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Novel Hole-Bar Standard Design and Inter-Comparison for Geometric Errors Identification on Machine-Tool

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Abstract : Manufacturing of freeform parts may be achieved on 5-axis machine tools currently considered as a common means of production. In particular, the geometrical quality of the freeform parts depends on the accuracy of the multi-axis structural loop, which is composed of several component assemblies maintaining the relative positioning between the tool and the workpiece. Therefore, to reach high quality of the geometries of the freeform parts the geometric errors of the 5 axis machine should be evaluated and compensated, which leads one to master the deviations between the tool and the workpiece (volumetric accuracy). In this study, a novel hole-bar design was developed and used for the characterization of the geometric errors of a RRTTT 5-axis machine tool. The hole-bar standard design is made of Invar material, selected since it is less sensitive to thermal drift. The proposed design allows once to extract 3 intrinsic parameters: one linear positioning and two straightnesses. These parameters can be obtained by measuring the cylindricity of 12 holes (bores) and 11 cylinders located on a perpendicular plane. By mathematical analysis, twelve 3D points coordinates can be identified and correspond to the intersection of each hole axis with the least square plane passing through two perpendicular neighbour cylinders axes. The hole-bar was calibrated using a precision CMM at LNE traceable the SI meter definition. The reversal technique was applied in order to separate the error forms of the hole bar from the motion errors of the mechanical guiding systems. An inter-comparison was additionally conducted between four NMIs (National Metrology Institutes) within the EMRP IND62: JRP-TIM project. Afterwards, the hole-bar was integrated in RRTTT 5-axis machine tool to identify its volumetric errors. Measurements were carried out in real time and combine raw data acquired by the Renishaw RMP600 touch probe and the linear and rotary encoders. The geometric errors of the 5 axis machine were also evaluated by an accurate laser tracer interferometer system. The results were compared to those obtained with the hole bar.

Keywords : volumetric errors, CMM, 3D hole-bar, inter-comparison
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