Research Grants for PhD students from the China Scholarship Council

Research work for a PhD

Development of an advanced simulation tool for the robotized incremental forming process coupled with optimization strategy

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Subject:

Incremental sheet forming is an emerging process to manufacture sheet metal parts. This process is more flexible than conventional one and well suited for small batch production or prototyping [1, 2]. During the process, the sheet metal blank is clamped by a blank-holder and a small-size smooth-end hemispherical tool moves along a user-specified path to deform the sheet incrementally. In most of experiments performed in single point incremental forming (SPIF), classical three-axis CNC milling machines are usually used due to the high stiffness of their structure. Nevertheless, these machines have a limited workspace and can be used to form only simple shape parts. Larger dimension parts and more complex shapes can be produce by serial robots which also permit to improve production versatility. Main drawbacks of serial robot structures are their high compliance and low absolute positioning accuracy. The process forces acting on the tool lead to robot deflection and then to tool path errors which are not compatible with the required accuracy of an industrial part.

In order to compensate tool path errors due to the robot compliance during process, authors have proposed a Process/Machine coupling approach [3]. This approach consists in coupling a Finite Element Analysis (FEA) of the process with an elastic modeling of the robot structure to improve the geometrical accuracy of the formed part. The FEA, assuming a rigid machine, is used to evaluate the forces at the interface between the tool and the sheet during the forming stage. The predicted forces are then used as input data for the elastic model of the robot to evaluate the tool path deviations which are finally used to calculate a corrected tool path. Consequently accurate results of the numerical simulation are needed in order to predict the forces and integrate them in the elastic model of robots.

This process//Machine coupling approach has been applied to the Robotized Incremental Sheet Forming of an aluminum truncated cone. The final shape of the frustum cone formed by a Robotized Incremental Sheet Forming (RISF) operation was compared with the theoretical shape. It has shown that there were differences between the two shapes. Differences between the two shapes could be attributed to:

- the evaluation of the forming force by means of the Finite Element analysis which is not accurate enough
- the elastic springback of the formed part. After the unclamping stage, this elastic springback increases due to the residual stresses in the part at the end of the forming stage which can lead to large deviations.

The elastic springback has to be anticipated in the tool path whatever the forming machine used (CNC machine, robot, dedicated structure, …). For this thesis, The CNC machine will be used.

The aim of this thesis is:

- to develop a finite element model of the SPIF process allowing the shape prediction of the formed part and forces calculation with a good accuracy. The model must integrate a precise modeling of material behavior.
- to develop an optimization strategy of the tool path in order to minimize the springback and allowing to minimize the deviations between theoretical and real formed shapes.

This thesis work will be performed in collaboration with the INSA in Rennes.

References

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