Forming Dies, Cushion Systems and Sensors

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Basic Elements of Forming Die

- Ram
- Spacer
- Guide Pins
- Blank Holder
- Cushion Pins
- Lower Shoe
- Load Cell
- Bolster
- Punch
- Die
- Upper Shoe
Die Designs

Basic design of different draw dies
Courtesy: Schuler Inc.
Single-Action Die with Draw Cushion

1. Mounting area, die
2. Slide, ejector, draw punch
3. Press bed, draw cushion
4. Slide stroke, part height

Courtesy: Schuler Inc.
Cushion Systems
Cushion System for Deep Drawing Processes

- Blank holder force (BHF) plays a key role in controlling material flow in deep drawing.
- A cushion system delivers BHF on the sheet part.
- When estimated correctly, BHF provided by the press cushion system can prevent wrinkling and tearing in the formed part.
Single Point Hydraulic Cushion System

- **Draw Cushion System**
  - Exerts counter holding force on the metal blank
  - Ensures controlled flow of material into the drawing die
  - Prevents the formation of wrinkles and cracks in the drawn part

[Ref. Altan and Tekkeya, 2012]
Pneumatic Draw Cushion

Working media
- Air pressure generates the counter holding force.
- Spring drawing mechanism has become obsolete.

Pneumatic drawing mechanism
- Disc piston moves against compressed air, generating force
- Compression restricted to 300-psi
- Cushion retention and damping mechanisms required

[Ref. Altan and Tekkeya, 2012]
During Down Stroke, Cushion Pressure Generates Power (About 70% Energy Saving)

Servo-Hydraulic Cushion (Courtesy-Aida)
**Systems with Nitrogen Cylinder**

- The principle of nitrogen cylinder cushions is similar to pneumatic cushions, except that instead of compressed air, compressed nitrogen gas is used as a pressurizing medium.
- The three most common designs of nitrogen cylinders used in cushions:
  (a) one-chamber design for short stroke application
  (b) two-chamber design for large-stroke application
  (c) modified two-chamber design for control of two different pressures at either side of the piston.

[Ref. Altan and Tekkeya, 2012]
Multipoint Cushion Systems (MCS)

- MCS offers highest possible degree of flexibility with regard to blank holder application along the contours of the drawing part.
- Few pressure rods act directly on the blank holder in contrast to a single pressure box and large number of pressure pins.
- Each pressure rod is connected to a displacement cylinder and can be controlled individually.
- Parts can be formed by varying the cushion force along the contours of the blank holder, thereby eliminating the need to rework the die and prevent loss of valuable production time.
Software for Programming Multi-Point Cushion Systems (ERC/NSM)

New Developments in BHF Application

- Each cushion pin is individually controlled by a hydraulic cylinder
- Offers high degree of flexibility with regard to BHF application along contours of the part being drawn

(Source: Schuler Inc)

(Source: Siegert / IFU Stuttgart)
Industry Application of MPC

Multi Point Cushion by Dieffenbacher

- MPC is routinely used in deep drawing of stainless steel sinks

(Source: Pahl 1998  Cushion systems for deep drawing stainless steel sinks", New developments in sheet metal forming)
Sensors for Sheet Metal Forming
The quality of formed sheet metal parts is affected by variables such as sheet material, die material and surface, lubrication, and press characteristics.

Therefore, monitoring these variables and controlling their effects to produce high-quality products is critical and essential.

The purpose of using sensor technologies is to improve the sheet metal forming process by increasing tool and machine uptimes, reducing setup and downtimes, and reducing scrap.
Measurements of Forces

- Force sensor provides important information for operating a press by measuring the press loads.
- Force sensors are also referred to as tonnage monitors.
- Typically, they output the load values as a function of slide displacement, time, or crank angles in the case of mechanical presses.
- This information is also called force or tonnage signatures.
Benefits to use force sensors

Force sensors can help to achieve the following objectives:
- Protection of machine from overload
- Monitoring of tool wear
- Detection of changes in stock thickness and hardness
- Detection of changes in part lubrication
- Detection of parts that may be stuck in the die
- Detection of incorrectly feeding a blank
A load cell is a force transducer that converts force into an electric signal.

- Strain-gage-based load cells are the most commonly used type.
- Load cells typically contain multiple strain gages aligned and wired in a Wheatstone bridge circuit.
- When stress is applied to a strain gage, the resistance of the strain gage changes and unbalances the Wheatstone bridge, resulting in a signal output (voltage) that is proportional to the stress.

[Ref. Altan and Tekkeya, 2012]
Displacement Sensors

- **Linear variable differential transformers (LVDTs)** to measure the displacement of the slide.
- **Proximity sensors** to use for die protection.
- **Photoelectric sensors** to cover a larger sensing range by sending a beam of light from a transmitter to a receiver.
- **Ultrasonic sensors** operate by emitting and receiving high-frequency sound waves on the order of 200 kHz, which is beyond the audible range of the human ear.
Sensors for Tool Breakage and Flaws in Parts

- **Acoustic emission sensors** are used to detect disturbances or failures, that is, tool breakage and cracks in parts, during the forming process.

- **Ultrasonic Sensors** can be used to detect surface or subsurface flaws by flowing high-frequency sound waves into workpiece.

- **Eddy current sensors** can be used to detect cracks in parts by the change in flow of eddy currents in the part.
Machine vision system

- The strain and thinning distributions of stamped parts with the grid pattern can be directly measured, and compared to the simulation results.

[Courtesy: Trilion]
Sensors for online evaluation of material property

Principle of eddy current material testing

[Ref. Altan and Tekkaya, 2012]
Sensors for Lubrications

- Sensors based on high-resolution infrared spectrometry have been developed to measure the oil film thickness on metal surfaces.

Schematic diagram of a portable infrared analyzer

[Ref. Altan and Tekkaya, 2012]
Summary

- Cushion control and the use of multi-point cushion are useful in controlling the part quality and reducing fracture and springback.
- Hydraulic cushions, when available, are more effective than the cushions with nitrogen cylinders.
- Tonnage monitoring systems are essential in modern sheet metal forming.
- Sensors become more important in monitoring the equipment and part quality.
Questions & Contacts

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