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Process and machine system development for the forming of miniature/micro sheet metal products

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Abstract

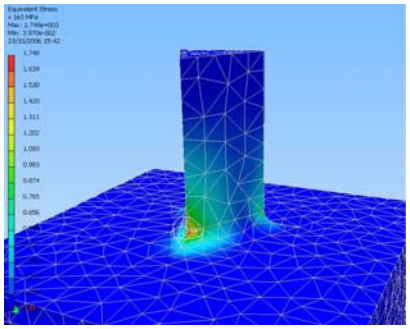
This paper reports on the current development of the process for the forming of thin sheet-metal micro-parts (t < 50μm) and the corresponding machine system which is part of the research and technological development of an EU funded integrated project – MASMICRO ("Integration of Manufacturing Systems for the Mass-Manufacture of Miniature/Micro-Products" (/www.masmicro.net/). The process development started with qualification of the fundamentals related to the forming of thin sheet-metals in industrial environment, for which a testing machine and several sets of the testing tools were developed. The process was further optimised, followed by new tool designs. Based on the experience gained during the process development, a new forming press which is suitable for industrial, mass-customised production, has been designed.

Micro-sheet-forming process development

Micro forming has been subject of intensive research recently due to its potential of enabling mass-production of micro-products with higher production rates than other processes. Forming of the micro-products is not new, but challenges do rise when the component/part and/or feature sizes go down further such as to a few hundreds/tens microns. The pioneer studies conducted previously laid down solid foundation for the development of the processes to achieve the potential of micro-forming [1-3]. Its industrial applications will be hampered if the issues related to the production were

not addressed fully [4], the issues including feeding thin strips, dealing with small scraps and parts, tool fabrication to incorporate smaller clearance and higher precision requirements, with consideration of higher speed production, etc. The current, joint efforts are addressing these issues [5].

Fundamental studies concerning micro-sheet forming included qualification of material deformations and interfaces with tools, during micro-stamping, micro-bending, micro-deep drawing and their combinations. Particular concerns are the springback and contacts between the sheet metals and tools, which gave the information on how these could influence the interaction with tools during stamping, therefore, on how these could influence design of the handling and release mechanism. Based on the fundamental studies, a series of forming-tools have been developed to test different process concepts. Special considerations for tool design include extra care on the guiding of the tools, holding of the strip during the stamping, as well as incorporating the vacuum for parts and scrap collections. Additional consideration during tool-fabrication is to deal with tiny punches with sharp transition requirments. To support the tool design and fabrication, FE simualtion was carried out to qualify the stress concetration at difficult locations and defelctions of the punches, etc.



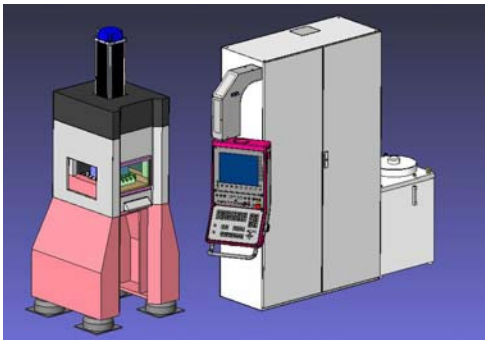
Micro-sheet forming testing machine

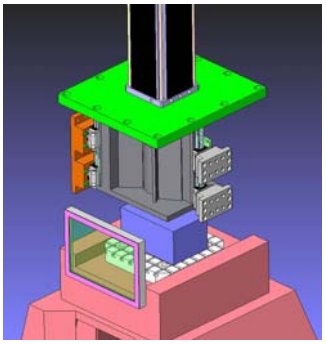
As part of the concept test process a “concept testing machine” is currently under advanced development in the Centre for Microtechnology of the University of Strathclyde. This includes tooling and design novelties, some of which are the subject of an upcoming patent application. The tested capabilities are net force up to approx

20kN, 1000 strokes/minute, and the ability to process sheet metals from 25–100 microns. The precision in the punching operation is down 5 microns, as is the inclusion of a high speed programmable servo-feed unit. The information generated during the tests is used as a reference for the development of an industrial version machine.

Industry-version micro-sheet-forming machine

A machine for performing the micro-sheet-forming process has been designed, starting from the experimental data collected from the research and development described above. Light-weight press ram is moved by a linear motor to ensure the following performance specifications (maximum): 20 KN of force, up to 1000 strokes per minute, accuracy of vertical press ram below 5 microns and bench-type design with maximum dimensions of 600 x 600 x 600 (mm) (not including the electrical cabinet and control interface).





The machine is designed for minimum sizes using the state of the art design solutions to ensure a desktop type configuration. Integration with other micro-forming systems being developed in this project has also been considered in the frame of a multi-system integrated manufacturing facility as planned in the MASMICRO project. For that consideration, a high level control strategy has been planned, that will lead to an uniform integration and operation of several different, miniaturised machines.

Sensor and control loops will also comprise state of the art solutions to ensure achievability of mass productive and precise working modes, specially with regard to

the synchronization between the press ram, the feeder, part carrier, force/displacement monitoring system, which is essential for reliable, long term operation and for the critical elements to ensure the requested high yield.

Summary

The results of the fundamental studies and micro-sheet-forming testing considering industrial application environment are encouraging. They show that the forming of micro-parts with thinner sheet metals (t<50 microns) with reasonable production rates is feasible, although some issues still need to be addressed further, such as tool life and feeding precision. The tests conducted so far confirmed a number of technical challenges due largely to size effects as well as the requirement to produce highly accurate tool-sets in order to cope with the stamping of the thin sheet metals. Additionally handling of the very light-wieight parts typically of the order microgrammes presents its own challenges. These have been considered in the development of the new forming machine and forming tools for the mass-manufacture of micro-sheet-products, as planned in the MASMICRO project [5].

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