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Surface Engineering with Industrial Robots: Compacting of Thermal Sprayed Hard Layers

INTRODUCTION

The ongoing demand for improved materials to optimize desired product properties is particularly often driven by the special needs of the automotive industries or in aircraft production. New alloys with enhanced capabilities are developed, surface refinement or coating can augment or upgrade the qualities of a certain material. For use in mass production reasonable processes have been developed to apply these techniques on a high number of pieces. But when the production comes down to batch size 1 or the product has a complex surface, the well-established production techniques are often no longer feasible with regard to financial aspects or practicability of the desired process. For these reasons industrial robots were again brought into new fields of applications e. g. surface refinement and thermal spraying of three dimensional surfaces [1].

Collaborative Research Centre 708 / SONDERFORSCHUNGSBEREICH 708

The SFB 708 "3D-Surface Engineering für Werkzeugsysteme der Blechformteilefertigung" [2] is concerned with the surface engineering for the tools used in shaping of sheet metal plates, esp. deep drawing tools. One of the goals of this research project is to develop an in-situ production solution combining the individual processes of thermal spraying and surface compacting, both processes based on coordinated industrial robots. The idea behind this is to apply a hard material layer by thermal spraying on the deep drawing tool and to immediately compact this layer. The process of compaction aims at maximizing the hardness of the material by closing pores which might emerge during thermal spraying. Additionally the quality of the surface is enhanced by reducing its roughness. Within the overall research project both the theoretical background as well as the practical realisation of different aspects of this approach is investigated. The particular project in which the authors work deals with the realisation of both the thermal spraying and the compaction process with the help of standard industrial robots which are equipped with one controller which is able to actuate both manipulators synchronously. As mentioned before, the goal of this research is to join both processes in an in-situ technique where they are conducted with a narrow temporal and spatial coupling.

THERMAL SPRAYING AND SURFACE COMPACTION WITH INDUSTRIAL ROBOTS

The first step in developing a cooperating robot solution is to deal with the individual processes of spraying and compacting which are to be combined. A process-aware programming environment for both processes has to be provided to define the desired results for both tasks. As both thermal spraying and surface compacting are not widely used applications for industrial robots at the moment, a production-ready solution does not exist. Figure 1 shows the graphical result of a spraying simulation which is a part of the process planning software solution which is developed during this research project [3]. The primary focus for the simulation is laid on providing an interactive feedback for the user rather than on being accurate.

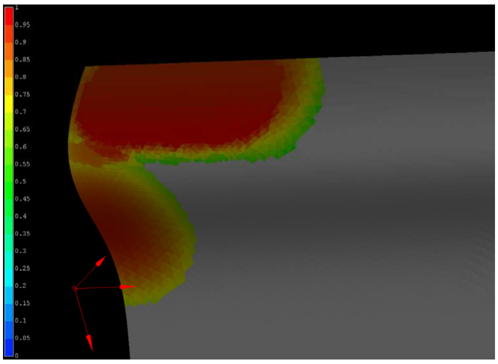

Figure 1: Spray simulation result

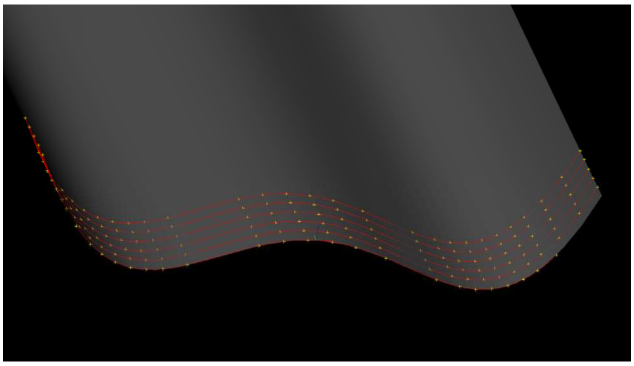

Figure 2: Curvature based path generation

Nevertheless the underlying spraying process model can easily be replaced by a customized model so the simulation vs. speed trade-off can be adjusted by the user of the process planning environment. The fast feedback enables the user to adjust the process parameters for the spraying process to meet the desired requirements for the process result. A similar approach will be developed for the compacting process. The interactive process planning helps to generate robot programs in consideration of process knowledge and the modular design of the process model component allows the integration of upcoming results of the overall research project.

The path planning of both processes is based on the geometry of the work object. Figure

2 shows the curvature sensitive path planning component for path generation. The robot controller requires the discretisation of the complex movement along the surface into simple, often linear movements. To minimize the discretisation error the path is not split uniformly but in a curvature sensitive way with user-adjustable maximum geometrical deviation.

Figure 3: Spring based damping tool

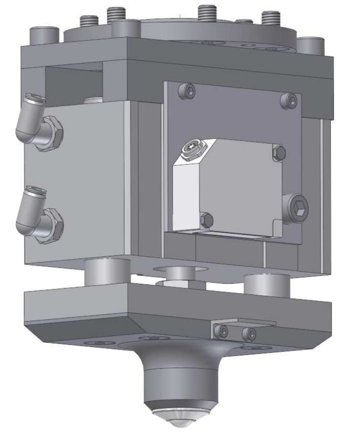

Figure 4: Damping tool with pneumatic cylinder

Although both processes are similar in the way of how the geometrical path planning to cover the surface is conducted, they are very different with respect to their other process constraints defined by their respective tools. On the one hand there is the spraying tool which has to be guided with a certain distance to the work object. To enable the use of the spraying tool by the robot, the tool itself doesn't have to be adjusted. The robot just has to be chosen to be able to handle the load of the tool and the required cables and tubes.

On the other hand the compacting tool has very different properties which bring up the need to optimize the tool to keep the applied force as constant as the process requires and to avoid vibrations. The movement of a standard industrial robot is defined by a geometrical description of positions to move to and the description of how the robot must move between two discrete positions. As the compacting tool is moved along the surface to apply a certain force, even small deviations of either the planned robot movement or the expected surface shape yields in an undesired change of the applied force. For this reason the compacting tool has been adjusted to be able to be used with the robot. Figure 3 and 4 show two different tools with the required damping properties.

Conclusion

Experiments have shown the ability of an industrial robot to apply the desired force by using a specially designed tool with damping action. As the robot based coating process is still under development, the thermal sprayed hard layer was produced in a former step and the sprayed metal plate was heated to emulate the later process conditions as a necessary base for reliable results. The technological process requirements of the compacting, especially the magnitude and the constancy of the force, were fulfilled. The next steps of the project, the very close temporal coupling of the coating process and of the presented compacting process, is directly leading to a close spatial coupling of the robots and therefore puts new challenges in planning and simulation environments for coordinated robot systems.

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