Available online at www.sciencedirect.com
ScienceDirect
Procedia CIRP 28 (2015) 106 – 112
www.elsevier.com/locate/procedia
3rd CIRP Global Web Conference

A testpart for interdisciplinary analyses in micro production engineering

H.-C. Möhring[a,*], P. Kersting[b], S. Carmignato[c], J.A. Yagüe-Fabra[d], M. Maestro[d], R. Jiménez[e], E. Ferraris[f], L.T. Tunc[g], F. Bleicher[h], W.W.Wits[i], K. Walczak[j], M. Hedlind[k]

[a] IFQ, OvGU Magdeburg, Universitaetsplatz 2, 39106 Magdeburg, Germany
[b] ISF, TU Dortmund, Baroper Str. 301, 44227 Dortmund, Germany
[c] DTG, University of Padova, Stradella San Nicola 3, 36100 Vicenza, Italy
[d] I3A, Universidad de Zaragoza, Zaragoza, María de Luna 3, 50018 Zaragoza, Spain
[e] I3A, Centro Universitario de la Defensa, Carretera de Huesca, s/n, 50090 Zaragoza, Spain
[f] Dept. of Mechanical Engineering, KU Leuven, J. De Nayerlaan 5, 2860 Sint-Katelijne-Waver, Belgium
[g] Manufacturing Research Laboratory, Faculty of Engineering And Natural Sciences, Sabanci Univ., Orhanli,Tuzla, 34956 Istanbul, Turkey
[h] IFT, TU Vienna, Karlsplatz 13, 1040 Vienna, Austria
[i] Lab. of Design, Production and Management, Fac. of Eng. Techn., Univ. of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands
[j] Joint Center for Artificial Photosynthesis Lawrence Berkeley National Laboratory One Cyclotron Road, Mail Stop: 976 Berkeley, CA. 94720, USA
[k] Global Industrial Development, Scania CV AB, 151 87 Södertälje, Sweden

* Corresponding author. Tel.: +49-391-67-18552; fax: +49-391-67-12370; E-mail address: hc.moehring@ovgu.de

Abstract

In 2011, a round robin test was initiated within the group of CIRP Research Affiliates. The aim was to establish a platform for linking interdisciplinary research in order to share the expertise and experiences of participants all over the world. This paper introduces a testpart which has been designed to allow an analysis of different manufacturing technologies, simulation methods, machinery and metrology as well as process and production planning aspects. Current investigations are presented focusing on the machining and additive processes to produce the geometry, simulation approaches, machine analysis, and a comparison of measuring technologies. Challenges and limitations regarding the manufacturing and evaluation of the testpart features by the applied methods are discussed.

Selection and peer-review under responsibility of the International Scientific Committee of the "3rd CIRP Global Web Conference" in the person of the Conference Chair Dr. Alessandra Caggiano.

Keywords: Micro Production Engineering; Testpart; Round Robin; Micro Milling; Additive Manufacturing; Metrology; Computed Tomography

1. Preface

Within the Research Affiliate network of the International Academy for Production Engineering, CIRP, a round robin test was initiated in 2011 and started in 2012, involving participants from all over the world. The goal of this initiative is to join interdisciplinary research activities and to provide a framework for the collective development and comparison of technologies. For this round robin test, a testpart was proposed which can be used to investigate various manufacturing processes (also regarding different part materials and sizes), machinery, simulation approaches, monitoring strategies, and metrology. It can also be applied for the comparison of different technologies with respect to energy consumption and resource efficiency. Starting with the task of programming the considered processing operations and ending up with the need to measure the features of interest, this testpart implicates some challenges which have to be solved with individual approaches.

This paper introduces the *pc-testpart* and describes current collaborative work using this testpart for several

Selection and peer-review under responsibility of the International Scientific Committee of the "3rd CIRP Global Web Conference" in the person of the Conference Chair Dr. Alessandra Caggiano.
doi:10.1016/j.procir.2015.04.018

investigations with respect to micro production engineering.

2. Introduction of the pc-testpart

The geometry of the testpart (22.6 mm x 15 mm x 3 mm) is shown in Fig. 1. The elements of the testpart partly consist of thin-walled sections with a thickness of 0.1 mm and grooves having a width of 0.6 mm.

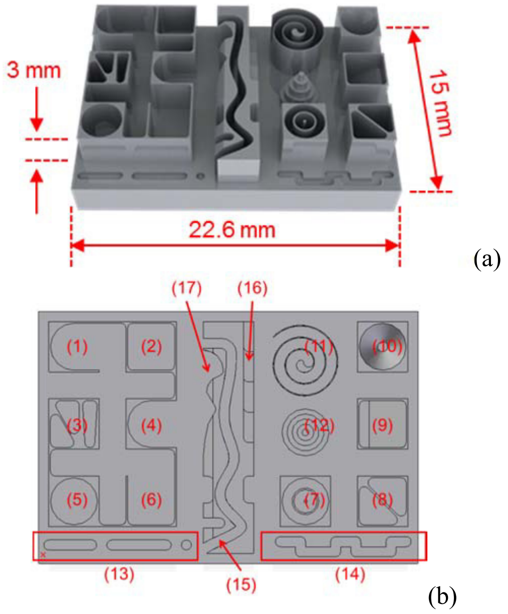

Fig. 1. (a) CAD model of testpart; (b) top view with numbered features

Different process technologies (e.g. 2½D or 3D milling, EDM, generative processes) can be applied for manufacturing the testpart. The analysis of how to produce the part starts with process planning, programming and simulation. It includes process characteristics as well as workpiece and machine behavior. Finally, measuring strategies have to be developed for accuracy and surface assessment. The following criteria are observed in the round robin test:

- Ability to produce the testpart features
- Shape of the elements and geometric part accuracy
- Surface quality
- Machine and process influences
- Time needed for manufacturing
- Time and effort for process setup
- Energy consumption
- Repeatability of the manufacturing result
- Time, effort and accuracy of measuring methods
- Additional effects (e.g. burr formation)

When machining the testpart elements, some technical challenges occur, which at the same time constitute objects of investigation (table 1).

Table 1. Elements of the testpart and aspects for milling

1-10	basic cubes are arranged regularly; machine accuracy can be assessed by a deviation grid
1-11	thin-walled elements tend to vibrate; open and closed profiles behave differently
1, 4, 5, 7, 10, 12	circular interpolation can be used; circularity deviation can be compared
2, 3, 5, 7, 8, 9, 10	appropriate immersion strategies are necessary
2, 3, 8, 9	different and difficult engagement situations occur
9, 10	machining of datum plane is challenging; beveled geometry can be machined with different strategies
11	archimedean spiral requires special programming, interpolation and dynamic path accuracy
12	pyramid planes can either be machined consecutively or interrupted by other machining tasks to investigate repeatability and thermal influences (see also 16)
13, 14	grooves require immersion and path accuracy
11-17	acceleration and deceleration behavior of the machine can be analyzed
15	sine sweep requires special programming and dynamic path accuracy
16	steps can be used to analyze positioning accuracy, repeatability and thermal influences
17	outer profile can be used to analyze acceleration and deceleration behavior of the machine; different engagement situations occur

An application of semantic associative GD&T conforming to the latest STEP AP242 data format and the GPS standards to describe the testpart has been performed using IDA-STEP software (by LKSoftWare GmbH) at KTH Stockholm, Sweden (Fig. 2).

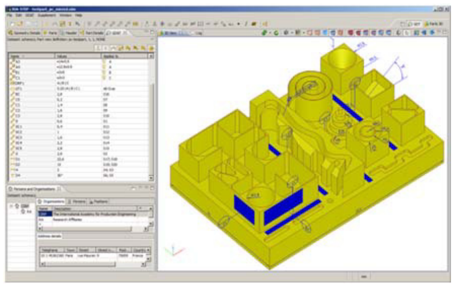

Fig. 2. ISO 10303-242 STEP based integration of semantic GD&T, lightweight shape tessellation, process plan and inspection results.

3. Micro part production

In this paper, investigations with respect to micro production engineering are presented. In particular micro milling and additive manufacturing are analyzed. For this, different equipment is applied. An analysis of produced parts and a comparison of computed tomography (CT) measurements are conducted.