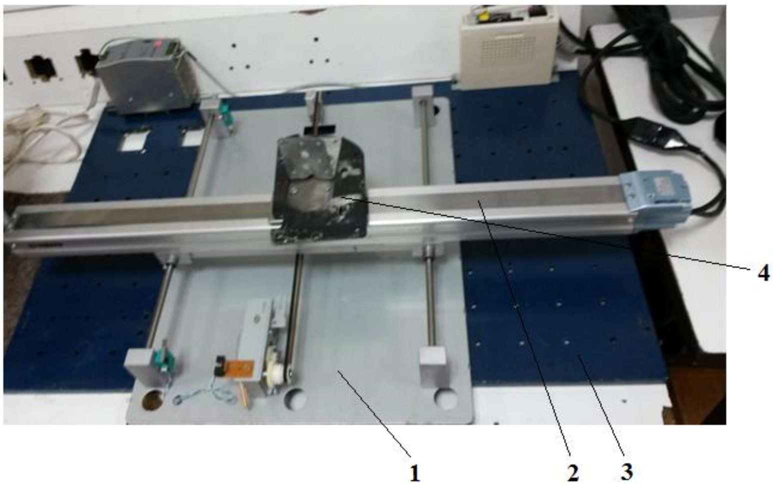

**Figure 4:** Two axes drive system: 1 – the first axis; 2 – the second axis; 3 – base support; 4 – conveyor with fixing system of the tested probes

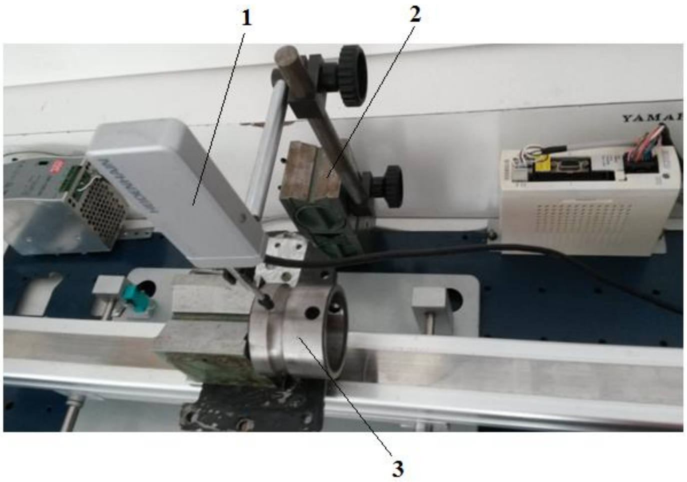

**Figure 5:** Measuring system support disposing: 1 – magnetic flexible support; 2 – measuring device; 3 – tested probe

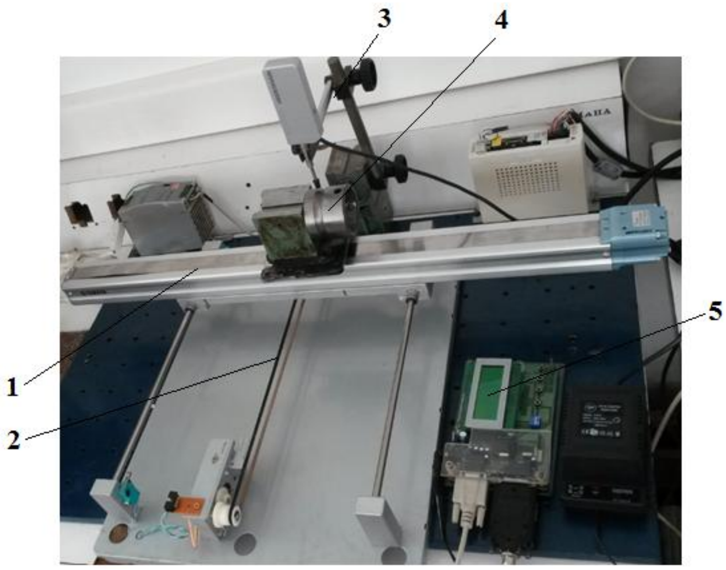

**Figure 6:** The 3-D CNC dimensional inspection system: 1 – the first axis; 2 – the second axis; 3 – the measuring system; 4 – the tested probe; 5 – the hardware device corresponding to the measuring system

Via a hardware interface, it was possible to connect to the PC the measuring system. Thus means that dimensional measurements and/or scans aided by PC, in real time, of the tested components, can be performed. The hardware interface consists into a signal decoder (providing from the displacement measuring transducer), a microcontroller, a display, push buttons a socket for transducer connection, a plug-in socket for supplying and an RS-232 interface protocol for data transfer to the PC.

## 3. DIMENSIONAL INSPECTION/SCANNING EXAMPLES, USING THE IMPROVED SYSTEM

Due to the hardware and software interfaces, the YAMAHA robotic axis was programmed for different dimensional measuring cycles, using the YAMAHA's axis software environment [5]. An example is presented in figure 2, representing measuring cycle command programming routine, in several successive points of the tested component.

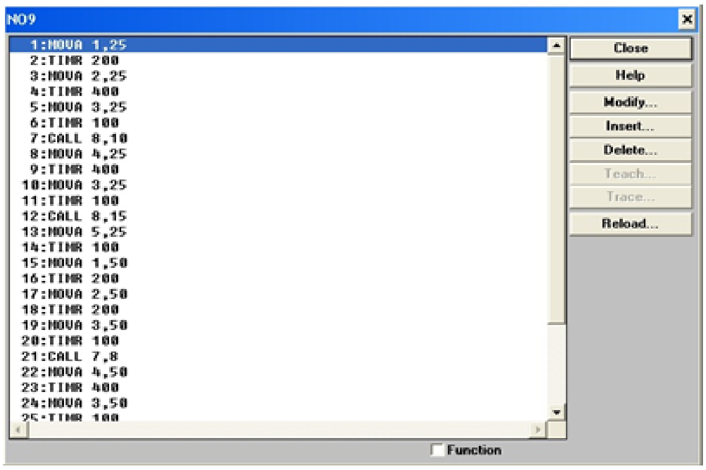


**Figure 2:** Programming routine for a step by step dimensional measuring cycle, using the first 1-entraining axis

On the second drive axis, the Arduino microcontroller allows the command programming routine, a case being presented in figure 3. It represents an example, in which the tested probe could be displaced step by step (which increment was predefined at 1 mm), in order to ensure a measuring cycle, along the second axis [4], [6].

```
lcd.setCursor(0, 1);
lcd.print("      ");
// position value incrementing by 1 mm
position = position + 24; }}
if (position < 7080) {
if (digitalRead(inc10) == LOW) {
lcd.setCursor(0, 1);
lcd.print("      ");
// position value decrementing by 1 mm
position = position - 24; }}
if (position > 120) {
if (digitalRead(dec10) == LOW) {
lcd.setCursor(0, 1);
lcd.print("      ");
```

**Figure 3:** Programming routine for tested probe's positioning displacement with 1 mm increment, for a measuring cycle along the second axis

Composing both algorithms, a measuring cycle for probes with complex geometry could be done, due to the fact that a composed displacement of the probe (fixed by the conveyor) along both axis could be performed.
For the probes testing, as devices can be used displacement transducers for dimensional measuring, having different principles. Until now, an incremental displacement transducer, optical principle (figure 4) could be adapted to the system, which technical characteristics are presented in the table below [7]:

**Table 2:** Technical characteristics for the implemented dimensional measuring device

| | |
|---|---|
| Measuring range | 25 mm |
| Accuracy | 0.2 μm |
| Output signal type | digital signal, type TTL |

**Figure 4:** Example of dimensional measuring device arrangement for 3-D scanning and dimensional measuring of components with applications in automobiles field

For signal decoding in order to, a PIC18F452 microcontroller was adapted as hardware interface, in order to connect the measuring device to the PC. The hardware interface is presented in figure 5 [8].

**Figure 5:** The hardware interface for signals decoding and measured values displaying, associated to the incremental displacement transducer

## 4. CONCLUSION

The research led to obtain a 3-D coordinate dimensional measuring and/or scanning system, CNC type, with performances close to the Coordinate Measuring Machines (CMM). The main advantage of the proposed system is that the cost is estimated to be 10 times less than those of CMMs. Besides, the system can be successfully used for dimensional inspection or scanning of different components with complex geometry. Another advantage refers to the measuring devices very quick and simple interchanging.

However, the main disadvantage is that currently the measuring system cannot allow synchronizing both axes, thus means that each axis must be programmed and commanded separately, meaning an inefficient testing process. Besides, the communication hardware protocol needs also serial devices, meaning to use PC old generation. For this reason, in the future, the research will be focused to improve the hardware and software system to solve the problem with the drive system synchronization. Another goal is to use only USB or wireless hardware communication protocols.

## REFERENCES


[1] Yamaha, Single-axis robot, http://www.yamaharobotics.com/Catalog/PDF/CurrentManuals/_Discontinued/T4-T5_E_V2.01.pdf , 2013.

[2] Yamaha, Robot user's manual, YAMAHA, 2008.

[3] Arduino, Functional characteristic and use, http://en.wikipedia.org/wiki/Arduino, 2014.

[4] Pirvulescu, I., Studies and research on optimizing training in translational applications in industry, Diploma Project, Transilvania University of Brasov, 2014.

[5] POPCOM, Yamaha drive axis programming instructions, http://www.yamaharobotics.com/Catalog/PDF/POPMANE.pdf, 2012.

[6] Visual Basic, Programming instructions, http://ro.wikipedia.org/wiki/Visual_Basic, 2013.

[7] HEIDENHAIN, Langen messen. Messgerate fur das Messen von Langen, www.heidenhain.de, Deutschland 2006.

[8] Stefanescu, O., Integrating incremental transducers in measuring systems, Diploma Project, Transilvania University of Brasov, 2006.