The idea for synchronized drawing comes from the Dresden Fraunhofer Institute for Machine Tools and Forming Technology (IWU): when the ram and die cushion of a press move in a phase-shifted rhythm adapted to the material properties and divide the drawing process into a number of small forming processes, almost without metal holders, the failure limits of the sheet metal are reached later than in a press stroke made in one movement. Optical marks and unevenness in the flange area of the workpiece are system-related and must be accepted in the application.

For the new press generation, Dunkes developed an efficient drive concept for the ram and die cushion.

Impressive Results

Newly developed servo-spindle presses with motion control create the conditions for the innovative technique of synchronized drawing.
Until recently, there was no machine that could move the masses of ram, die cushion, and forming tool up and down dynamically, precisely, in a synchronized manner, and with a frequency of up to 30 Hz, as is necessary for synchronized drawing. To achieve this, the phases of jolt, acceleration, and running up and braking nine axes with motion amplitudes of less than 0.1 mm must be synchronized exactly in a time frame of 33 ms.

Dunkes GmbH based in Kirchheim/Teck, Germany, manufactures presses for various technologies. In addition to stamping, deep drawing, and assembly presses, the company also builds straightening, powder, wheel mounting, and dismounting presses as well as spotting and tryout presses. For a new generation of presses, Dunkes developed an efficient servo-spindle drive concept for rams and die cushions in collaboration with the Fraunhofer Institute for Machine Tools and Forming Technology (IWU). This enables repetitively accurate positioning of less than 0.01 mm under centric load and a press portal that is fit for the new servo-spindles in terms of rigidity and the quality of the ram and die cushion control but also in terms of the extremely dynamic response and high degree of precision.

Repetitively accurate positioning

Five water-cooled 1FW3 torque motors with a power of 39 kW each are used as drives for the ram-side 400 kN spindles – four motors for the ram and one motor for the sheet pressure pad. Four water-cooled 1FW6 torque motors of 12.5 kW each were installed for the die cushion. In connection with frequency converters from the Sinamics S120 series, the torque provided by the torque motors gives the spindles a great dynamic response with very good control at the same time. The nominal values, preset isochronously up to 2,000 times per second by the Simotion P350-V3 motion control system (bus cycle 500 ms with Profinet with IRT [isochronous real time]), are adjusted 800 times per second at the drive level. The high control and positioning accuracy meets the requirements of the demanding applications that characterize the press manufacturer’s market. It is not only a question of increasing productivity requirements but also of the precision of the press technology. And it is becoming increasingly expensive to meet these demands with hydraulic presses. “A well-controlled servo-electric spindle is faster, more rigid, and more precise than a hydraulic axis even under consideration of all basic conditions,” explains managing director Ralf Dunkes. “Development of force, acceleration, and precision are available with repetitive accuracy throughout the stroke. This is unique.”

Dunkes can also use this technology in other product areas. For example, assembly presses can be implemented with end-position accuracy in the micrometer range, as required in ball head assembly, for example. During stamping, all the force is taken out of the movement at a defined position just before the tool breaks through the sheet so that a cutting impact is reliably prevented without any additional devices and a very clean cut is produced.

Software computes optimum sequence of movements

Contact between the IWU and Dunkes has existed for many years. Based on a specification of the Dresden IWU, the ES 4 160/120 press with a ram force of 1,600 kN was developed in Kirchheim and handed over to the IWU laboratory for testing of the technology of this special drawing process. The ram and die cushion of the press are equipped with four or five electronically symmetrized servo-spindles. The original requirement was that the ram equipped with forming tools execute a predefined sequence of movements at least 15 times per second in synchronization with the die cushion. This value has since been bettered.
The press movement is distance-controlled until the die hits the material. In the actual forming process, the top and bottom of the tool are guided either with a defined distance or independently of each other. Periodic switching between distance- and force-controlled motion control is possible. Software developed jointly by Dunkes and the IWU computes the optimum sequence of movements depending on the material and tool properties. The program offers the operator a practical user interface and therefore a simple, intuitive introduction to the new technology.

The first drawing tests with the new press were convincing. Two types of kinematics were compared under identical basic conditions: one was a conventional deep drawing process with the minimum possible cushion force, and the other was a forming process with the "synchronized drawing" option switched on.

Synchronized drawing immediately achieved double the drawing depth. This tendency was also confirmed in the subsequent tests. Other factors in addition to the high forming performance contribute to the productivity and economy of this new press type. For instance, no hydraulic oil and no oil pumps and pressure accumulators are required for servo-spindle presses. This saves space and eliminates the need for complicated and dangerous handling of hydraulic oil.

**Energyefficient and economic**

Servo-spindle presses also use energy efficiently. This begins with the drives of the die cushion operating in generator mode when displacing the die cushion. Part of the energy used by the ram is fed back into the connected intermediate circuit of the spindle drives, a clear advantage over the energy losses with hydraulic cushions. In addition, the energy drawn from the supply network in this process phase is reduced.

However, synchronized drawing is only economically useful with feedback. At 30 Hz, greater current flows are moved backward and forward between the motor and the intermediate circuit in a cycle of 33 ms, and the energy released during braking is collected. Actively controlled feeding is available for the Sinamics S120 drive family used by Dunkes, which minimizes the retroactive effect of the press on the supply network. In addition, it contributes to the compensation of the phase offset between current and voltage caused by other machines.

However, the greatest contribution to energy savings is promised by introducing the new technology of synchronized drawing. It is conceivable that great drawing depths can be achieved by a press in one action. It should also be possible to produce complex drawn parts with this technique without any problems. Intermediate annealing of the parts can be omitted, and lower-cost lubricating oil coats and sheet metal qualities can be used. There is no cutting impact, and the wear on the tool and machine is reduced. Better cutting quality is also achieved.

**Optimized for new challenges**

In view of the considerable process advantages of the new forming technology, the interest of the producing industry in the servo-spindle presses of the German machine manufacturer is great. But the developers are interested in sustainable rather than rapid success, as managing director Ralph Dunkes makes clear in light of the excitement with the achieved results: "The process and our new press design are being tested systematically at the IWU in Dresden. The industry needs a stable process with high process security and availability, which we as a machine manufacturer want to provide. We will not launch synchronized drawing onto the market until the process and the machine are mature enough."

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