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Process monitoring and closed loop controlled process

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There are a number of variables which can seriously affect the sheet metal forming process. By determining the process fluctuations, it will ultimately be possible to improve the production process. To do this, monitored or closed loop controlled processes potentially constitute an important tool for the reduction of defects, reduction of rework and a better quality of final products.

The Fraunhofer Institute for Machine Tools and Forming Technology (IWU) in Chemnitz investigated typical process variables such as flange movement as the basis for control systems. Different kinds of non-contact sensors were successfully tested. A multi-point cushion or tool integrated piezo-elements in conjunction with torsion-elastic tools were used as reacting systems.

One application used process monitoring with one or more sensors to support quality control, or the same system with an add-on for early error recognition and automatic recommendation of corrective measures. Finally, fully controlled loop systems based on intelligent algorithms were developed.

Keywords: *process monitoring, closed loop control, in-process, deep drawing, sheet metal forming, sensor, laser, piezo-actuator*

1. Introducation

With the increase in complexity of customer-specific component geometries in production and the simultaneous improvement in the properties of the finished components, the tasks facing the metal processing industry are ever more challenging, bordering on the impossible. For this reason, technologies and processes which exploit the potential of manufacturing options more effectively than was previously the case, which open up broader fields of application and reduce costs, are of crucial importance. In this connection, process monitoring and process control are of particular importance, since they firstly enable more prompt recognition and correction of faults and secondly facilitate seamless quality control.

The use of high-strength materials such as aluminium and the simultaneous increase in the complexity of components for reasons relating to design and functionality intensify the problems even further. The requirement for reproducibility must be regarded as a further, very important criterion for mass production [1–5].

When combined, the points listed above, which characterise almost all production operations at the present time, result in the following general specification criteria:

- work at the limits of the forming capability of the materials,
- work in a very narrow process window.

The resulting links are shown in Figure 1. What stands out, compared with processes in use to date is the narrower field of tolerance within which manufacturing must now take place.

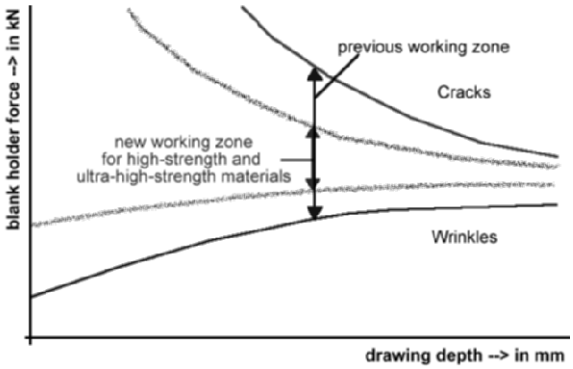

Fig. 1. Working zone during deep drawing

Production which is reproducible and free from defects thus becomes increasingly more difficult as the working zone becomes smaller. There are two options for countering this:

- The boundaries of the process window must be widened. This is facilitated, for example, by the use of multi-point drawing technology in conjunction with blank holders with flexural elasticity or by means of a drawing process with superimposed vibration.
- Manufacturing must remain constantly at the centre of the available working area. This variant requires process monitoring or process control in order to be able to intervene in the event of any deviation in the parameters.

As most presses in industrial use are in plants where the aforementioned multi-point drawing technology is not available, attention is focused mostly on the second alternative. The following conditions must be met for maximum effectiveness:

- a process variable which can be detected and which characterises the changing process with an adequate degree of precision,
- appropriate sensors to monitor this process variable (wherever possible in-process),
- analytical software which processes these data and generates a response (correction factor) as output,
- an option to implement the correction in the plant, which can be carried out manually in the context of a process monitoring capability.

2. Factors affecting the forming

In addition to pre-process and post-process factors, it is of course the forming process itself which has the greatest influence.

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