AN ALTERNATIVE TECHNIQUE TO THE GEOMETRIC TEST OF MACHINING CENTERS

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Abstract

An alternative technique for the geometric test of machining centres was developed, to congregate metrological reliability with operational and economical advantages, when comparing to methods classically used for such task. A touch probe is used on a 3-axis vertical machine center to check against artifacts calibrated on a coordinate measuring machine (CMM). By comparing the results obtained from the machine tool and CMM, the main machine tool error components are measured, attesting the machine accuracy. The method is easy to use, has lower cost than classical test techniques, and the results have shown that its uncertainty is comparable to well established techniques.

1. INTRODUCTION

The development of the Computer Numerical Controls (CNC) has made possible to correct some of the mechanical errors of the machine tools, taking their accuracy beyond mechanical limitations [1]. However, to take advantage of these means, the users should periodically test their machines but, in spite of most CNCs have these means available, most users do not test their machines to update the CNC error compensation table. The economic, metrological and operational limitations of the geometrical test techniques used to verify the machine accuracy are the main reasons for this problem. Classical techniques usually are expensive or very time consuming or are not metrological reliable. More, usually the results are not formatted for compensation at the CNC.

This work describes an alternative technique for the geometric test of machining centres, developed to congregate metrological reliability with operational and economical advantages, when comparing to methods classically used for such task. A system called QUALIMAQ was developed to make this operation easy and time efficient, combining the coordinate metrology with the use of calibrated artefacts [2]. The method is an alternative to the expensive and/or very time consuming classical techniques that are the main reasons for what the machine tool user do not undertake tests with greater frequency.

The QUALIMAQ method was applied to the geometric test of a vertical machining centre, tested also with classical techniques (laser interferometer, straightedge and square). The results showed that the uncertainty of QUALIMAQ is comparable to well established techniques, with significant advantages in operational and economic aspects. Its time efficiency is 7 times better and the costs involved with the operation are 6 times lower than the same geometric tests performed with the classical techniques.

In order to verify the efficiency of the CNC correction, the errors were used to correct the machine and two plates with holes were machined, one of them before and the other one after the correction. The measurement of both workpieces on a Zeiss CMM indicated that a maximum error in the first workpiece has decreased in more than 70%.

2. THE ALTERNATIVE TEST TECHNIQUE

The use of probes on machine tools for *automatic workpiece setup*, *tool setting*, *digitalisation* and *in-process measurement* has increased in the last years, improving the machine productivity, as non-cutting times are reduced by up to 50% [3]. In this paper, the touch probe is used for another (important) function: verify the geometric accuracy of the machine and update its CNC error compensation table.

In the QUALIMAQ system, a touch probe is installed on a 3-axis vertical machine centre to check against calibrated artefacts (an aluminium hole plate and a vertical detachable artefact), previously calibrated on a Coordinate Measuring Machine. The artefacts are measured on the machine tool and the coordinate points are transferred via serial interface, to a portable computer where a software acquire and process these points, comparing them to the calibrated values.

As a result, the errors of positioning, straightness and squareness are measured, attesting the machine tool accuracy. These errors can be easily formatted to update the error compensation table at the CNC, enhancing the geometric behaviour of the machine. The software also give reports of the errors, monitoring the machine accuracy condition. The figure 1 illustrates the system, and the artefacts.

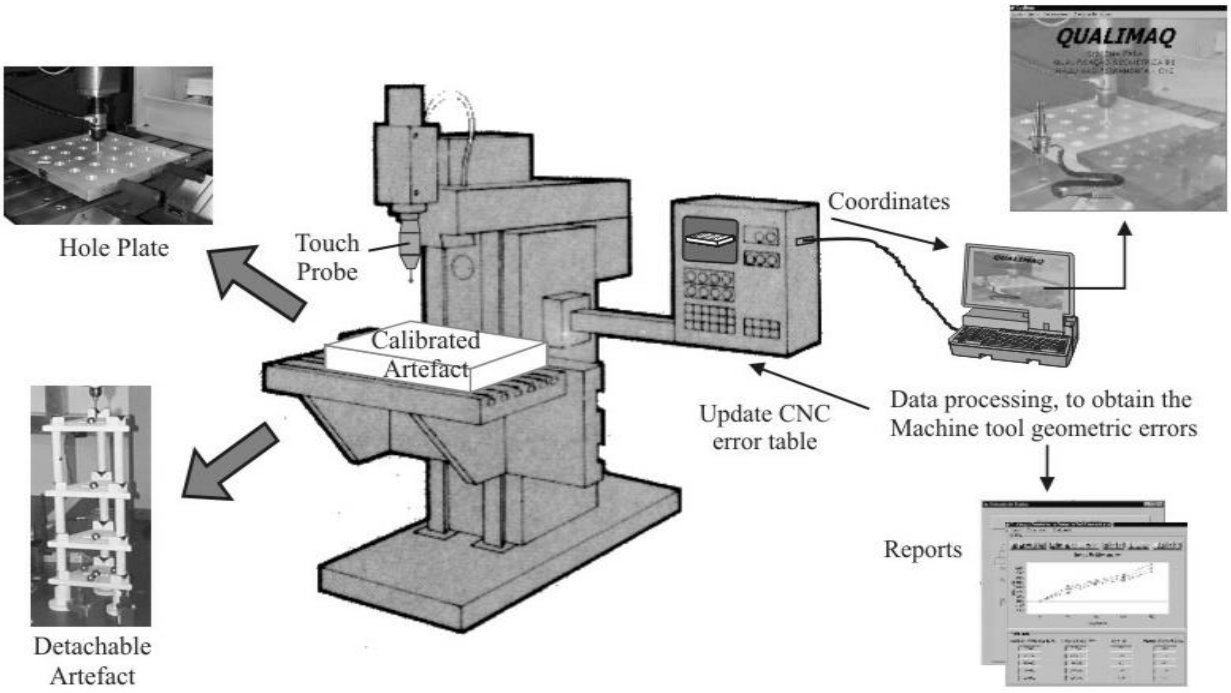

Figure 1 - Basic configuration of QUALIMAQ system

A **Hole Plate** and a **Vertical Detachable Artefact** are calibrated in a Coordinate Measuring machine and used in the geometric test of the machine tool. The **Plate** has 25 holes disposed in a square grid, with the position of the centers calibrated, and is used to test the horizontal plane (XY) of the machine. The **Detachable Artefact** was developed to test the vertical planes of the machine (XZ and YZ) and has dismounted parts with kinematics mounting, that can be repositioned very precisely [4]. Both artefacts have their temperature measured and the thermal expansion compensated.

3. EXPERIMENTAL RESULTS

In order to compare the time efficiency and to evaluate the metrological reliability of QUALIMAQ system, a same machine tool was tested with different methods. A CNC vertical milling machine was tested with laser interferometer (linear positioning), square (squareness) and straightedge (straightness). After that, these errors were verified with QUALIMAQ system and all of the results compared. These experiments are illustrated in the figure 2 and typical results for linear position and straightness can be seen in the figure 3 and 4. As described previously, in the horizontal plane of the machine tool (XY) the hole plate was used and for the horizontal planes, the vertical detachable artefact.

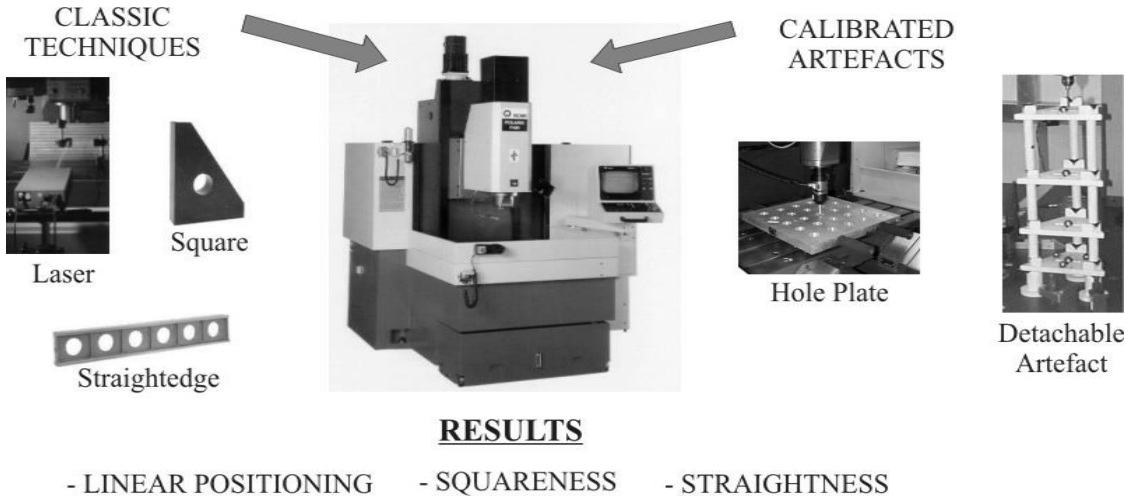

Figure 2 – Comparisons between QUALIMAQ and Classical Techniques

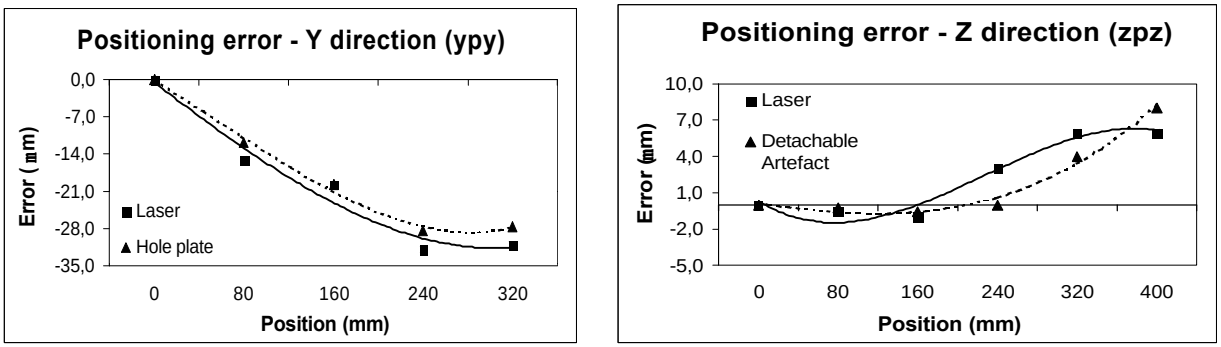

Figure 3 – Typical results obtained with Laser and artefacts for the linear positioning test

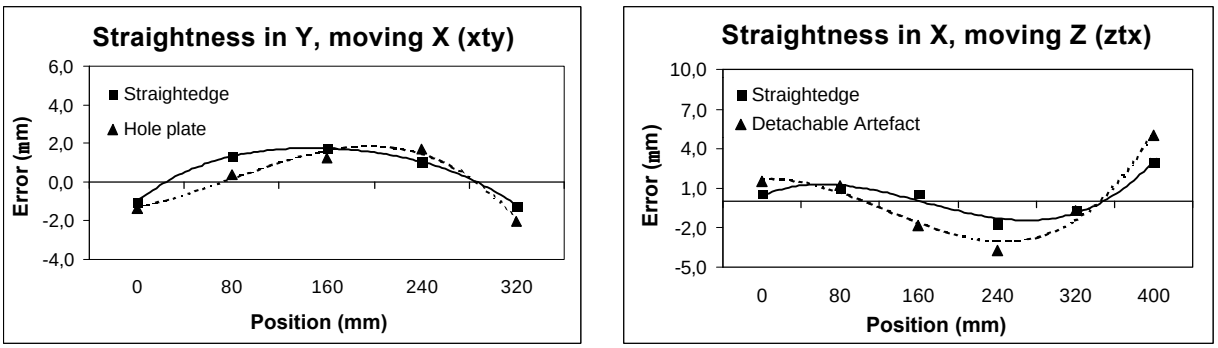

Figure 4 – Typical results obtained with Straightedge and artefacts for the straightness test

In all these graphics, the results obtained with classical methods and QUALIMAQ have a very close concordance and the measurement uncertainties are also similar. But, when operational and economical aspects are analysed, the numbers are very different.

The figure 5 shows the time necessary to perform all of geometric tests on the milling machine, employing classical and QUALIMAQ methods, as well as the cost of the equipment involved in the experiments. From these numbers can be concluded the higher operational and cost efficiency of the QUALIMAQ method for this size of CNC machine tools, when compared to that classical techniques.

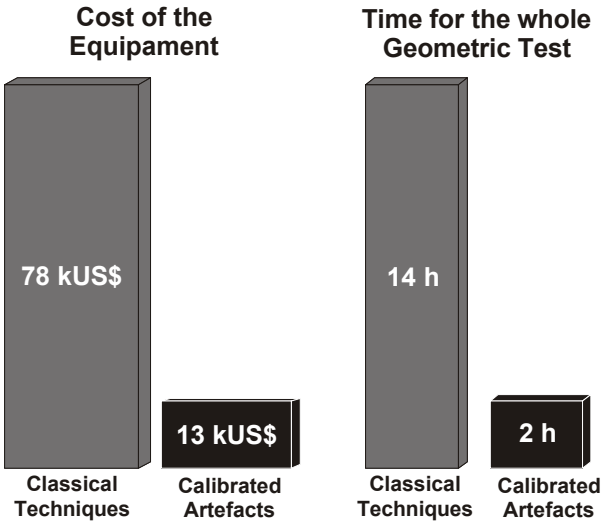

Figure 5 – Operational and economical comparisons

4. CONCLUSIONS

The results obtained in this work showed that the geometric test with calibrated artefacts can be a low cost, easy to use and reliable method to verify the accuracy performance of machine tools. A vertical machining center with a touch probe was tested with the method proposed and, for comparison, also with classical techniques. The results revealed a promising method not only in the metrological aspect, but in operational and economical aspects also.

The uncertainty of QUALIMAQ is comparable to well established techniques, with significant advantages in operational and economic aspects. Its time efficiency is 7 times better and the costs involved with the operation are 6 times lower than the same geometric tests performed with the classical techniques. A geometrical test technique with such advantages could motivate the machine tool users to more frequent tests, and to update periodically the CNC error compensation table.

To motivate the machine users to undertake testing with greater frequency, several techniques have been developed and applied, trying to congregate operational advantages, low price and reliability. The research and development of such techniques is important for the users to explore that new error compensation resources of machine controllers, important for the quality assurance in machining processes.

5. REFERENCES

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