

# Design and Analysis of Ejection Pin System for 1500T Press

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## ABSTRACT

In manufacturing industries hydraulic press are used to produce different parts required for automobile and other industries. To produce different parts by stamping process dies and position patterns of cushion pins are changed. Depending upon the shape of part to be produced respective die and the position pattern of cushion pins in the bolster plate is selected. Before the production starts position of this cushion pins is tested to secure the safety of die and parts to be produced. But the testing consumes more time and effects production rate. In this project the time required for the testing is reduced by automating the cushion pin ejection system. A separate hydraulic system is used for the required automation in order to reduce the idle of the hydraulic press. AUTOCAD and ANSYS software are used for design and analysis of the automation.

**Keywords :** Hydraulic Press, Cushion Pin

## I. INTRODUCTION

### Hydraulic Press

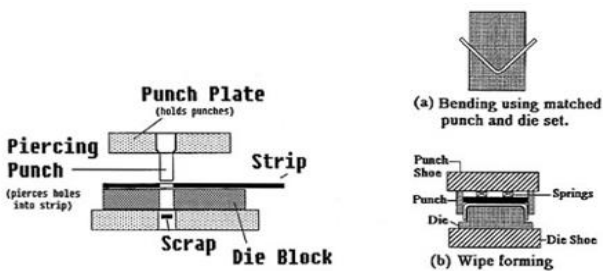
A hydraulic press is a device using a hydraulic cylinder to generate a compressive force. It uses the hydraulic equivalent of a mechanical lever. The hydraulic press depends on Pascal's principle; the pressure throughout a closed system is constant. One part of the system is a piston acting as a pump, with modest mechanical force acting on a small cross-sectional area; The other part is a piston with a larger area which generates a correspondingly large mechanical force. Only small diameter tubing (which more easily resists pressure) is needed if the pump is separated from the press cylinder. Pressure on a confined fluid is transmitted undiminished and acts with equal force on equal areas and at 90 degrees to the container wall. A fluid, such as oil, is displaced when either piston is pushed inward. The small piston, for a given distance of movement, displaces a smaller amount of volume than the large piston, which is

proportional to the ratio of areas of the heads of the pistons. Therefore, the small piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the small piston is moved divided by the ratio of the areas of the heads of the pistons. This is how energy, in the form of work in this case, is conserved and the Law of Conservation of Energy is satisfied. Work is force applied over a distance, and since the force is increased on the larger piston, the distance the force is applied over must be decreased. Bramah's basic idea is also exploited in hydro forming. The benefits of hydraulic press:

- Full tonnage throughout the stroke
- Customization
- Dedicated or multi-functional
- Lower upfront costs / fast ROI
- No design limitations
- Over pressure protection
- Unlimited control options
- Part accuracy

## Stamping Operation

Stamping is a process in which thin walled metal parts are shaped by punches and die. The punches and dies are mounted on mechanical or hydraulic presses and they perform two functions during stamping process: shearing and bending. Mechanical presses utilize a flywheel to store the energy required for stamping operation. The flywheel turns continuously and is engaged by a clutch only when the press stroke is needed. The drawback of mechanical forces is driving force varies with the length of stroke. Hydraulic presses use pressurized oil acting against one or more pistons to drive the punch and die on the press. It is capable of providing full force of the hydraulically driven piston over the entire length of stroke. However, hydraulic presses are slow compared to mechanical presses. Most stamping operations are carried out on high speed mechanical presses even though they are more expensive than hydraulic presses.



**Fig 1.1 : Stamping Operation**

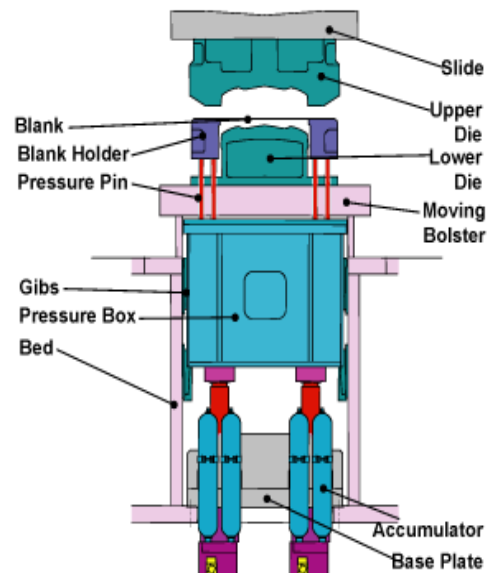
Stamping operation can be done at either a single die station or multiple die stations using progressive dies. Progressive dies is often use when part contains closely spaced features or if they have bend angle greater than 90°. They can also reduce die wear and decrease the amount of spring back (thus improve geometric accuracy). The disadvantage of progressive die is that they requires multiple stations, which requires more space to accommodate additional presses.

### 1.1 Die Cushioning

A die cushion device for press machine includes: a hydraulic cylinder for supporting a cushion pad and generating a die cushion pressure when a slide of the

press machine moves downward; a proportional valve and a hydraulic pump/motor connected in parallel between a lower chamber of the hydraulic cylinder and a low pressure source; an electric motor connected to a rotating shaft of the hydraulic pump/motor; a die cushion pressure command issuer for outputting a predetermined die cushion pressure command; a pressure detector for detecting pressure in the lower chamber of hydraulic cylinder; and a controller for controlling an aperture of the proportional valve and a torque of the electric motor in a manner that the die cushion pressure becomes equal to a pressure corresponding to the die cushion pressure command, based on the die cushion pressure command and the pressure detected by the pressure detector.

The main function of the cushion is to provide a flexible, controlled blank holder force, which fixes the work piece between the upper die and blank holder. This force must be controlled precisely to guarantee optimal material flow during the forming operation.



**Fig 1.2 : Die Cushioning Device**

The use of a draw cushion in the lead-off press of a press line is recommended for producing consistently high-quality parts through reproducible production parameters.

The draw cushion performs a number of functions over the entire slide stroke cycle:

- Preacceleration to adapt to the slide speed
- Pressure build up to the required blank holding force
- Drawing operation with programmable cushion force over the length of the drawing stroke and individually for each cylinder
- Pull-down of the cushion at bottom dead center (BDC) to prevent part damage
- Upstroke into the pickup position and controlled upstroke into the start position

#### Preacceleration

Preacceleration of the die cushion minimizes the impact of the upper die on the blank holder. Adapting the cushion to the slide velocity improves the quality of parts and lifetime of dies and reduces noise.

Preacceleration is calculated by the cushion control for slide kinematics, crank angle, stroking rate, and draw depth parameters. Preacceleration can be selected or cancelled.

#### Pressure Build up

The cushion force is generated after contact of the slide and upper die with the blank holder. The elasticity of the complete system, and in particular the oil head in the lower cylinder chamber, results in a certain stroke length to build up the desired cushion pressure.

The requirements of the drawing operations in the lead-off press determine the type of draw cushion to be installed.

The actual stroke for pressure build up is determined by the pressure of the cushion and drawing stroke (height of oil head).

#### Drawing Process

During the actual drawing process, the blank is formed between the upper and lower die and held with a predetermined force by the blank holder. The

draw cushion provides this blank holder force by displacing oil out of the hydraulic cylinder. The process is controlled by pressure via one proportional valve per cylinder. This means that a pressure sensor permanently measures the oil pressure in the cylinder, compares it with the required value, and opens the proportional valve accordingly.

The blank holder force either can be kept constant or programmed in force profile. Such force profiles can be individually programmed for each cylinder module with regard to the permissible pressure difference. Finished parts can be damaged by resilience of the cushion if pads or ejectors are used in the upper die. To prevent this, the cushion will do an additional controlled down stroke at BDC.

#### Pickup Position and Upstroke

The drawn part is stripped off the bottom die by the upward motion of the draw cushion and brought to the pickup position. The timing and stroke of this motion to the pickup position are programmable.

After the part has been removed from the die, the draw cushion returns to top dead centre (TDC) in a controlled manner without overshooting, so it is ready for the next cycle (press stroke). The timing, or crank angle, of this upstroke motion also can be programmed.

#### Modular Draw Cushion

The modular draw cushion system is a new development that allows stampers to tailor fully hydraulic draw cushions to their specific needs. All active control processes for the draw cushion functions (preacceleration, draw force control, relief stroke at BDC, controlled upstroke, and pickup position) take place within the cylinder modules rather than requiring separate actuators.

Because of the compact, uncomplicated design and stiffness of the hydraulic system, vibration problems are avoided. An extended force range and precise blank holder force are provided. The number of spare

parts is reduced, and the cushion is easy to maintain because cylinder modules are identical.

Each cylinder module is an independently functioning unit. The necessary drawing force is achieved by combining several units. The cushion control keeps the modules synchronized with each other.

Depending on the requirements in the first drawing station, the cushion can be designed with one, two, four, or six points using the same modular components.

### 1.2 Statement For Project

The statement of project is “Design and analysis of automated cushion pin ejection system to improve uptime of the hydraulic press.

### 1.3 Scope

In this project we are going to design cushioning pin ejection system for 1500t hydraulic press tool. This project includes design of supporting plate with supporting rod and lifting frame to test the position of cushion pins in the bolster plate according to the requirement of finished product, with hydraulic system. Also we will analyze the major component for comparison of theoretical result with software evaluated result, cost estimation, work study and time study.

## II. LITERATURE REVIEW

The hydraulic press is one of the basic machine tools. The hydraulic press, invented by Englishman John Brahma, was one of the first workable machines that used hydraulics in its operation. It consists of a plunger pump piped to a large cylinder and a ram. This press found wide use in England because it provided a more effective and economical means of applying large, uniform forces in industrial uses.

In deep drawing of large automotive panels or stainless steel sinks the use of multiple point cushion (MPC) systems are well accepted to improve metal

flow and part quality. The optimum distribution of blank holder force (BHF) components upon various hydraulic or nitrogen cushion pins requires extensive experimentation or die try-outs or could be estimated by FEA simulation. In this paper Taylan Altan and Lars Penter reviewed (2010) various practical MPC systems and discussed the results obtained from FEA predictions and how they compare with experimental observations. Finally, a robust and practical closed loop MPC control strategy is suggested, that makes use of the comparison of the FEA estimated flange geometry with that obtained during actual production. [1]

An important and developing topic in sheet metal forming is the improvement of reproducibility of the deep drawing process. Klaus-Jürgen Pahl studied a new generation of the multi-point-control system consisting of a hydraulic press. a multiple cylinder unit for the blank holding function and flexible forming elements as punch drive. Based on the principles of separating the blank holder function from the slide operation, a part-geometry related blank holder cylinder pattern and providing of centric loading of the forming elements, an improved process stability is achieved. [2]

Tobias Schulze, Jürgen Weber, Lars Penter (2015) developed a system simulation model of a deep drawing press including its mechanics, hydraulics, and control. It serves as a basis for developing an advanced control system which improves system performance with potentially higher slide speeds, and therefore, a more efficient production. Another aspect in the paper is the development of a coupled simulation consisting of the machine model and a process model. This includes the elasto-static as well as the dynamic behaviour of the drawing press and allows for simulations with the highest possible level of detail. The model was used to determine individual set forces for the die cushion cylinders which allowed for the production of sound quality parts without manual die spotting. [3]

Sheet Metal forming is facing many difficult problems such as forming of hard formable materials with high strength and low ductility, high precision forming and improvement of productivity. Due to the recent development, there has been increase in the use of servo presses and servo cushions. The use of servo press is expected to improve tool life, increase productivity, improve processing accuracy, reduce noise and vibration, develop complex processes and shorten forming processes. Pratik Mehta (2017) studied whether the draw ability of the part can be improved by using (a) Servo Press and Servo Cushion characteristics such as Attach – Detach, variable blank holder force and Pulsating blank holder force and (b) optimum slide velocity and forming conditions (lubrication, blank holder force and blank size). [4]

### III. BASIC COMPONENTS

#### 3.1 SUPPORTING PLATE

Supporting plate is an important component which supports the cushion pins so it is designed to handle the direct load due to the weight of the cushion pin thickness of the plate plays an important role in handling the weight in order to limit deflection and stresses of the plate. But basic stress equation for compressive, tensile loading are developed with prime assumption that, there should not be any discontinuities along cross section and also no abrupt change in cross section of plate, which fails when applied on actual operation. Finding out dimension of impact plate, thickness, stress and deflection are major consideration, when plate is subjected to loading it deflect from its original position, when it is sufficient strong to resist force and bending moment then design based on strength while, if it has adequate stiffness criteria Macaulay's is one who gave basic formula which provides basic equation for bending moment at any section expressed in systematic order, Which is similar to double integration technique. Whenever plate subjected to transverse loading it bent. Flexure is one which gives formula for pure

bending which ultimately given satisfactory results for designing thickness of plate.

#### 3.2 SUPPORTING ROD

The function of supporting rod is to support the load due to the weight of cushion pins and the supporting plate. It connects the supporting plate and lifting frame. Supporting rods are primarily subjected to axial force so it is designed to withstand the maximum compressive load imposed by cushion pins and supporting plate. The diameter is an important factor while designing the supporting rods it should be large enough to withstand bending and crushing stresses.

#### 3.3 LIFTING STRUCTURE

The primary purpose of a structure is to transmit or support loads. If the structure is improperly designed or fabricated, or if the actual applied loads exceed the design specifications, the device will probably fail to perform its intended function, with possible serious consequences. A well-engineered structure greatly minimizes the possibility of costly failures.



Fig. 3.1: Lifting Frame

Lifting structure supports the weight of whole assembly including the weight of cushion pins. Its main function is to provide lift to the supporting plate so the position of cushion pins could be tested. It is powered with the help of hydraulic system.

### 3.4 POWER PACK

Power package units consist of an oil reservoir, pump, valves and various require Controls all assembled into one unit to supply pressurized fluid. They are not only compacting size but also economical and they also provide the function of direct pressure and flow control within the basic package. They have been developed from extensive experience by manufacturers of fluid power components to fulfill a specific need. They result in substantial cost savings to the consumer. Power packages are available as stock units or can be assembled to meet customer specifications incorporating features peculiar to a particular application. These power packages are also equipped with pressure' gauge, monitoring system, pressure relief, heat exchanger and sight level gauge to facilitate the consumer. These power units conform to HC and other fluid power standards. Single or double pumps of the gear and vane type are most common, mounted directly to the motor through a flexible coupling. Fig shows a basic compact power unit incorporating direction, pressure and flow control functions. It employs a constant displacement pump to pressurize the fluid. The drive motor is reversed to change the direction of flow from the pump. Check valves in pump inlet line provide the correct suction characteristics regardless of rotation direction of the pump. The unit consists of a spool type D.C. valve.

#### 3.4.1 Components of power pack:

Strengthening testing machine-hydraulic press works with integration of some essential components. Fatigue testing machine uses the hydraulic fluid for its applications. Hydraulic fluid is stored in the tank called reservoir. Hydraulic system requires varies components for controlling the various parameters of hydraulic fluid. The energy content in this hydraulic fluid is converted into mechanical energy by using actuators. Following are the components of hydraulic press:

1. Reservoir
2. Filter
3. Hydraulic pump
4. Direction control valve
5. Pressure control valve
6. Actuators
7. Flow control valves
8. Control panel
9. Manifold block and hydraulic Piping
10. Bell housing

### IV. WORKING

Firstly the bolster plate is removed from the bed and transferred to the loading platform. Here cushion pins are inserted in the bolster plate in a pattern according to the die. Then the bolster plate is moved above the ejection pin system. For testing the hydraulic system is activated which lifts the lifting structure, this motion of the lifting structure moves the cushion pins upward which are rested on the supporting plate. Hence the position of cushion pins can be tested.

### V. BENEFITS

- Uptime of the hydraulic press increases.
- The time required for testing the position of cushion pins is reduced due to the use of ejector pin system hence every time the die is changed the ideal time of the hydraulic press is reduced.
- Production rate increases.
- The increase in uptime of press results in increase of production of parts.
- Power consumption is reduced.
- The consumption of power in ejector pin system is less than the power used in the cylinders of die cushion device.

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