Case study

Higher precision of machine tools with FANUC controllers

„Volumetric calibration and compensation of a high-speed drilling centre increases precision fourfold“

The „3D Error Compensation” feature in the 30i and 31i-A5 series FANUC CNC control units can correct geometric machine errors by processing three-dimensional performance data of the total machine volume. The result of error compensation: much higher processing precision.

The function „3D Error Compensation“ for the Fanuc CNC controllers of the series 30i and 31i-A5 corrects geometric machine errors.

No machine tool is perfect, as all axes are error-prone one way or another: absolutely typical are spindle pitch errors, a certain sagging with long axes or inclination with high super-structural parts. Errors, against which modern CNC control units can be effective thanks to special features. However, compensations are carried out separately for each axis as a rule. Further common errors such as the slight deviation in the angularity of the axes to each other and slight twists thus go unnoticed. These are most often eliminated by the corrections in the NC-program – with the disadvantage that such a program can not be used on any other machine without readjustment.

With the 3D Error Compensation from FANUC such axes errors can also be compensated for. A prerequisite is an exact spacial measurement of the machine and all axes. A procedure that many avoided as a result of considerable time and effort needed. Thanks to a new method of spacial measurement the process has become considerably easier, as a manufacturer of modern drilling centres learned. High-speed CNC machines are known above all for reliability, durability and high precision. In figures: The positioning precision in the direction of the spindle is 0,006 mm/300 mm, the repeatability precision is ±0,002 mm. The efficient and precise cutting machines are constructed in a comparatively compact way with usable axes lengths of 500, 400 and 330 mm. They are used for the processing of car parts, electrical components, in the clock, watch and jewellery industry and also in medical technology.

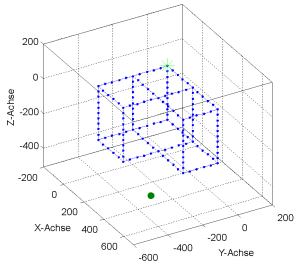
The Etalon system enables simple calibration

The LaserTracer in combination with a reflector is the only necessary measurement equipment.

In order to optimise the precision of these drilling centres further, the manufacturer used the 3D Error Compensation function in his FANUC control unit. To record the geometric residual deviations of the process axle the calibration system from Etalon as used it comprises of a universal measuring device named LaserTracer and software that can calculate the axes deviations directly from performance data and give necessary adjustment data. An extremely high precision of measuring is possible as a result of ingenious methods: By using longitudinal differences alone, the uncertainties of using angle measurements or additional tools are eliminated. A patented principle inside the device eliminates the inevitable mechanical deviations of the rotational axis.

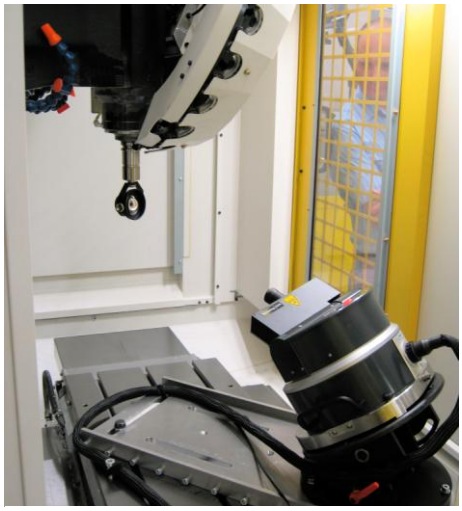
To determine the axes deviations the LaserTracer was positioned in the machine, replacing the machined part. A universal mounting bracket enabled the positioning of the LaserTracer in the limited working space of the machine. An air temperature probe, which is responsible for correcting the laser wavelengths, was also attached here. On the outside of the machine an air pressure and air humidity sensor were located. In place of the tool a reflector was attached to the spindle.

The substantial part of the work is in the planning of the measurement. The measuring path for the machine, among other things, is defined in the Trac-CAL software. The measuring paths of the drilling centre comprised of a total of 998 measuring points for the chosen dot pitch of 40 mm. For the required error model of the machine, 4 different positions were planned with the corresponding machine path for the LaserTracer. The Monte Carlo simulation indicated uncertainty of maximum 1 µm or rather 1 µrad for parametric deviations of the planned measurement configuration.



Measuring points on the machine path for one stand point (green point)

Calibration requires little time

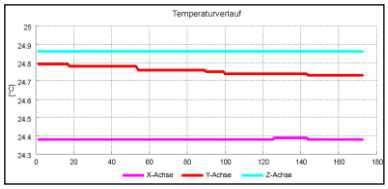


The calibration system from Etalon simplifies geometric error mapping of the machine axes: Instead of a workpiece the LaserTRACER will be put on the moving table and instead of a tool a reflector called cat-eye will be mounted in the spindle. After to compile a machine program the calibration can begin.

To control the drilling centre, the measurement technicians created four machine programmes in G-code format that were subsequently copied to the control unit using a data storage medium. Existing compensations were deactivated. Afterwards the four programmes were started one after the other and the LaserTracer was modified in the interim periods. Already during the measurement the specified repeatability of the machine of less than 2 µm was confirmed. One programme run took less than seven minutes. The total calibration process, including assembly and modification, took only 90 minutes.

In order to account for the expansion of the axle measuring rods during calibration, the technicians used a temperature measurement system available from Etalon. The system delivered exact information about each individual measuring rod temperature during the whole calibration process. Three sensors were attached close to the individual measuring rods. The temperature data was sent by a transmitter to the base station. This in turn was connected to a data analyser that calculated the appropriate corrections. The analysis showed that the temperatures remained relatively stable, but differed from axis to axis.

From the measurements a reduced error model was calculated, as for this type of machine the rotary deviations of the last axis are irrelevant. One was then able to determine the positioning deviations, straightness, squareness of the axes to each other and also in part pitch, yaw and roll. Thereafter the corrective data was copied to the CNC control unit and the compensation activated.

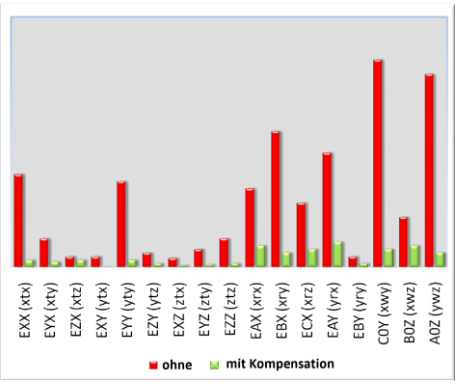


The axes temperatures during the calibration time.

3D Error Compensation shows makes a large impact

In order to demonstrate the effectiveness of the corrections, calculated by the FANUC 3D Error Compensation, on spacial precision the machine was subsequently measured once again. The comparison of the rest deviations, without and with the compensation activated, showed a clear improvement of all parametric deviations. They were reduced by an average of 77 %, which corresponds to an improvement in precision by a factor of 4. In the final independent examination according to ISO 230-2 and -6 with the Trac-Check software this increase in precision was confirmed.

The results reached with the FANUC 3D Error Compensation are of course dependant on the measurement and the mechanical possibilities of the machine. However, an increase in precision will always be reached. For machine tool manufacturers, that set a high value on the precision of their products, the 3D Error Compensation is a promising option with minimal operating expenditure and high benefit. But also an end user can benefit from the new possibilities: as every machine – from three to five axes – equipped with a FANUC 30i or 31i-A5 series CNC control unit can subsequently be measured and improved using 3D Error Compensation.



Comparison of the single parametric errors: with and without compensation

About FANUC

FANUC LTD, with it's headquarter at the Fujiyama mountain in Japan, is worldwide the most diversified company of industrial automation, robots, machine tools and injection molding machines. Since 1956 FANUC is working about automation of machine tools and is considered as pioneer for the development of CNC controller systems. The FANUC technology is setting again and again trends in the production which yields the automation of single machines up to complete production lines. Also in the 21th century FANUC continues to develop the best and reliablest products.

About ETALON

Etalon AG is specialized on the calibration, monitoring and accuracy enhancement of measuring machines and machine tools. The company is arised in 2004 as spin off from the National Metrology Institute of Germany, the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig. Innovative ideas are converted by ETALON into user-friendly system solutions. Scientific know-how, standardization requirements and instrumentation experience are integrated into custom-made software. Meanwhile a worldwide sales network exist. Famous customers from the machine tool branch, industrial metrology, automotive sector and research are counting on the Etalon technology.

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