POWERFUL, HIGHLY DYNAMIC, AND FLEXIBLE: THE MOOG MODULAR DIE CUSHION SYSTEM

The Moog modular die cushion system

Deep drawing is a key processing step in forming semi-finished products on presses, and die cushions play a key role in this process. They build up and regulate the forces required to draw the part, reduce the impact of plungers on the work piece and ensure that the desired product quality level is reached. The Moog modular die cushion system allows press manufacturers to develop machines with the highest possible levels of productivity and flexibility.

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The requirements for hydraulic presses used in deep drawing operations frequently change for a number of reasons. For example, highly precise process control units are required to manufacture chassis parts, and without these new difficult-to-form materials cannot be shaped into a desired form. Moreover, production processes are becoming increasingly flexible to enable shorter product cycles and tool change times, and ultimately the amount of scrap must be kept as low as possible in order efficiently to operate press machinery. Modern hydraulic die cushion control units need to surmount all of these challenging aspects related to the production process and ensure product quality.

The perfect interplay for securing optimal product quality

A hydraulic draw press consists of top piston (plunger) elements and die cushion components. The die cushion is located beneath the blank holder ring, and contains the pressure box (including the pressure pin) as well as the die cushion cylinders and their hydraulic modules. The cylinders are connected with the press frame via the cylinder-bearing seat (Image 1).

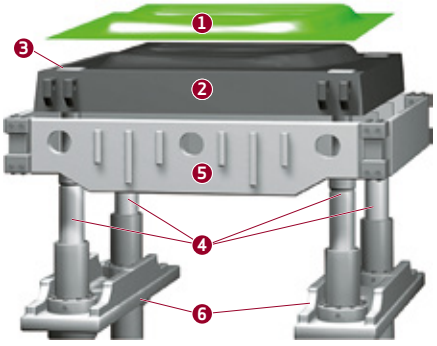

Image 1
Draw press structure:

1. *Drawing component*
2. *Lower tool*
3. *Blank holder ring/ pressure pin,*
4. *Die cushion cylinders,*
5. *Pressure box/die cushion plate*
6. *Cylinder bearing seat*

The die cushion represents the 'heart' of the forming process, having a decisive impact on the quality of the pressed (formed) parts. During the drawing process, a sheet metal blank is pulled in and formed by the upper and lower tool, to a constant level of sheet metal thickness. The sheet metal cannot shift out of place during the pressing process, as this could cause wrinkles or tears to form. The die cushion prevents this from occurring by fixing the work pieces over the blank holder, and ensuring that the sheet metal is precisely tracked during forming. The force of the top piston is guided via the blank holder ring and the pressure pin into the die cushion. Prior to any transmission of force between the top piston and the die cushion, the moveable elements of the die cushion are pre-accelerated to reduce impact. After the work piece has been clamped to the blank holder, the die cushion is moved in a force control unit. The control units are highly dynamic, and prevent damage from being incurred to the drawing component and the tool. In order locally to adapt the drawing forces for asymmetrical work pieces and loads, the total drawing force is often distributed across several pressure points with independently working cylinders (such as two-point, four-point, or six-point die cushions). The combination of several die cushion modules makes it possible to implement different drawing forces related to the pressure point. Each axis functions independently, and is controlled by a superordinate control unit for the entire system.

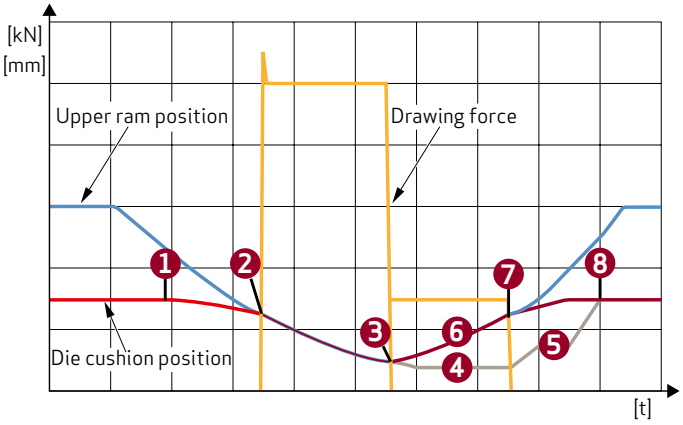

Image 2
Standard work cycle of a drawing process:

1. *Die cushion begins pre-acceleration*
2. *Low-impact transfer and build-up of cushion force (programmable development)*
3. *Lower dead point of the top piston press, decompression of the die cushion*
4. *Withdrawal of the die cushion*
5. *Freely programmable extension of the die cushion*
6. *Closed extension of the die cushion under freely programmable drawing force*
7. *Opening of the blank holder and movement of the formed part into the part removal position*
8. *Starting position for a new cycle*

Constructing the modular die cushion system

The main components contained in the kit system are cylinders with an integrated position measuring system and the flanged control manifolds as well as the accumulators, hydraulic power unit and the control unit's software and hardware components (Image 3). The die cushion manifold, including the adapter manifold and the accumulators, is directly flanged onto the cylinder. This combines to form a compact, rigid hydraulic system that enables highly dynamic control. The control unit is implemented within the system using separate hardware and software modules. This reduces force overshoots, and achieves customer-specific force profiles with a high level of accuracy.

The hydraulic system structure is identical for all nominal sizes. It consists of a unit with pressure supply, and a separate bypass flow filter and coolant circuit. The pressure from the hydraulic accumulator loaded by the main pumps continually increases on the piston side of the cylinder. The proportional valve controls the cylinders on which the pressure box is supported. The control unit takes on a superordinate role. It reads out the data from the pressure and position sensors, and moves the cylinders over the respective proportional valves into the correspondingly coordinated pressure or position control loops.

The safety related part of the hydraulic control unit is also integrated in accordance with EU Machinery Directive (2006/42/EC). The pressure build-up and load side of the axis are redundantly protected. This prevents possible hazards from arising during the deep drawing process – such as a risky downward motion of the axis – and enables secure separation of the pressure supply.

The die cushion drive control unit

The system's software is based on the continuous development of Moog's die cushion control technology. This has given rise to a software library for using CODESYS- or TwinCAT-based (IEC 61131-3) motion controllers that contain classic pressure controls, as well as power and position status controls. The library also includes a function for pressure or force profile generation, with a gentle force progression that keeps the work piece free of tension. Together with a precise control unit, this prevents cracks and wrinkles from forming on the work piece. Moog has developed a unique algorithm for controlling pre-acceleration, which synchronizes the pre-acceleration trajectory to the plunger position.

The software library is coordinated with the hydraulic components of the modular die cushion system. Hydraulic components are available in various sizes to cover the special requirements for attainable deep drawing forces and stroke rates. Size plays a subordinate role for the control unit. The number of die cushion modules and the design of the valve interfaces are decisive. This makes the intended area of application in one-point or multi-point die cushion systems implementable with independent pressure or force profiles.

Moog offers three options as far as this is concerned:

- Different functional blocks in libraries that customers can combine themselves.
- A complete package based on functional blocks for die cushions with the same configuration.
- A customized programmed solution.

The complete package contains a motion controller with software that controls Moog valves. Moog EtherCAT field bus valves enable disruption-free digital target value specification and a detailed diagnostics option, and include an integrated I/O function for decentralized reading of the pressure sensors. A Profinet interface that transfers non-time-critical deep drawing and driving parameters and releases the die cushion control unit, is used for superordinate machine control.

At a later stage, the control unit executes the parameterized work cycle (depending on the linear plunger position) entirely independently. An HMI connection enables a simple, easily readable diagnosis.

Customer-specific solutions

Each new deep drawing press poses special challenges for designers, which is why Moog application specialists support customers in selecting components and assembling the entire system in line with their specific framework conditions and cycles. Since it is highly flexible, the Moog modular die cushion system effectively helps to create competitive solutions that benefit customers.

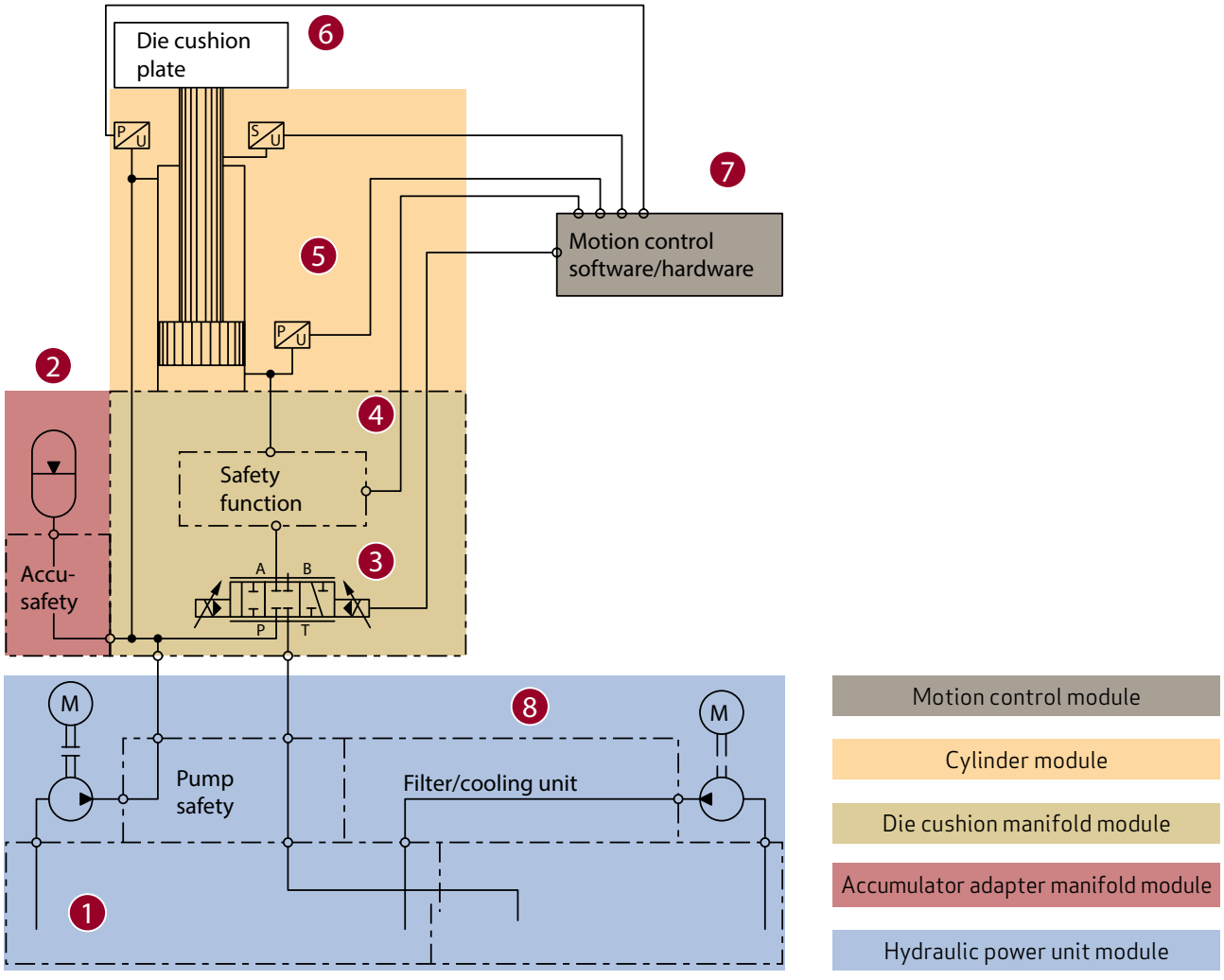

Image 3
Modular die cushion system structure:

1. *High-pressure pumps*
2. *Storage safety*
3. *Moog proportional valve*
4. *Safety-related elements*
5. *Cylinders*
6. *Pressure box*
7. *Software/hardware control*
8. *Filter/cooling unit*

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The Moog Modular Die Cushion System
Rev. A, June 2019