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Form By Wire (Electrically Controlled Forming)

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Abstract

Forging machinery traditionally gives an impression of heavy, greasy, noisy and approximate equipment. Recent demands from markets, especially automobile, have made machine designers to reconsider their concept. It is also noted that more advanced technologies in other industries, such as electronics and IT, have become accessible. Naturally these technologies were first applied in highly sophisticated fields for additional performance or features with extra expense. Drastic cost reduction in last decade changes this picture. They provide not only performance and functions but also a chance in reducing costs.

Powerful servomotors, accurate sensors and fast processor satisfy performance, precision and machine control requirement. Control by wires replaces traditional mechanical linkage. Additional features such as factory automation will come almost free.

Introduction

This paper describes a conceptual design of parts formers (horizontal press) that utilize latest technologies. Some of them have been already implemented in production machines. Recent introduction of servo-controlled presses should be highlighted as a major breakthrough in this field. It widens up possibility of cold forming productions. This paper will cover the possibility of other areas that can take an advantage of these technologies. The technologies mentioned here are numerical control, servo control and information processing. True factory automation in forging may start here. Designing and simulating on computer, confirmation and production will be done at production machines.

Function Island:

Former can be segmented as following:

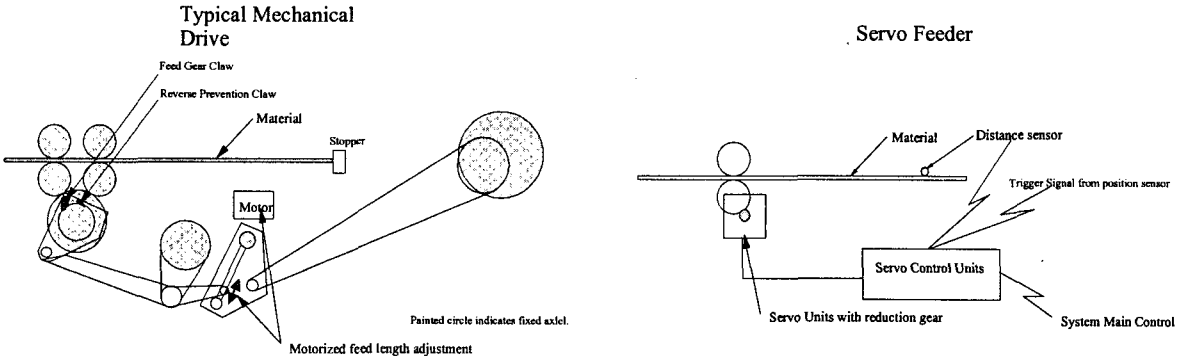
- Feeding material
- Shear/Cut material into proper size
- Transferring blanks
- Pressing (Forming)
- Ejecting from die
- Repeat the above for the number of stations

In following sections, new methods are proposed by comparing against current design per section.

Feeding:

Feed rollers used to be most common method to move material. The rollers are driven mechanically, and changing linkage dimension provides a mean of travel length adjustment. A stopper at feeding end gives accuracy, although it requires slippage between feeding grips and material. Some newer machines are equipped with so called linear feeder, which provides a larger area of contact. This allows more gripping force without distorting material, and eliminates the slippage. It also eliminates necessity of stopper. (Existence of a stopper influences conditions of blank end surfaces.)

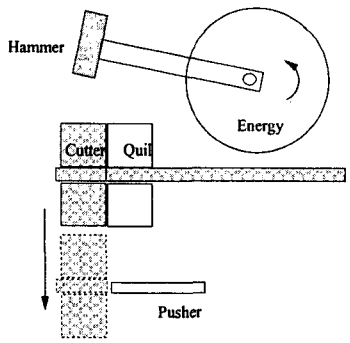
New method proposed here utilizes a servomotor. Material movement is measured directly, and information is used as servo feedback.



Simpler structure gives a cost advantage over mechanical one. The adjustment of cut-off is straightforward. Key components of this mechanism are a servomotor and distance sensor.

Cut-off/Shear:

This may be claimed as the first process that an actual work is done on material by a former. Naturally the quality of this process effects all processes followed. Machine designers have been improving a rigidity of its components and tried to increase a cutter speed. The speed is considered as one critical parameter influences a surface condition. Some of latest formers are equipped with an impact cut-off system to achieve it. Loosely linked system, such as by-wire, guarantees cut-off speed independent of machine operating speed.



A hammer unit stores energy in the form of kinetic, potential or pressure, and releases it by impacting a cutter unit. The hammer must have enough mass and travel over a target shear speed at its impact.

Transfer:

Transferring a blank from station to station is not directly related to a forging process, but an essential function a former needs to provide. Most formers utilize multiple cams to control gripping fingers' movement. Initial adjustment of these cams' timing is time-consuming. Replacing these cams with servomotors reduces this set-up effort. Adjustment and confirmation is simulated on a computer. The same program shall be downloaded on a target machine that will control transfer mechanism exactly as simulated. Trajectory of fingertips can be modified freely, unlike mechanical cam that is constrained by its geometric dimension. Grip timing, duration and even force can be optimized for every production.

Forming:

Most formers obtain its forging force by converting flywheel energy through a crank to a ram. Some manufacturers of vertical press have started shipping new products utilize servomotors, replacing their low to mid range mechanical presses. These presses give wider freedom in forming and improve production efficiency same time. Availability of servomotors, which produce large torque in low rpm, contributed this achievement. Mighty 250KW servomotor is available now. Transferring rotational force into proper reciprocal movement effectively and reliably is still major hurdle.

Every inch of forming process is monitored, and its data is fed to servo for control. Massive data collected during production may help narrow the gap between production and laboratory study.

(Detail description of servo-press is spared to other presentation.)

KO/PKO:

Mechanically operated cams and linkages are used to provide this function. Controlling movements of KO or PKO increases freedom of productions along with transfer. Movements are fully modifiable through servo programming. Many ingenious mechanisms to compensate its own constrains will be replaced by straightforward servo control. Synchronized movements among KO, PKO and punches make blank ejection and transfer more reliable and flexible.

Information Processing:

Many sensors are installed in a modern former. They are mainly used for warnings and safeties. Digitally collected data represents machine states and process. Immediate state matrix is used for control feedback. Statistically processed data is utilized to improve product quality and tool life. It will be also used to control machine parameters.

Whole processes in a former are repetitive. Adoption of control algorithm, such as learning, gives a chance to enhance its efficiency.

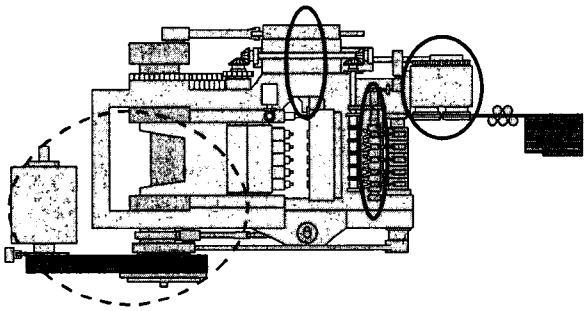
Standard PC will play major roll to achieve above efficiently and economically.

Overall:

- Many parameters fixed during machine design will become modifiable. A machine will be more flexible to support variety of productions.
- Individual servomotor and electrical wires will replace bulky mechanical linkages. Freedom from flywheel and mechanical linkage potentially changes fundamental structure of machine.
- FA, Factory Automation, becomes closers to an ideal goal. More time may be spent in engineering, less time in physical operation. Pipeline approach is achieved effectively across manufacturing and engineering.
- More advance technique will be applied for machine control, such as adapting learning algorithm. Former will be more efficient and user friendly.
- As by-products, characterization of fundamental parameters in metal forming may become available from production.
- Paradigm shift in both machine supplier and user environment. User understanding and acceptance are essential.
  - ✧ Statistical approach
  - ✧ Muscular force to precise control
  - ✧ Mechanical to Electrics/Software

Development Status:

Former Function Segment



Circle portions have been available or tested with servo.
Pressing portion has been available in vertical press.

Conceptual Diagram:

By-wire design promotes modular structure. It even provides expansion capability.