Computer-aided laser surface treatment and combined nitriding of forging dies with the objective of a lifetime increase

Rendicontazione

Informazioni relative al progetto

CURARE

ID dell'accordo di sovvenzione: 222317

Sito web del progetto

Progetto chiuso

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Questo progetto è apparso in...

Final Report Summary - CURARE (Computer-aided laser surface treatment and combined nitriding of forging dies with the objective of a lifetime increase)

Executive summary:

The European forging industry, which is dominated by small and medium-sized enterprises (SMEs), is steadily forced to reduce production costs and increase production volumes as well as part quality. One opportunity to meet these challenges is the application of innovative surface treatments to increase the forging die lifetime significantly and thus to reduce the overall die costs by 30 %. Therefore, in close cooperation, a consortium of two well-established research and technologically development (RTD) performers with specialised knowledge in surface treatment, five forging enterprises and two enterprises operating as job-shops from five different countries developed the 'Computer-aided laser surface treatment (laser alloying / dispersing) and combined nitriding of forging dies with the objective of a lifetime increase' (CURARE).

To enable the successful implementation of the project results in industrial applications four main objectives have to be achieved within this project:

(a) the design of an industrial applicable machining system;
(b) the development of geometrical flexible machining strategies for laser alloying / dispersing process;
(c) the development of a CAx-module for laser surface treatment;
(d) the benchmark of nitriding technologies.

The technological objectives of the project were achieved. On the basis of elementary process investigations concerning laser alloying / dispersing, characteristic geometrical elements of tools and dies, provided by the industrial partners, were treated by laser. In addition, the National Institute for Laser, Plasma and Radiation Physics qualified different nitriding processes for the combined surface treatment.

Parallel to the process technological investigations, Fraunhofer IPT developed a CAx-module for displaying the entire planning chain for the automated laser surface treatment: starting with the detection of

geometry of the part to process simulation leading to the generation of the numerical control (NC) codes for machining.

Especially for the 5-axis laser surface treatment a machining system was built up. Selected tools and dies of the end users were locally laser alloyed / dispersed in the highly stressed areas. After the subsequent nitriding, the tools and dies were already applied in production with good results. Due to the surface treatment the lifetime of the tools and dies was extended as well as the geometry stability of the specific geometrical elements. Because of the improved wear resistance, the economic efficiency was increased significantly - especially for complex and expensive tools and dies and for large batch sizes.

Project context and objectives:

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Therefore, in close cooperation, a consortium of 2 well-established RTD performers with specialised knowledge in surface treatment, 5 forging enterprises and 2 enterprises operating as job-shops from five different countries developed the CURARE.

The CURARE process chain for combined surface treatments is verified by the use of selected forging dies and aluminium die-casting tools in production under industrial conditions in the enterprises of the cooperating end users.

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Project results:

The first objective is to design an industrial applicable machining system for the addresses automated 5-axis laser surface treatment. With regard to this objective, the requirements concerning an appropriate machining system as well as additional components for flexible laser surface treatment were identified and assembled. As machining system, a 5-axis machining system with gantry-design was built up. Furthermore, a diode laser system, a processing head including a powder nozzle with a co-axial rotary powder feeding gap, a powder conveyor system as well as a touch probe were integrated in the machining system. The build-up of the machining system has already been finished at the end of October 2010. With regards to the selection of a laser system, comparative process investigations with a diode laser and a fibre laser have been performed. Because of the adequate beam quality and process stability in

connection with the lower investment costs, a diode laser was finally chosen.

The second main objective is the development of geometrical flexible machining strategies for laser alloying / dispersing process. Therefore, a selection of adequate additive materials as well as basic investigations concerning the laser alloying / dispersing process has been carried out. The additive material tungsten carbide - cobalt - chromium (WC-Co-Cr) with a combined plasma nitriding provides the best results concerning abrasive wear resistance. Therefore the additive material WC-Co-Cr has been selected for subsequent process investigations.

Further investigations included the variation of process gases and base material hardness with regard to the influence of the machining result. The investigations concerning the variation of process gas show that the influence of the used process gas (nitrogen, helium and argon) is insignificant to the penetration depth of the additive material as well as to the hardness of the surface. Furthermore, with increasing hardness of the base material, a higher decrease within the heat affected zone of the material could be recognised. This effect has just a slight influence on the laser alloying / dispersing process, but a high influence on the penetration depth of the nitriding layer. In addition, investigations concerning the hatch distance exhibit that with regard to technological and economic aspects, a path overlap between 40 and 60 % is optimal. Here, a homogenous useable alloyed / dispersed layer is achieved in a reasonable machining time. Moreover, investigations concerning the maximum angle of incidence for the laser treatment are of high importance for the layout of 5-axis machining strategies in the developed CAx-module. The results show that a maximum angle of 30 % does not need to be exceeded.

For higher angles, an inadequate surface quality and penetration depth is achieved. With the results of the basic investigations and the development of a CAx-module, which is the third main objective within the project, the development of geometrical flexible machining strategies is possible. On the basis of a bar geometry specific parameter variations were tested. By a step wise adaption of the laser power and the feed rate of the laser the contour accuracy as well as the penetration depth of the alloyed/dispersed layer was optimised.

The required CAx-module was developed at the Fraunhofer IPT. With this module an automated laser surface treatment can be achieved, including a database for the laser alloying / dispersing process. For the CAx-module the process chain was defined. Starting with the detection of geometry of the part to process simulation leading to the generation of the NC codes for the machining system the entire planning chain for the automated laser surface treatment is covered.

This CAx-module was developed concurrent to the investigations of the combined process of laser alloying / dispersing and nitriding. The simulation of machining strategies refers to the process know-how of the laser alloying/dispersing process, which has been generated by the basic investigations mentioned above. With the creation of a simplified graphical user interface (GUI) for the CAx-module an easy selection of the process parameters, machining strategy and treated area of the part is possible. After a short instruction period also non specialists will be able to handle this software.

The benchmark of nitriding technologies, the analysis and later the design of a quality control concept is the fourth main objective of CURARE. The investigations concerning an optimised nitriding process are

carried out by the National Institute for Laser, Plasma and Radiation Physics. The investigations contain a benchmark of the nitriding methods plasma nitriding, gas nitriding and salt bath nitrocarburising. One result is that with a plasma nitriding similar penetration depths can be achieved in comparison to gas nitriding, but in a significant shorter duration period. A further investigation reveals to the influence of the chemical composition of the additive material of laser alloying / dispersing on the penetration depth of the nitrided layer. A main result is that with decreasing amount of tungsten the penetration depth increases. This effect also occurs by decreasing the hardness of the base material. However, by decreasing the hardness of the base material the wear resistance of the material will be reduced and shorter lifetimes are expected. An optimised ratio between the hardness of the base material and the depth of the nitriding layer has to be investigated.

The final result of the benchmark of the nitriding processes is that all mentioned nitriding processes can be applied successfully in combination with laser alloying. All developments regarding laser alloying / dispersing process, nitriding process, machining strategies and CAx-module are the basis for the automated 5-axis treatment of tools and dies of the partners. Five different tools and dies, provided by the partners, have been combined treated within the project duration. Three of them were already put in application or are still in production. The other tools and dies will be applied closely after the end of the project duration. Between the laser treatment and the ongoing nitriding, the laser treated surfaces of the tools and dies have to be finished by milling or grinding, to achieve the requested surface quality. The final nitriding of the applied tools and dies was carried out on the basic investigations of the National Institute for Laser, Plasma and Radiation Physics.

Potential impact:

The combined treated tools and dies of the partners achieved a higher lifetime of about 50 % compared to conventionally treated tools and dies. Furthermore, the geometrical stability of the tools and dies was highly improved which leads to a higher reproducibility of the forging and aluminium die casting process. The analysis of the applied tools and dies offers that the combined surface treatment regarding economic and technological aspects is reasonable for complex tool or die geometries as well as for large batch sizes. For simple geometries with small batch sizes the combined treatment is not economically, because of the additional time for programming and laser treatment.

By the development of the automated surface treatment the competiveness of the SMEs will be improved. The participating job-shops can use the knowledge of the developed machining system as well as the CAx-module to offer an automated combined surface treatment. Because of this, a higher quality can be assured. Furthermore, these companies can acquire new customers, because of the dissemination of the results of this project, Europe-wide. In addition the participating forging enterprises gain extended lifetimes of their tools and dies in application increasing the resource and production efficiency as well as the reproducibility of the produced parts. The close and permanent cooperation with the European forging association EUROFORGE and their national member associations ensures a sustainable Europe-wide dissemination and use of the achievements even after the end of the CURARE project.

List of websites:
http://www.ipt.fraunhofer.de/en/Competencies/processtechnology/Projects/130_Curare.jsp

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Documenti correlati

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