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# CONTRIBUTIONS ABOUT GANTRY MACHINE TOOL GEOMETRIC ACCURACY IMPROVEMENT BY LASER ALIGNMENT

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**Abstract**: *Linear measurement is the most common form of measurement performed with a laser. The laser system measures linear positioning and repeatability by comparing the position displayed on the axis read-out with true position measured by laser system. Positioning errors in the Gantry machine tool axis are measured and captured using a laser interferometer system comprising a Renishaw ML 10 laser, EC10 environmental unit, linear optic components and a PC*
**Keywords**: *machine tools repeatability and linear accuracy, laser interferometer system, optic components, high speed machining*

## 1.INTRODUCTION

The industry standard method of measuring machine tool performance has utilized a free-standing laser on a tripod, in combination with remote (i.e. separate) interferometer and reflector optics, mounted directly to the machine table and spindle.

In figure 1 is shown the design of the Renishaw ML10 Laser Interferometer set-up for linear measurement.

For each type of measurements (linear measurement; angular measurement; straightness measurements) are used some specific interferometer optics for a laser beam deflection

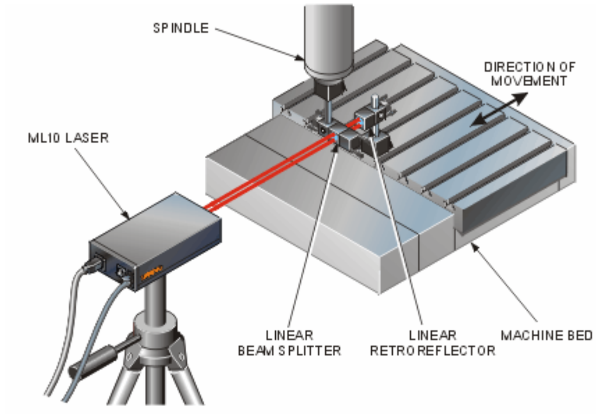


**Fig.1**. Renishaw ML10 Laser Interferometer

Atmospheric temperature, pressure and humidity changes all alter the laser wavelength, and must be compensated for in order to achieve high accuracy. The accuracy of the weather station sensors over the full range of operation is critical. To ensure that each individual sensor contributes less than ±0.5 ppm of error to the wavelength compensation (and hence to the linear measurement accuracy), the next sensor accuracies are required: Air pressure sensor: . ± 1.5 mBar ( ± 1 mm Hg) ; Air Temperature ± 0.5°C ( ± 1°F) and Air Humidity ± 20% RH. [1]

The accuracy of linear measurements will also depend critically on the accuracy of the material temperature sensor system. The Renishaw System includes a temperature sensor with an accuracy of ±0.1°C, over the full operating temperature range of 0-40°C.

By using a tripod mounted laser, with only the remote interferometer optics mounted directly to the machine has some advantage [3]

*The heat generated by the laser is kept away from the interferometer optics*. The linear interferometer and reference arm form the reference point from which all machine movement is measured. Any changes in the interferometer position or in the reference arm length, caused by thermal expansion or contraction, will degrade the accuracy of this measurement..

*The heat generated by the laser is kept away from the machine under test.* A Helium Neon laser head will dissipate at least 5 watts of heat, (more if it contains power supplies)..

*The laser head doesn't obstruct axis movement***.** If the laser head is mounted on the machine, its size will often reduce the available range of travel of the axis under test.

*Beam alignment adjustments can be made outside the machine***.** If the laser is mounted inside the machine, ***all*** laser beam alignment adjustments have to be made ***inside*** the machine..

*No trailing cables inside the machine***.** The laser head requires power and signal cables, but interferometer optics doesn't. Mounting the laser on an external tripod with just the optics inside the machine, avoids the need to route these power and signal cables into the moving machine.

## 2. LASER SETUP FOR LINEAR MEASUREMENT ON GANTRY MACHINE

The laser beam alignment, by using 3 parts of components (laser source on tripod, linear beam splitter and linear retroflector), with machine tool axis take some time, depending of machine tool architecture and tripod foundation state. For an easy setup of laser by respecting all producer conditions it was used a solution with ML10 Laser and linear beam splitter mounted on the same support and only the linear retroflector mounted on the machine tool movement parts of the axis.

In figure 2 is presented a solution with Laser unit and linear beam spliter mounted on the same tripod. For this it was made a light support from aluminum with some specific dimension so that the heat generated by the laser is kept away from the interferometer optics. The advantage of this solution is the easy way for laser beam alignment with machine axes.

The linear beam spliter and the laser unit on the same support have the advantage of precision movement offered by fine tuning of support. The entire assembly linear beam spliter and LASER unit are moved in 2 direction **a** and **b** by fine tunning system **1** and **2** (fig.2). The movement **c** and **d** are specific only to LASER unit only and it can be made by mechanism **3** and **4.** This solution was realized by National Center of Research of the Technological Systems Performances and successful applied in industrial condition on different type of machine tools

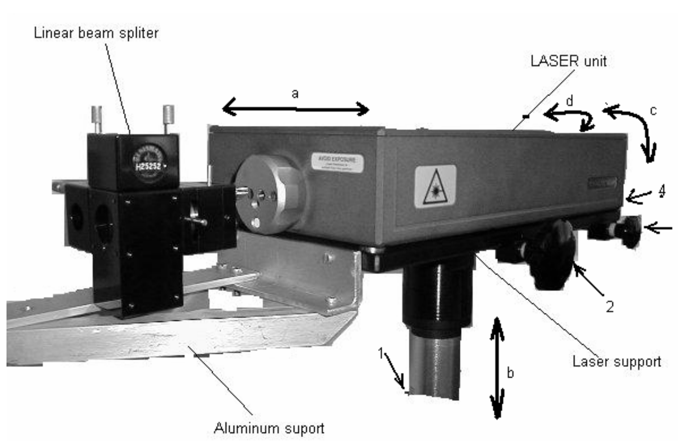


**Fig.2** Laser Alignment setup innovation

### 3. LASER MEASUREMENTS FOR THE PORTAL MILLING MACHINE ACCURACY

High performance and efficient milling technologies are the backbone of the modern model mould and tool making industries. They are decisive for the success and profitability of the whole workflow in this area. The peculiarity of the problem to be solved lies in the need to reconcile apparently opposing demands. Milling machine tools with portal design are the solution for these goals.

One explanation for the advantages of the portal structure is to be found in the application of the basic principles of mechanics: through fixed sides, only the portal is moved with the Z-slide and the milling head. The reduced moving masses – compared to other constructions – have a positive effect on the dynamic behavior and speed of machining. Even with large dimensions high stability is achieved, making the provision of a large transverse axis (Y-axis) feasible. Additional advantages of this increased mechanical rigidity are dimensional accuracy and improved surface finishes. [2]

The FAV 3300 portal milling machine with overhead gantry is based on a modular machine concept, which permits construction of a wide variety of versions with different travels and drive technologies. The FAV 3300 is designed for the high speed machining of the whole range of materials, right through to HSC roughing of cast iron and steel. The machine concept is rigorously optimized for maximum rigidity and dynamic performance,

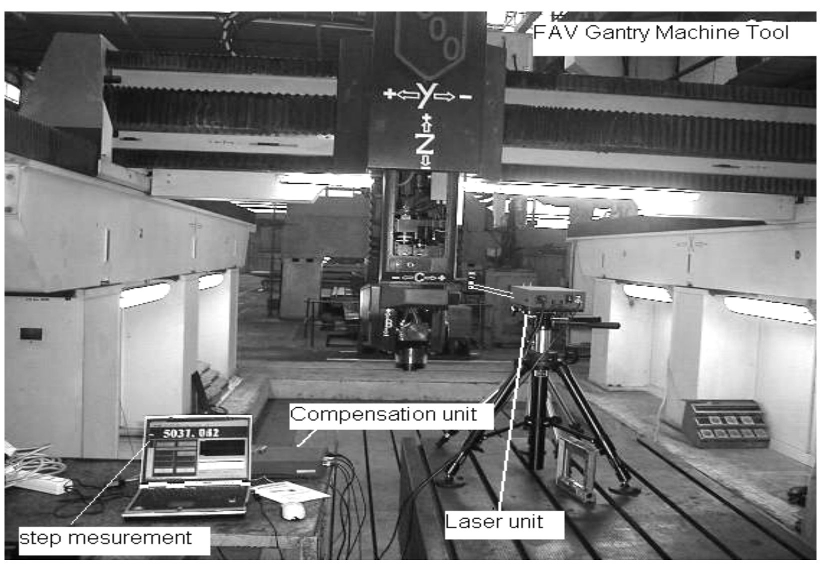


**Fig. 3** Mesurements on x axis on FAV 3300 Gantry Machine

The milling machine tool has a linear movement up to 5500 mm on X axis, 3300 mm on Y axis and 2300 on Z axis with maximum 15 000 mm/min. The movement on the X direction is made by using a rack mechanism with error compensation system and linear guides NSK with mechanism for parallelism error compensation. The movement on y direction is made by using a ball screw with double ball nuts. Also are used NSK linear guides. In figure 3 is presented the FAV 3300 Gantry Machine. The machine precision is up to maximum 20 micrometers in hard work condition.

### 3.1. Laser measurements

By the laser interferometer, it can be measured almost all axes. One axis is measured at a time, while the other axes are kept motionless. [4]

In the following section, it is presented some of the measurement results obtained by Rainshow laser interferometer measurement of the FAV3300 gantry machine tools.

All the measurements were done from a reference point of each axis in double direction for all the working space, while keeping other axes fixed. The machine was commanded to move from the reference by 100 mm/step.

For example on x axis the initial errors measured are presented in figure 4. After the first set of measurement the errors measured by laser interferometer were introduced into NC error compensation program of the machine tool. In figure 5 it is presented the final measure. For each axes a set of 4 measurements were made. Each time the errors were introduced into NC compensation program. After these 4 measurements the result of accuracy and repeatability were like producer specifications.

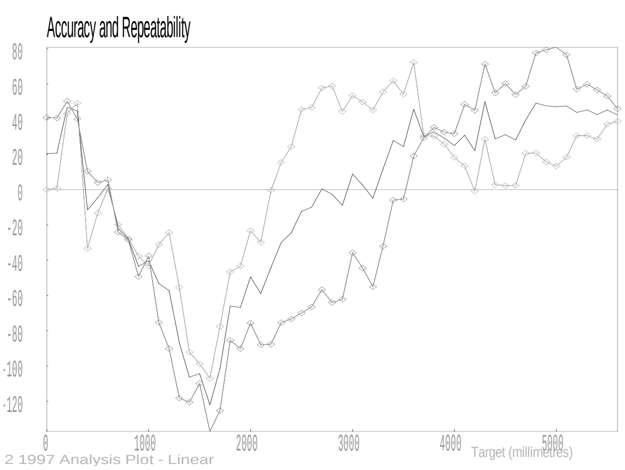


**Fig.4** Initial measurement on x axis

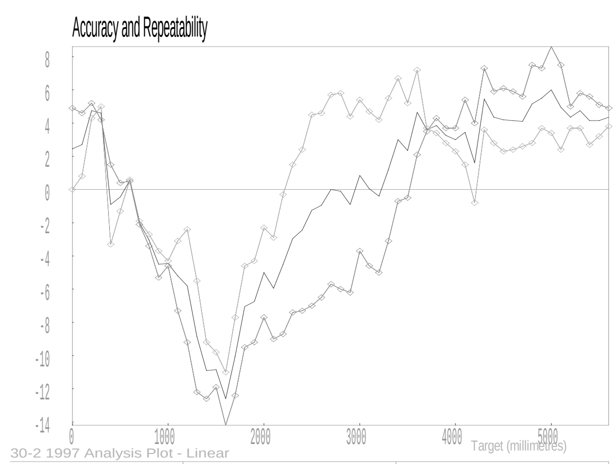


**Fig.5** Verification measurement on x axis

## 4. **CONCLUSION**

The LASER Interferometer is a powerful tool for machine tools fine tuning regarding geometrical precision, but for high performances it has to be correctly used into stabile industrial environment

By using Rainshow interferometer the FAV Gantry Machine was set up for hard working milling process in optimal condition in according with machine manufacture.

At first a disadvantage was the long time necessary for laser alinagment with machine tool axis (1h till 3 h depending the specific condition of the machine). However by using the solution of Laser unit and linear beam splitter on the same support (realized and used by CNCPST-Optimum) this time is reduced to ½ hour

Machine tools are very complex in nature with their functionality. Due to wear, the geometric error will change with time. Machine tools calibration with a long period of time shows that a calibration period of one year is advisable.

## 5. **REFERENCES**:


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