# NextGen Deep Drawing

## Closed Loop Control of the Deep Drawing Process using a 3D-Servo-Press

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**Abstract**

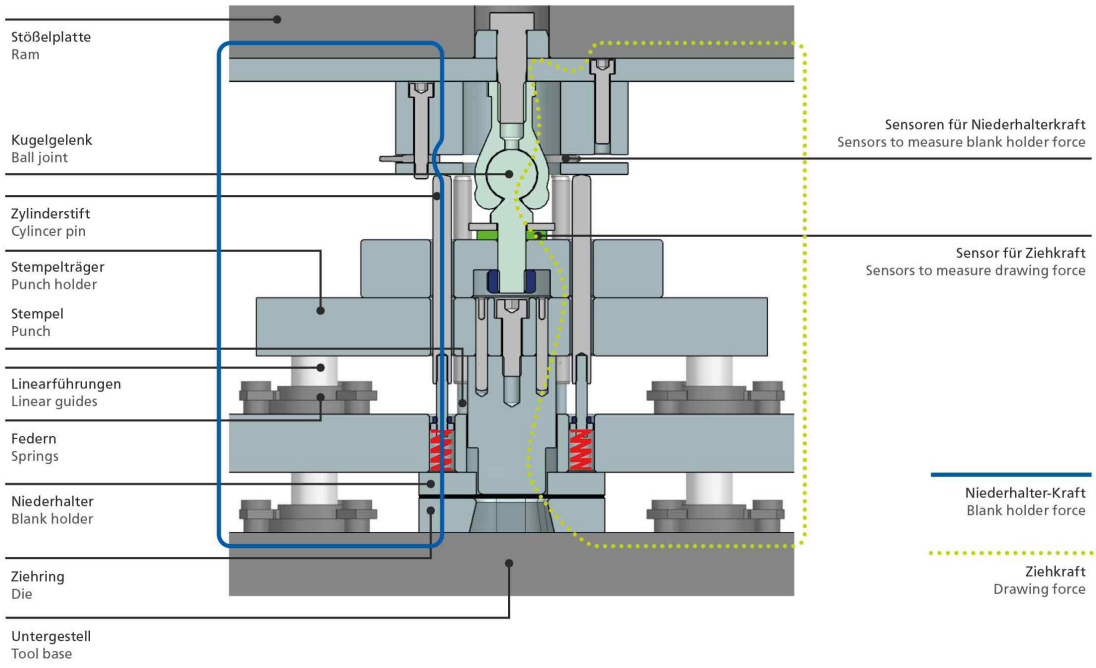
Deep drawing is an industrially very frequently used process for sheet metal forming. Current trends in the automotive industry, such as the use of higher-strength sheet metal, result in smaller process windows. Due to fluctuations in material properties, tribological parameters, or wear of tool components, the reduced process window poses the challenge of ensuring consistent product qualities. In order to guarantee a robust process, research is being carried out to integrate the deep drawing process into a closed control loop. However, previous approaches are based on actuator technology integrated in the mold, which drastically increases the development effort and the associated costs.


**Project description**

The 3D servo press offers two degrees of tilting freedom in addition to the vertical ram movement also found in conventional presses. The developed die concept can be seen in figure 1 and is constantly being further developed: Tilting the ram plate causes the cylindrical pins to be displaced vertically, which leads to compression of the springs underneath. In this way, locally different forces can be applied in the blankholder.

After the basic process influenceability was presented, different model-based control strategies were developed and investigated. The first control strategy makes use of the three force sensors in the hold-down: The position of the resulting force application point in the plane (“Center of Pressure”- CoP) is calculated from three individual forces. For the rotationally symmetrical components investigated, there should be a uniform pressure distribution on the component flange, which corresponds to a centered position of the CoP. An off-center position, which could be caused by a broken spring, for example, can be reliably detected and compensated for by the developed control system.

The second model-based control measures the tilt of the blankholder relative to the drawing ring – to ensure uniform contact, the blankholder should always rest evenly. This can be ensured by the tilting of the slide, with which product properties (wrinkling) can be directly controlled via the press.




[1] Design of a Cardanic Deep Drawing Tool for the 3D Servo Press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**Results**

During the project, a novel forming tool with a cardanic blank holder was developed, which can make use of the additional degrees of freedom provided by the 3D servo press. It was demonstrated that the passive use of a cardanic blank holder can aid in the local distribution of the blank holder pressure. To allow for closed loop control of the process, two observers were developed and successfully implemented into the machine controller. The first one is based on the location of the resulting blank holder forces and can be an indicator for an offset in the machine, while the second one is monitoring the occurring wrinkles during the process.

Actuating the blank holder actively using non-linear ram movements, the developed control strategies successfully stabilize the process and thus increase robustness. To allow for a better assessment of the chosen observers and controllers prior to carrying out experimental work, a numerical model was implemented. This model contained the tool, including the cardanic blank holder, as well as the developed observers and control strategies. Thus, the process could be investigated numerically before experimental work was carried out. Lastly, a promising step was taken in terms of failure localization using acoustic emission sensors. It has been shown that three acoustic emission sensors mounted on the punch of a Marciniak test, can pinpoint the location of failure ex-situ, just before the failure becomes visible in the optical systems. While this can currently only be done ex-situ, the approach itself is promising and could lead to an in-situ observer with further research.

**Acknowledgement**

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