

PRESS SELECTION AND MAINTENANCE

Success in any activity requires that a number of tasks be done correctly. In metal stamping, everything from poor quality parts to accelerated die wear and damage often is caused by poor press selection, diesetting and machine maintenance. No responsible machine shop manager would neglect machine tool lubrication, alignment and repair.

The same principle must be applied to press selection and maintenance. A power press is a machine used to supply force to a die that is used to blank, form, or shape metal or nonmetallic material. Thus, a press is a component of a manufacturing system that combines the press, a die, material and feeding method to produce a part.

The designer of the manufacturing system must also provide proper point of operation guards to safeguard pressroom personnel. Each of the components of this manufacturing system is important and will be discussed in turn later in this work. A foundation for understanding the system is acquiring a working knowledge of the press.

Examples of good practices and warnings against bad practices are to be found throughout this training. It is very important that the good practices that are appropriate for your shop are the ones that you adopt as your standard diesetting, production and die maintenance procedures.

Types of Presses

There are over 300,000 presses in use in the United States and many more worldwide. Mechanical and hydraulic presses fall into two predominant types: *gap frame* and *straight side* presses. The frame types used in mechanical presses are similar to those used in many hydraulic presses. Most power presses are actuated by electrical motor driven mechanical or hydraulic energy. However, gravity drop hammer and foot powered *kick presses* are also used.

The drive systems, clutches, brakes, counterbalance systems, die cushions, electrical, hydraulic and pneumatic features are similar in both the gap frame and straight side types. The type and size of press selected is mainly determined by the work to be done.

Gap Frame Presses

Gap-frame or C-frame presses derive their name from the C-shaped throat opening. In addition to the familiar open back design, this style of machine has a long history of use for portable hole punching. The press-brake is also a type of gap-frame press.

Features of Gap-Frame Presses

Gap or C-frame presses have many useful features. These include excellent accessibility from the front and sides for die setting and operation. The machines also cost substantially less than straight-side presses. The open back is available for feeding stock as well as ejection of parts and scrap.

A further advantage of a gap frame press is that the machine is easier to set-up than a straightside press. The diesetter has much greater freedom of access to locate and bolt the die in place. The open back is also accessible for discharging finished parts and scrap as well as feeding stock. Gap-frame presses generally have less height than a straightside press of comparable tonnage. This is a valuable consideration when overhead clearance is limited.

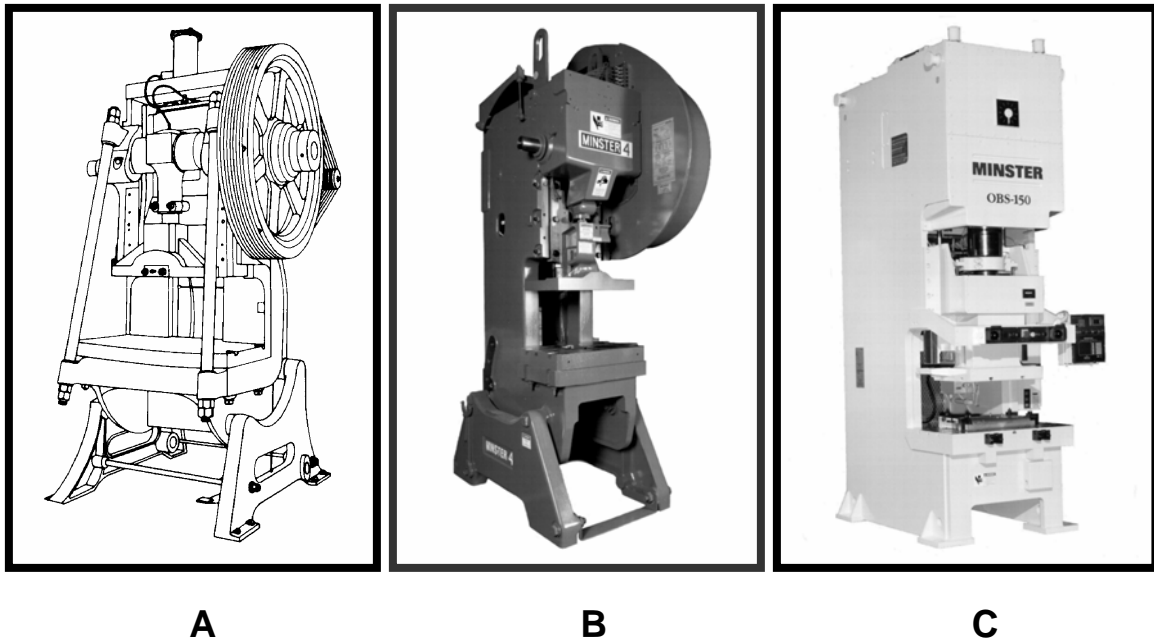


Figure 1. An older style unguarded open back inclinable (OBI) gap frame press (A) with tie-rods added to reduce angular deflection. A modern gap frame OBI press (B). A modern OBS guided plunger press (C). *Illustrations (B) and (C) Courtesy of Minster Corporation*

Presses with force capacities up to 250 tons (2,224 kn.) and larger, gap frame presses are less costly than a straightside press having the same force capacity. In the 35 to 60-ton (311 to 534 KN) force range, they cost approximately half that of straightside presses.

The main disadvantage of gap frame presses is an unavoidable angular misalignment that occurs under load. Limiting the amount of angular misalignment requires very robust construction—this adds to the weight and cost of the machine.

Examples of Gap Frame Press

Figure 1 illustrates three types of gap frame presses. Illustrations (A) and (B) a style of machine is known as an *open back inclinable* or OBI press. The press frame is secured in a cradle, which permits the machine to be inclined backward. This is done to facilitate gravity loading as well as part and scrap discharge out of the *open back* of the press.

The frame of older OBI presses is cast construction. The most commonly used materials are gray cast iron or steel. Figure 1 illustrates two pre-tensioned tie-rods across the open front of the machine. Lugs are cast into the frame of the machine to accept the tie-rods that are installed as an option to reduce angular deflection.

The development of timed air blow-off devices and a variety of small conveyors has lessened the demand for the OBI style of presses. Today, many OBI presses are operated in the vertical position. While the OBI style is still built (Figure 1B), the open back stationary (OBS) type (Figure 1C) is more popular.

Open Back Stationary (OBS) Gap Frame Presses

The open-back stationary gap-frame press shown in Figure 1-C is more compact and often a more robust machine than the older OBI style that it has largely replaced. The OBS press has a box-like structure. OBS presses are made of high strength cast iron or fabricated of heavy steel plate and assembled by welding.

Limitations of Gap Frame Presses

The chief limiting factor of this type of machine is that it has more deflection than a straight-side press for a given load. The deflection has both a vertical and angular component. The angular deflection or misalignment that occurs is due to the spreading of the throat opening as tonnage is developed. In many applications, this angular misalignment under load may not be objectionable. This style of press is popular for short-run work, where high accuracy of die alignment or close part tolerances are not necessarily controlling factors. For low tonnage high-speed work, precision gap presses are widely used. Here, the work is done before bottom of the stroke and the light loading avoids angular deflection problems.

However, straightside presses are generally recommended for any application where angular machine deflection would cause unacceptable part quality and accelerated die wear. The lower cost of gap frame construction machines may be poor economy if accelerated tooling wear and quality problems result.

Measurement of Gap-Frame Press Stiffness

An older accepted American standard that has been used by builders of gap-frame presses is 0.0015-inch per inch (mm per mm) of throat depth measured from the centerline of the connection to the back of the throat opening. This measurement includes both vertical and angular deflection. Angular deflection is by far the greatest concern because it results in misalignment between the punch and die.

ANSI standard B5.52 M specifies both the allowable vertical and angular deflection in machines built to metric standards. A practical measurement procedure is to place a jack capable of full rated tonnage at the centerline of the slide and bed. The vertical deflection is then measured between the centerline of the slide and bed. It should not exceed 0.002-inch per inch (mm/mm) of distance from the centerline to the back of the throat opening. Some press builders design for a lower value of deflection.

Since this measurement is intended to pick-up an angular value, measuring the difference from front to back across the slide face will give similar results. For many applications, angular misalignment under load is harmful. If the job cannot be run in a straightside press, some reduction in angular deflection can be achieved by installing tie-rods across the open front of the press.

Adding Tie-Rods to Gap Presses

Some older gap-frame presses have existing lugs for tie-rod installation in the front of the machine. This is illustrated in Figure 1A. In other cases, the manufacturer may supply lugs, which can be welded in place. Provided the rods are properly pre-stressed, a significant reduction in deflection results.

The best method of installing tie-rods is to use them in conjunction with tubular steel spacers around the rods. The spacers help ensure that the tie-rods are not over-stressed, and serve to further stiffen the machine.

At best, adding pre-stressed tie-rods to a gap frame press will result in reduced total angular misalignment. The physically limiting factor is that the cross sectional area of the tie-rod and spacer is small compared to that of the press frame. Also, adding tie-rods to the front of the press limits access to the die opening, and can make the point of operation more difficult to guard properly.

The spacer should have 1.5 times the area of the tie-rod. In addition to adding stiffness, the spacers will reduce the alternating load in the tie-rod thread. The tie-rod area should be sufficient to support half the force capacity of the machine. A conservative nominal pre-stress in the tie-rod is approximately 14,000 psi (96,516 kPa).

Straightside Presses

Straightside presses derive their name from the vertical columns or uprights on either side of the machine. The columns together with the bed and crown form a strong housing for the crankshaft, slide and other mechanical components.

The housing or frame of most straightside presses is held together in compression by pre-stressed tie rods. Some straightside presses have solid frames. Generally, a solid frame straightside press is less expensive than one having tie rods. However, tie rod presses are easier to ship disassembled and have better ability to withstand overloads.

Straightside Press Advantages

A major advantage of the straightside press compared to the gap-frame machine is freedom from angular misalignment under load. Maintaining true vertical motion throughout the press stroke is critical to minimize tool wear and obtain accurate part tolerances.

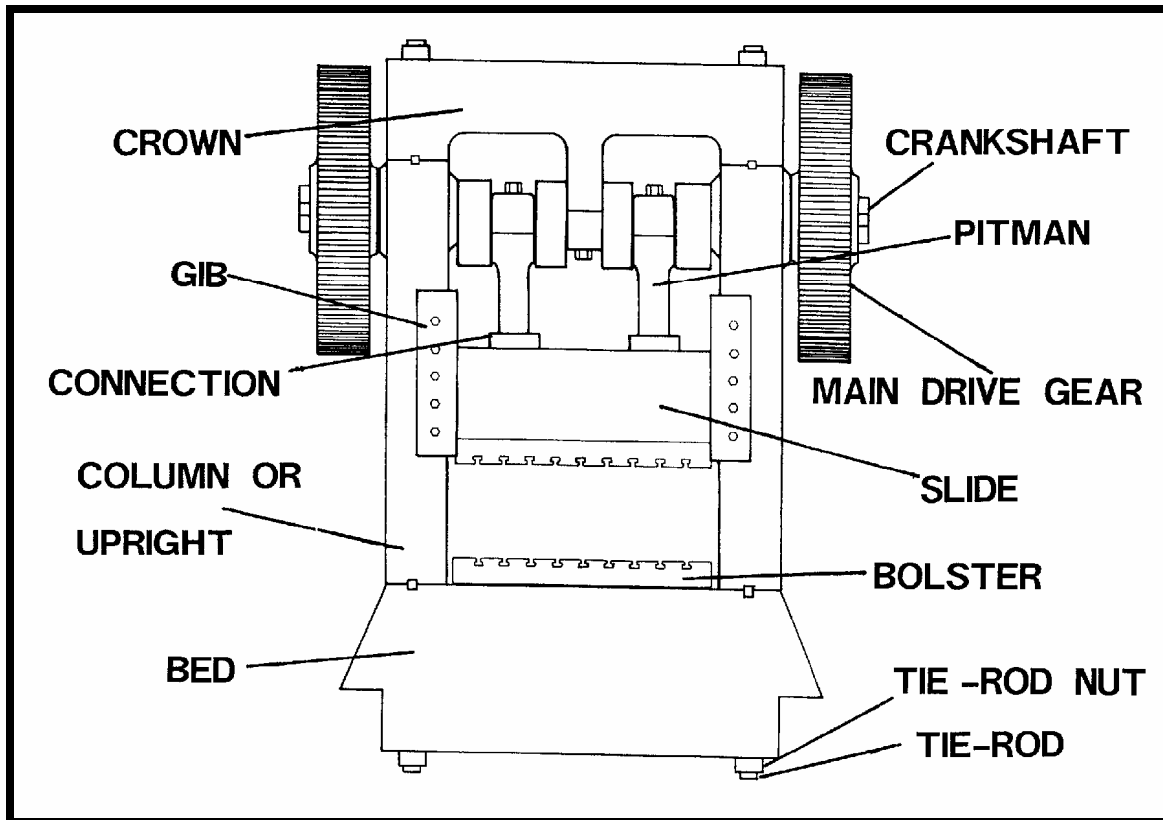


Figure 2. A straightside mechanical press having double end drive gears and two connections. *Smith & Associates*¹

Production of Precision Stampings

Many high-volume close-tolerance stampings are made in straightside presses. These include electrical connectors, snap-top beverage cans, spin-on oil filter cartridge bases and refrigeration compressor housings. Tiny computer connectors are stamped at press speeds up to 1,800 strokes per minute (SPM) or more. Often two to eight or more parts are completed per hit. Precision stampings are also produced at low speeds. For example, large refrigeration compressor housings may be stamped at press speeds of approximately 12 SPM. The housing consists of two mating halves, which must fit together precisely in order to properly align the internal parts.

Straightside Press Construction

Figure 2 illustrates some of the principle mechanical components of a straightside press having double end drive gears and two connections. The bed is the base of the machine. The columns support the crown. They also have *gibs* or *gibbing* attached which guide the slide. The crankshaft end bearings may be contained in the columns or crown.

¹ D. Smith, *Fundamentals of Pressworking*, The Society of Manufacturing Engineers, Dearborn, Michigan, © 1994, 416 pages cloth-bound. This reference has several chapters which cover the types, selection and maintenance of stamping presses

The crown serves many functions depending upon machine design. Typically, the clutch, brake, motor and flywheel mount on the crown of the press. The gears shown in Figure 2 may be open having only a safety guard designed to contain the gear in the event that it should fall off due to a failure such as a broken crankshaft. In modern designs, the gears are fully enclosed and run in a bath of lubricant. Enclosing the gears in separate enclosures permits using the proper gear oil—this permits a heavy viscosity lubricant that would not be correct for other machine parts such as the bearings. The latter are often supplied from a recirculating lubricant system. The separate gear housing and lubricant bath system serves to lessen noise and insure long gear life.

Press Terminology and Component Identification

The following terms are used to describe some of the principle characteristics and specifications of power presses. Many of the terms apply to both mechanical and hydraulic gap frame and straight side presses.

Terms that describe the bolster size determine the maximum size die shoe that can be accommodated in the machine. The minimum and maximum amount of vertical open space between the ram and bolster must be known in order to know if a die will fit the press. Of course, the force capacity is very important. In the United States, it is illegal to overload a stamping press.

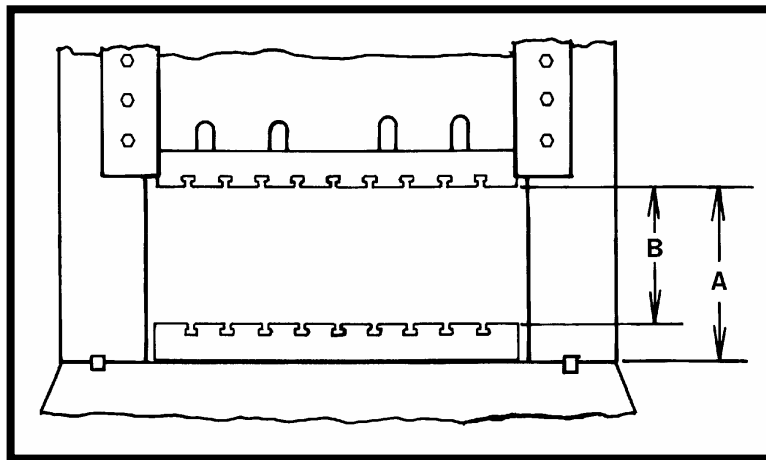


Figure 3. Example of shut height measurement taken (A) from ram to the bed, and (B) from ram to the bolster. *Smith & Associates*

Shut Height

The space available between the press bed or bolster and the slide or ram is called the *shut height*. It is always measured with the press *shut* or at bottom dead center. It may be specified as the vertical space between the ram and either the top of the bed or bolster as illustrated in Figure 3.

When a die must be put in an existing press, the distance from the top of the bolster to the bottom of the ram is the shut height figure that is used for diesetting. This distance, specified with the screw adjustment at maximum and minimum values, determines the range of closed heights of the dies that will fit into the press.

At times, more shut height than that which can be accommodated with the press bolster in place is needed. Some shops have removed the bolster and fastened the die directly to the press bed. This is a poor practice. The bolster is needed to stiffen the bed and spread the load evenly.

Figure 3 illustrates two example of shut height measurement. Measurement (*A*) is taken from ram to the bed and measurement (*B*) from ram to the bolster. Since the bolster is needed to add stiffness to the press bed, measurement (*B*) is the one that should be used when determining the allowable maximum die shut height.

Bed and Bolster

The bolster adds stiffness to the press bed. It has tapped holes, or preferably T-slots, to permit the die to be fastened in the press. T-slots permit dies to be changed quickly and fastened in the press more securely than tapped holes.

Gears

In mechanical press drives, gears are used extensively to permit an increased flywheel speed and provide greater press torque capacity. Gears are expensive press components. Proper lubrication is an absolute necessity. Where pairs of gears must work together such as twin end drives, it is essential that the load be shared equally.

Pitman

The link between the crank and slide is generally termed a *pitman*. When eccentrics drive the press, the link between the eccentric and connection is called an *eccentric strap*. The flexible attachment of the pitman or eccentric strap to the slide is called the *connection*. A means to accomplish shut height adjustment by an adjustable screw mechanism is nearly always a part of the connection system.

Press Slide Connections

A mechanical press connection is the point of attachment of the pitman or eccentric strap to the slide. Ball and socket type bearings are frequently used in smaller machines. A connection bearing of the type shown in Figure 2 has both a bronze-lined saddle-type bearing and a wrist pin to transmit force to the slide.

Connection Strength

The connection is designed to transmit large compressive forces to the slide. If subjected to an extreme overload, the ball and socket type may be damaged by a crack or deformation of the socket. Large overloads may extrude the bronze bearing material out of saddle-type bearings and the wrist pin may be bent or broken.

Hydraulic Overload protection

Hydraulic presses limit overloading by restricting the maximum pressure supplied to the actuating cylinder(s). Placing a hydraulic cylinder in series with each connection as shown in Figure 4 provides overload protection.

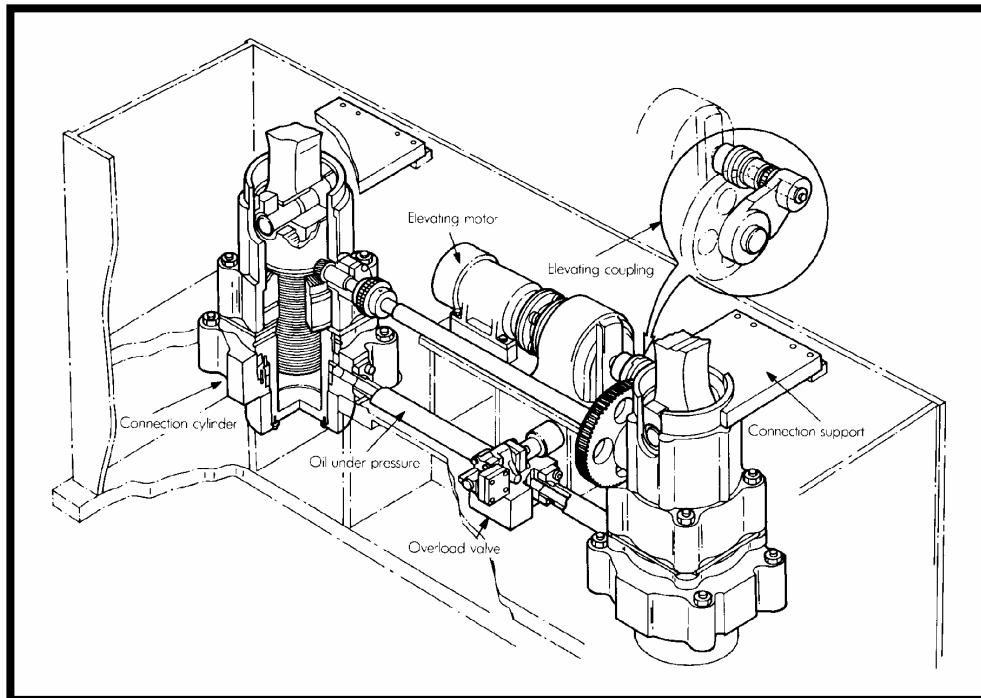


Figure 4. Precharged hydraulic cylinders under each connection provide fast acting easily reset overload protection. *Verson Corporation*

When a preset maximum limit is exceeded, an overload valve dumps the precharged oil from the overload cylinders, and trips a limit switch, stopping the press. The cause of the overload condition is first corrected, and the overload system recharged by actuating a key locked switch. Such systems can accommodate maximum overload errors of approximately 0.75-inch (19 mm).

Slide Adjustment

The connection may incorporate a screw adjustment mechanism. Larger machines have an electrically or pneumatically powered adjustment screw drive. Normally a mechanical brake in the motor automatically engages to hold the adjustment in place. In the case of presses having multiple connections, a single motor is used in conjunction with shafts, bevel gears and flexible couplings, to drive all adjustment screws in synchronism. This is illustrated in Figure 4.

Mechanical Overload Limiting Devices

Other types of press overload devices include shear collars, bellville washers, shear pins and stretch links. These devices are simple and low in cost. Shear collars and bellville washer overload devices are placed under the connection in place of the hydraulic overload cylinders shown in Figure 4.

However, there are several major problems with this type of overload protection. The failure point of stretching or fracture overload devices is uncertain and subject to change with repeated cycling. The occurrence of a failure of these devices may not be immediately detected. This may result in a slide out of level condition that can score the press gibbing, damage the die and result in the production of poor quality stampings. The machine must be shut down and the failed part replaced. This results in unscheduled maintenance and production delays that are normally unacceptable.

Tie-Rods Limit Machine Overloading

Most, but not all straightside presses employ tie-rod construction. The rods hold the press housing in compression. They provide a means to move large presses in sections. Should the press become stuck on bottom they can be heated to relieve the pre-stress. The rods also limit press overloading.

As long as the press columns are maintained in a pre-loaded condition by the tie-rods, the deflection in the die-space occurs at a linear rate as a function of increasing tonnage. However, once an overload condition exceeds the tie-rod pre-load, the crown lifts off the press column. Once crown lifting occurs, press stiffness is greatly decreased, limiting overloading.

Types of Mechanical Press Drives

Both gap frame and straightside presses are built with direct and geared drive systems. In nongearred or direct drive presses as they are also known, the flywheel is mounted on the end of the crankshaft. The flywheel is motor driven by means of a belt drive. Directly driven presses are capable of much higher operating speeds than geared types. Speeds range from under 100 strokes per minute to over 1,800 for short stroke high-speed operation.

Direct Drive Mechanical Press Applications

Nongearred presses find widespread application in blanking, high-speed production and shallow forming operations. They have several major advantages over all other press types. First, the design is simple. There are few bearings and no gears to wear out. In addition, frictional losses are lower than that of mechanical geared and hydraulic presses. The high operating speeds provide much greater productivity than that of geared presses. The direct drive press is very popular for precision progressive die and high speed perforating operations.

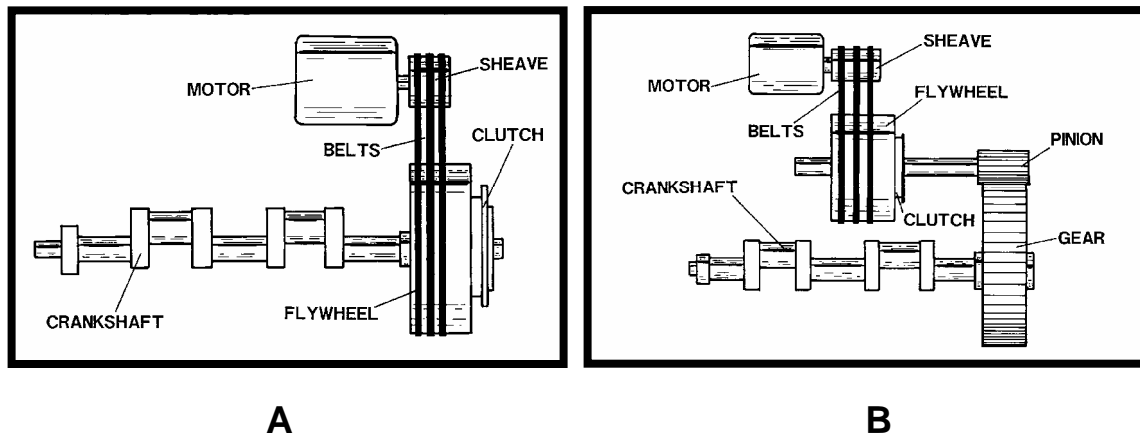


Figure 5. A nongear drive (A) illustrating a double-throw crankshaft directly driven by the flywheel through a frictional clutch. A single geared drive (B) illustrating a double-throw crankshaft driven by a single end gear and frictional clutch. *Smith & Associates*

Two main factors limit the application of the direct driven press. First, the full rated force of the machine is only available very close to the bottom of the stroke, typically 0.060-inch (1.524 mm) from bottom dead center. A second disadvantage is that the ability to deliver rated forces is substantially reduced if the press is operated at less than full speed.

Single Gear Reduction Presses

In single reduction presses, the flywheel is mounted on the backshaft and the power is then transmitted through a pinion to a main gear mounted on the crankshaft. Some single gear reduction presses have main gears mounted on both ends of the crankshaft, which is mounted on a pinion double end gear presses. Single gear reduction presses typically operate in the speed range of 16 to 200 strokes per minute (SPM).

Because these presses utilize gear reduction, with the flywheel on the high-speed backshaft, more flywheel energy can be provided for a given flywheel weight than in a nongear press. This greater amount of flywheel energy provides greater torque capacity, thus making the single geared press better suited for drawing and heavy forming operations than a direct drive press. A single end drive single gear reduction press system is illustrated in Figure 5B.

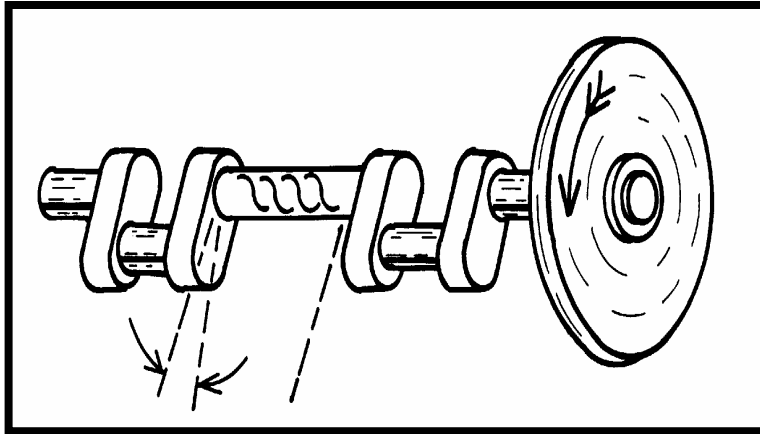


Figure 6. Angular misalignment proportional to the torque transmitted through a crankshaft with two throws occurs in single end drives. This factor results in a ram left-to-right tipping alignment error. *Smith & Associates*

Angular Misalignment Due to Crankshaft Twist

Figure 6 illustrates how an angular misalignment proportional to the torque transmitted through a crankshaft with two throws occurs in single end drive presses. The result is that the side of the ram nearest the driven end of the crankshaft will reach bottom dead center before the other end. The amount of ram tipping will be approximately proportional to the force delivered by the machine if the ram is uniformly loaded.

The error will be made worse if the largest load is placed on the side of the press opposite the driven end of the crankshaft. Presses having driving gears on each end of the crankshaft are often specified for heavy presswork.

However, using a very large and rigid crankshaft in comparison to the machine force capacity permits the use of two point single end drive presses for precision high-speed presswork. High-speed press crankshafts have short stroke lengths. These crankshafts have very low amounts of torsional twist. Because the shaft diameter is large compared to the stroke length, these are termed eccentric type crankshafts.

Twin End Drive Presses

Figure 7 illustrates a single gear reduction twin end drive on a press having a crankshaft having two throws. By driving the crankshaft equally on both ends, there is more accurate left to right ram to bed alignment under load than is the case of the single end drive system. It is important that the machining and timing of the gears, keyways and crankshaft be accomplished in a precise manner in order to avoid binding and ensure smooth operation.

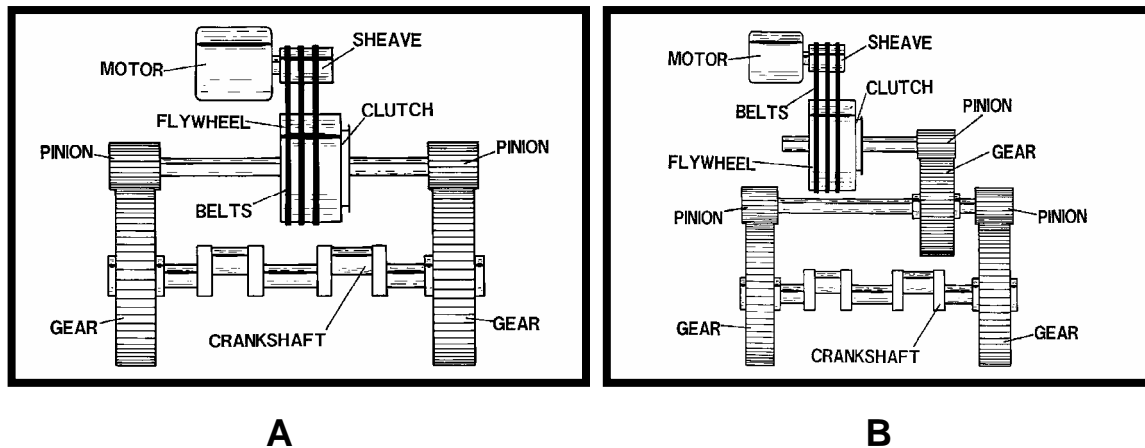


Figure 7. Providing a driving gear on either end of the crankshaft (A) avoids the angular misalignment under load illustrated in Figure 6. A typical style of clutch and gearing arrangement (B) used on double gear reduction presses. *Smith & Associates*

Double Gear Reduction Presses

Presses having two gear reductions from the flywheel to the crankshaft are termed double gear reduction presses. These machines normally achieve a speed range from 8 to 30 SPM. These presses are used for difficult applications such as heavy deep drawing, cold forging and forming large parts such as truck frame rails. Large transfer presses also frequently employ double gear reduction. Figure 8 illustrates one type of clutch and gearing arrangement.

Single Connection Presses

Straightside presses with single connections often are built to provide very high force capacities in a machine having a relatively small bed size. Figure 8 illustrates a high tonnage single-action, straitside, eccentric-type mechanical press.

The gear train is of the double reduction type. A large gear on either side drives the eccentric. This type of machine is very useful for heavy forming, as well as both warm and cold forging work. The double-gearred eccentric is capable of transmitting a great amount of torque. Presses of this type are capable of developing full tonnage relatively high in the press stroke. This factor makes them very useful for closed die forging work.

The heavy construction and narrow bed and slide result in low deflection under load. A press of this type is ideal for blanking work involving thick high-strength materials. Very stiff machines, with bed sizes no larger than necessary, are subject to much less snap-through energy release than presses with bed sizes that are much wider than necessary for the application.

In order to avoid ram-tipping problems, the load must be carefully centered under the connection. While this is always very important, it is especially necessary in single point presses. Keeping the load centered minimizes the pressure on the gibbing and lessens die wear.

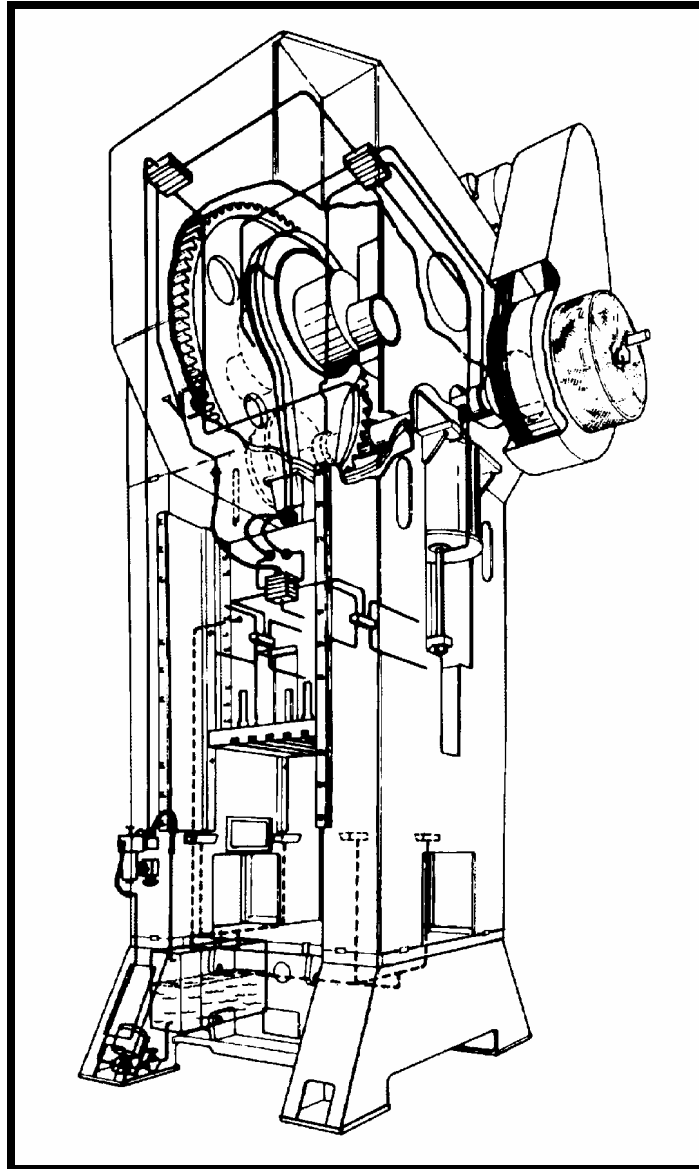


Figure 8. A single-action, straightside, eccentric-type mechanical press showing features including the cascade lubrication system and large reduction gears in the press crown.
Verson Corporation

Eccentric Drive for Two and Four Point Presses

Double or quadruple gear driven eccentrics normally rotate in opposite directions to aid in slide guiding and avoid lateral thrust. This feature is found in most two and four point presses, which are top-driven by eccentrics.

The timing of the gearing from the left to right side of all presses is critical. Couplings are provided on the shaft driven by the clutch which are either adjustable or may be fitted with offset keys.

Both crankshaft and eccentric driven straightside presses with two connection points are in very widespread use. Ram parallelism from left to right is mainly controlled by the connections, while front to back alignment is provided by the gibs. The press shown in Figure 10 has two connections that are driven by gear-actuated eccentrics.

Two point presses are guided by the correct adjustment of the pitman straps from left to right. Some front-to-back guiding of the slide is provided by the saddle bearing and wrist pin type connection. However, the gibbing provides the majority of the front-to-back guiding. Again, it is important to center the load especially from front-to-back.

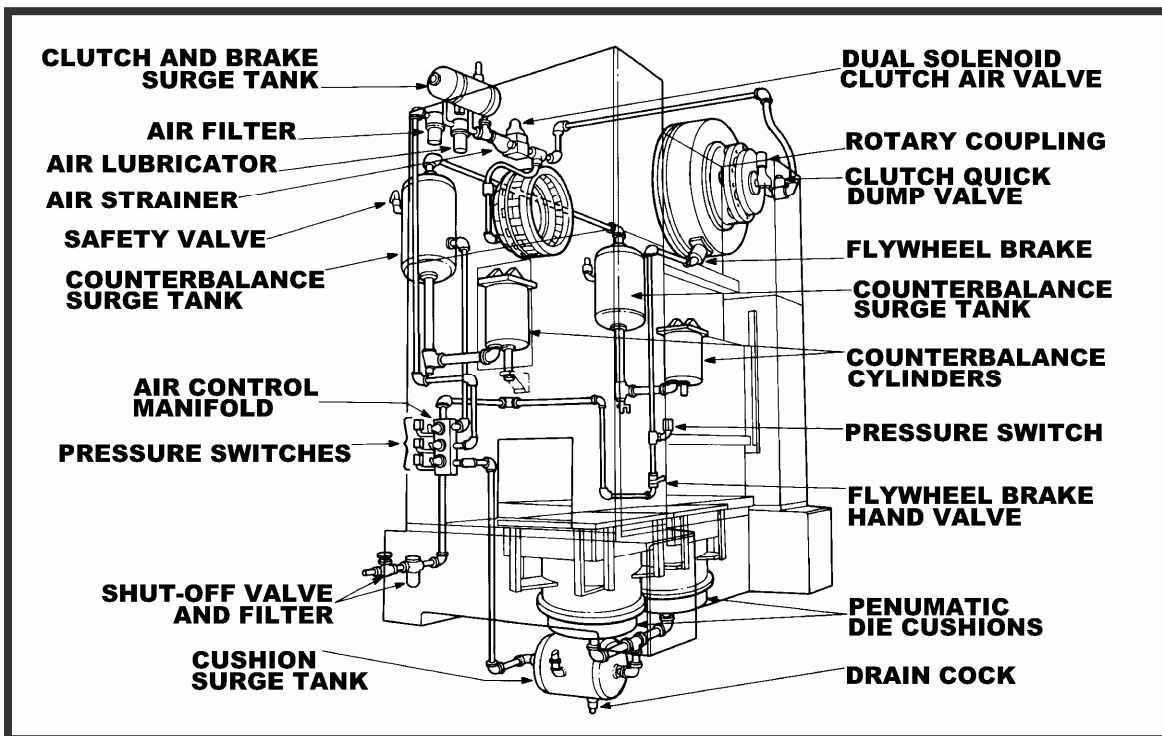


Figure 9. Pneumatic piping, tanks, and controls installed on a straightside press.
Verson Corporation

Placement of Pneumatic Controls

Figure 9 illustrates the placement of pneumatic piping tanks, and controls for a typical straightside press. The system is typical of a good pneumatic arrangement for a press equipped with an air-actuated friction clutch and die cushions.

Mechanical Press Electrical Controls

Figure 10 illustrates a two-point eccentric-driven straightside press. Typical electrical control components needed to power and control the machine are shown. Note that the rotary cam switches are separately driven. This adds an extra measure of safety in addition to chain breakage monitors.

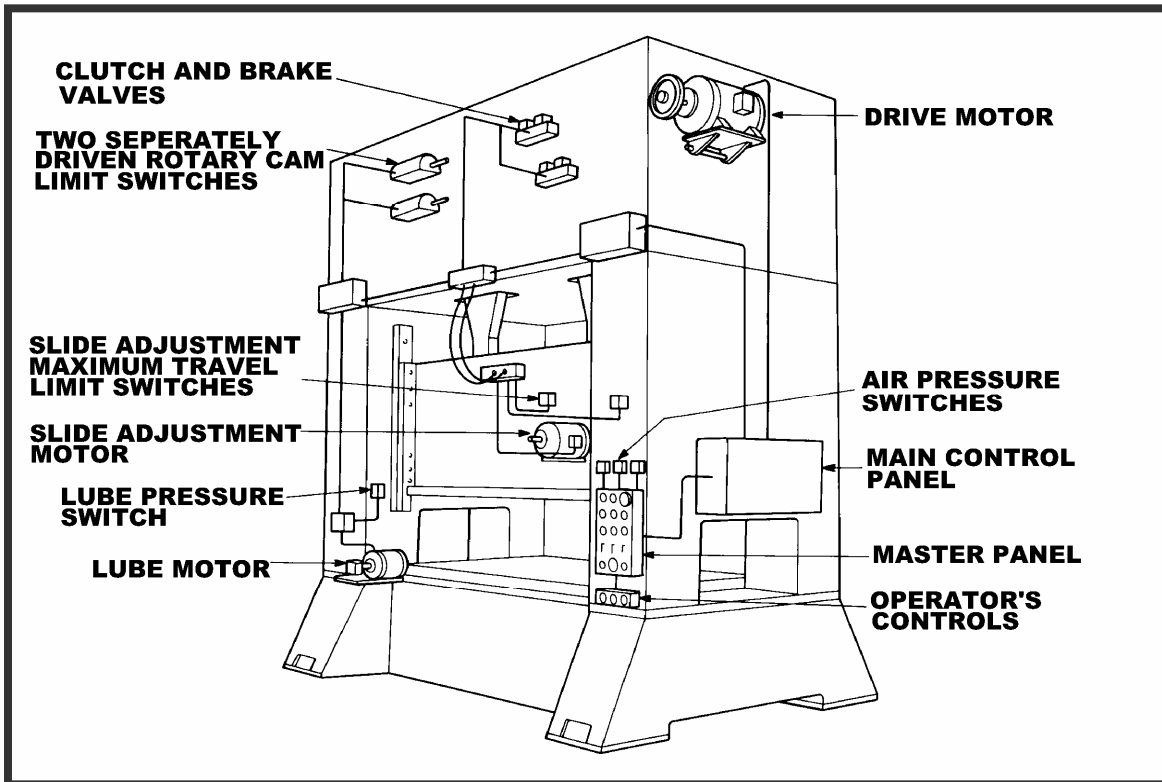


Figure 10. Two-point eccentric-driven straightside press illustrating typical electrical control components. *Verson Corporation*

Mechanical Press tonnage Curve

Mechanical presses have the full rated force available only very near the bottom of the stroke. A chart giving distance from bottom of stroke versus available force is called a force or tonnage curve. The force curves for six different mechanical presses are shown in Figure 11.

Speed Reduction and Torque Capacity

The motor furnishes energy to the flywheel. Once the flywheel is up to speed and not being cycled, the motor need only supply enough energy to make up for frictional losses. The flywheel stores the energy until some is used to perform work.

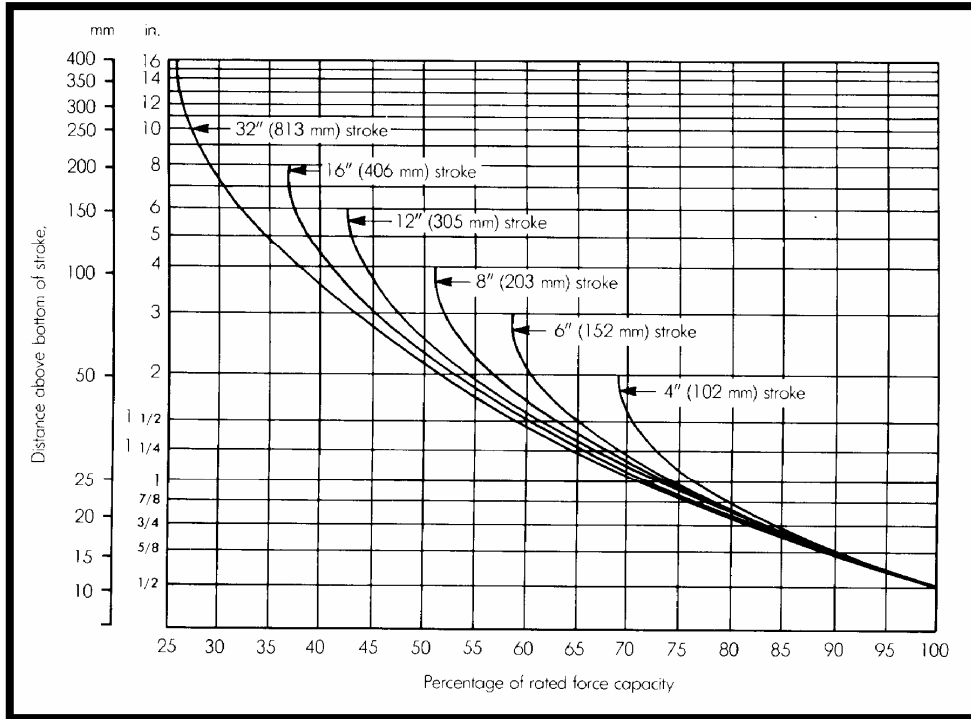


Figure 11. Percentage of force capacity for straightside presses at various distances above bottom of stroke. *Danly Machine Corp.*

The press must take the energy of the flywheel and transmit it through the clutch, gears (if a geared press), crankshaft, connection and slide to perform the required work. The energy stored in the flywheel increases as the square of the flywheel rotational speed. Thus, presses having variable speed drives vary greatly for flywheel energy available depending upon the speed adjustment setting.

When the flywheel speed is reduced, the flywheel energy decreases by the square of the speed reduction. Likewise, if the speed is increased, the flywheel energy is increased by the square of the speed increase. This may cause problems if the press is slowed for work such as deep drawing, which requires more energy than cutting and bending.

There must be enough time between successive strokes for the motor to restore flywheel speed. Otherwise, the press may stall. Belt slippage and motor overheating can result from not having enough flywheel energy. If the variable speed drive cannot be increased, a press with sufficient energy to accomplish the work will be required.

Mechanical versus Hydraulic Presses

Mechanical presses are built with force capacities through 6,000 tons (53.4 mN) or more. Force capacities of 50,000 tons (445 MN) or more are available in hydraulic presses. The very large hydraulic machines are used in hot and cold forging applications as well as various rubber-pad and fluid cell-forming processes.

Both single and double-action hydraulic presses are used for forming large parts for the automotive and appliance industries. An advantage for deeply formed or drawn parts is that full force is available anywhere in the press stroke.

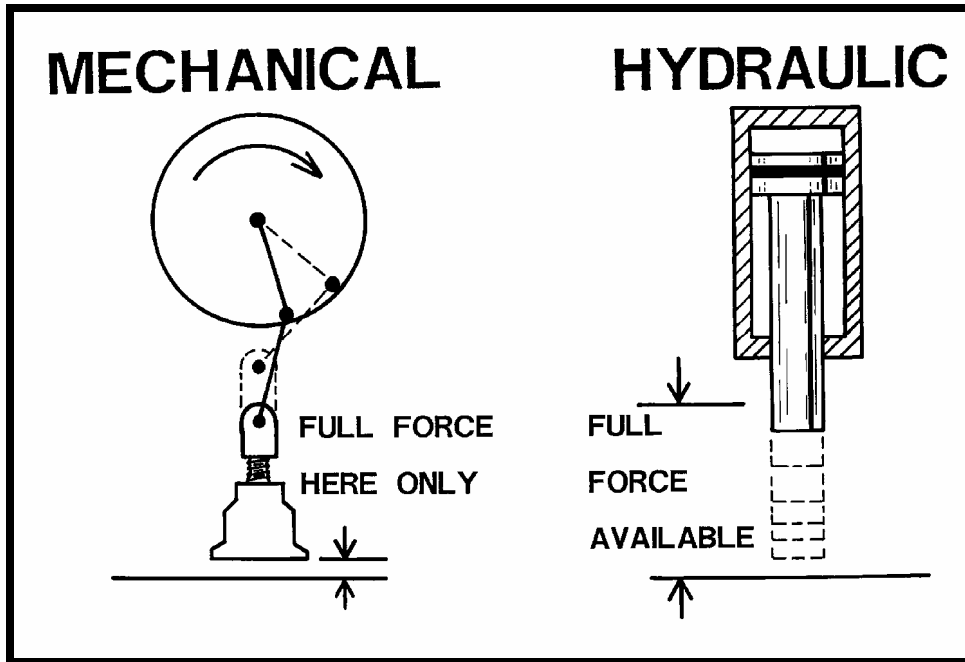


Figure 12. The rated capacity of a mechanical press is available only at the bottom of the stroke. The full force of a simple hydraulic press can be delivered at any point in the stroke.

Unique Features of Hydraulic Presses

In most hydraulic presses, full force is available throughout the stroke. Figure 12 illustrates why the rated force capacity of a mechanical press is available only near the bottom of the stroke. The full force of a hydraulic press can be delivered at any point in the stroke. This feature is a very important characteristic of most hydraulic presses.

Deep drawing and forming applications often require large forces very high in the press stroke. Some mechanical presses do not develop enough force high enough in the downward stroke to permit severe drawing and forming applications such as inverted draw dies to be used without danger of press damage.

Another advantage is that the stroke may be adjusted to match the job requirements. Only enough stroke length to provide part clearance is required. Limiting the actual stroke will permit faster cycling rates and reduce energy consumption. The availability of full machine force at any point in the stroke is very useful in deep drawing applications. High force and energy requirements usually are needed throughout the stroke. The ram speed can also be adjusted to a constant value that is best for the material requirements.

Built-in Overload Protection

The force that a hydraulic press can exert is limited to the pressure applied to the total piston area. One or more relief valves limit the applied pressure. A mechanical press usually can exert several times the rated maximum force in case of an accidental overload. This extreme overload often results in severe press and die damage. Mechanical presses can become stuck on bottom due to large overloads, such as part ejection failures or diesetting errors.

Hydraulic presses may incorporate tooling safety features. The full force can be set to occur only at die closure. Should a foreign object be encountered high in the stroke, the ram can be programmed to retract quickly to avoid tooling damage.

Large Force Capacity

Mechanical presses with high force capacities are physically much larger than their hydraulic counterparts. Few mechanical presses have been built with force capacities of 6,000 tons (53,376 mN) or more. Higher tonnages and/or compact construction are practical in hydraulic presses. Hydraulic presses for cold forging are built up to 50,000 tons (445 MN) or greater force capacity. Some hydraulic fluid cell presses have force capacities over 150,000 tons (1,334 mN).

The pressure at which the press delivers full tonnage is important. The most common range is from 1000 psi (6,894 kPa) to 3000 psi (20,682 kPa). Some machines operate at substantially higher pressures. There is no set rule on the best peak operating pressure for a press design. Obviously, higher pressures permit the use of more compact cylinders and smaller volumes of fluid. However, the pumps, valves, seals and piping are more costly because they must be designed to operate at higher pressure.

Advantages of Adjustable Force

The force of a hydraulic press can be programmed in the same way that the movements of the press are preset. In simple presses, the relief valve system that functions to provide overload protection may also serve to set the pressure adjustment. This allows the press to be set to exert a maximum force of less than press capacity.

Usually there is a practical lower limit, typically about 20% of press capacity. At extremely low percentages of force capacity, a stick-slip phenomenon known as *stiction* in the cylinder rod and piston packing can cause jerky erratic action.

Press Construction Depends on the Type of Work Performed

The bed size, stroke length, speed and tonnage of a hydraulic press are interdependent specifications. Press construction depends upon the amount of total force required and the size of dies to be used. Figure 13A illustrates a large bed size press having low force capacity. Note the small cylinder size. Some uses for these presses include cutting and pressing soft materials such as fabric, and in wood or plastic laminating applications. The press design illustrated in Figure 13B is suitable for high force applications such as heavy forging.

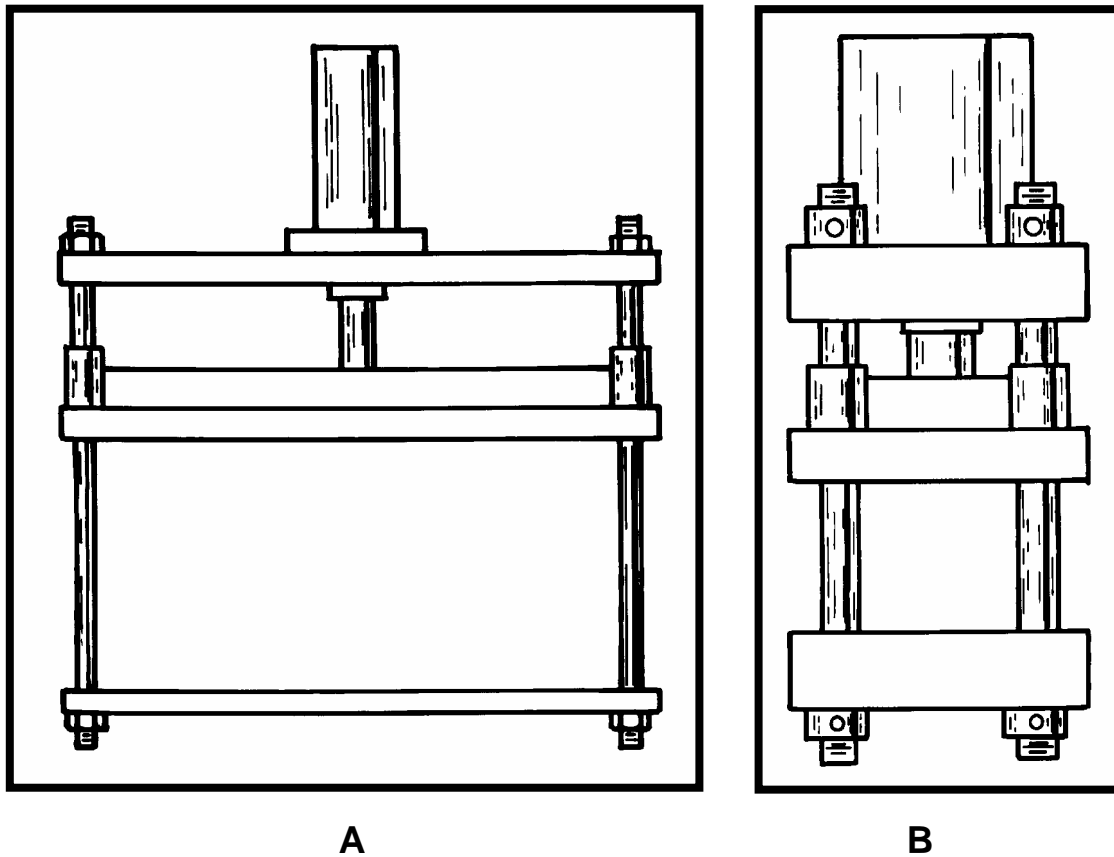


Figure 13. Cutting soft materials and laminating work may require a low force capacity machine with a large bed area (A) such as the one illustrated in this simplified drawing. Heavy work such as coining and cold forging requires a compact machine (B) capable of delivering high forces over a small bed area. *Smith & Associates*

Guidelines for Press Selection

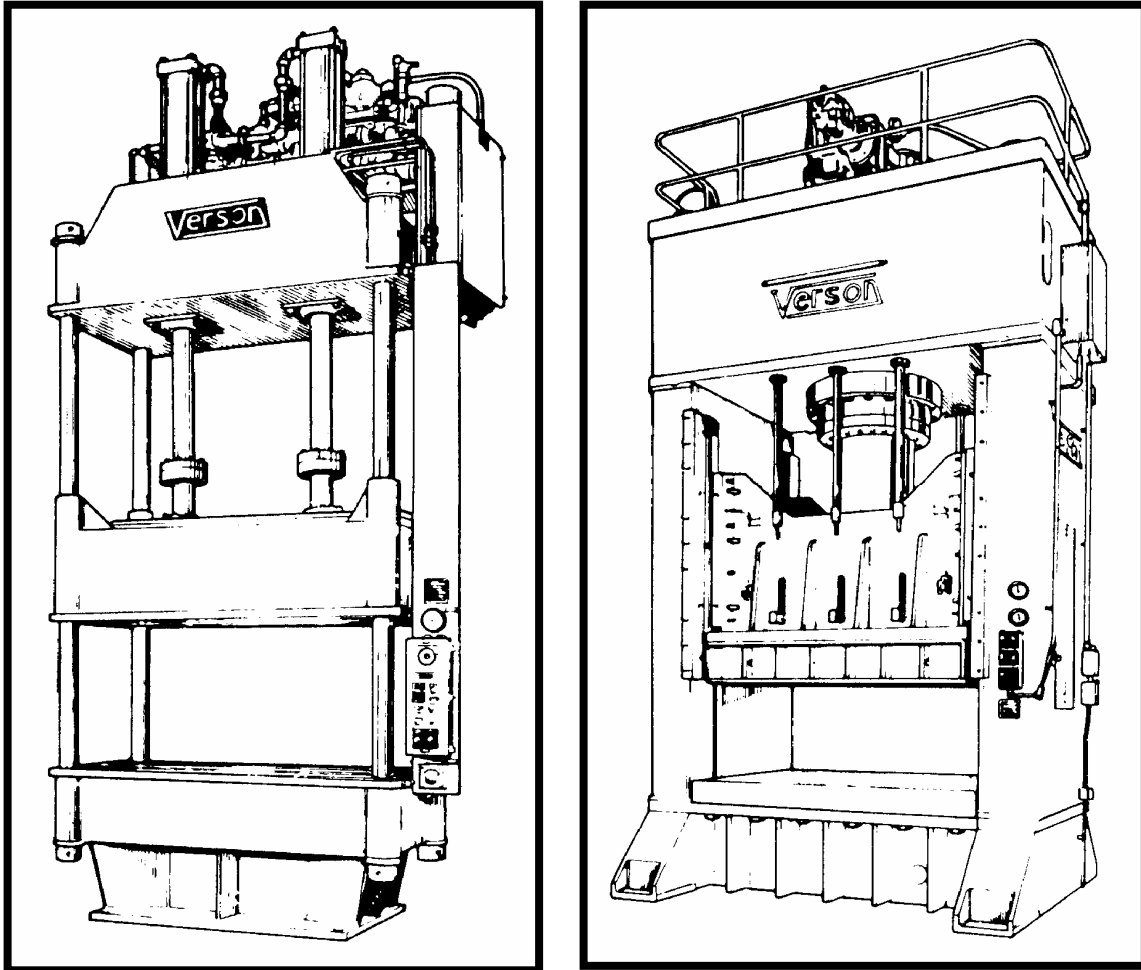
Figure 13 illustrates how bed size does not directly relate to press force capacity. Presses that use the tie rods for ram guiding are unsuited for jobs that produce lateral loads. Like mechanical presses, hydraulic presses are available in many types of construction. Factors to consider when deciding between a hydraulic and mechanical press are stroke length, actual force requirements and the required production rate.

Hydraulic Press Speeds

Most press users are accustomed to describing press speeds in terms of strokes per minute. Speed is easily determined with a mechanical press. It is part of the machine specifications.

The number of strokes per minute made by a hydraulic press is determined by calculating a separate time for each phase of the ram stroke. First, the rapid advance time is calculated. Next the pressing time or work stroke is determined. If a dwell is used that time is also added. Finally, the return stroke time is added to determine the total cycle

time. The hydraulic valve reaction delay time is also a factor that should be included for an accurate total time calculation. These factors are calculated in order to determine theoretical production rates when evaluating a new process. In the case of jobs that are in operation, measuring the cycle rate with a stopwatch is sufficient.



A

B

Figure 14. A two-cylinder four-post hydraulic press (A) suited for light to medium duty work that does not involve lateral (side) loads. A straight side hydraulic press (B) designed for applications requiring close alignment and high forces. *Verson Corporation.*

Force Requirements

When choosing between a mechanical and hydraulic press for an application a number of items should be considered. The force required to do the same job is equal for each type of press. The same engineering formulas are used.

There is always a possibility that an existing job operated in a mechanical press requires 20 to 30 % more force than the rated machine capacity. The overloading problem may go unnoticed, although excessive machine wear will result. If the job is placed in a hydraulic press of the same rated capacity, there will not be enough force to do the job. Always make an accurate determination of true operating forces to avoid this problem.

In some cases, a sharper coined impression may be obtained at a rapid forming rate. In some cases, a sharper coined impression may be obtained at a rapid forming rate. Jewelry and medallion work makes use of both high force hydraulic presses and drop hammers. Each process has its own advantages. Often in die pressures in excess of 250,000 psi (1,724 mPa) occurs in hydraulic press medallion work.

Machine Speed

The forming speed and impact at bottom of stroke may produce different results in mechanical presses than their hydraulic counterparts. Each material and operation to form it has an optimal forming rate. For example, drop hammers and some mechanical presses seem to do a better job on soft jewelry pieces and jobs where coining is required.

In deep drawing, controllable hydraulic press velocity and full force throughout the stroke may produce different results. Often parts that cannot be formed on a mechanical press with existing tooling can be formed in a hydraulic press. Hydraulic presses can be provided with controllable force throughout the press stroke and variable blankholder pressure distribution.

Ram Tipping Controls

Some two piston presses similar to the design shown in Figure 14 feature a system of linear position transducers and servo valves to vary the force to each piston in order to maintain the ram level with the bed. How well such a system works depends on the accuracy of the position sensors and reaction speed of the servo valving. If snap through energy release is involved, the servo system may not be able to react quickly enough to prevent ram tipping that may be harmful to the press, tooling and process.

The Verson press shown in Figure 14A is not necessarily available with servo anti-tipping controls. Nor would it be a needed feature for the recommended press application. If heavy punching work and limited ram tipping under lateral or snap-through loads were required, a press such as that shown in Figure 14B would be a recommended choice.

Some manufacturers have marketed light weight dual ram presses having servo leveling with an implied claim that they are a direct replacement for two point mechanical presses in critical work such as progressive die operation. Taking any advertising claim at face value can result in highly unsatisfactory tooling operation. The ability of a sensing system to acquire data and redirect oil through servo valving faster than the several milliseconds during which a snap-through release occurs is extremely difficult to achieve.

Straightside presses such as that illustrated in Figure 14B are much better able to withstand off-center loading and snap through energy release than the type shown in Figure 14A. Quality features to look for in a press designed for severe work when ram tipping is to be minimized are a single piston design together with a large ram or slide with long guiding and eight point gibbing. However, loading should be carefully balanced and cutting dies timed to minimize snap through shock to the best extent possible in any pressworking operation.

The Type of Press Frame

Like the mechanical press, open gap-frame machines provide easy access from three sides. Like the mechanical counterparts, the machines shown in Figure 13 insure even. Some manufacturers have marketed light weight dual ram presses having servo leveling with an implied claim that they are a direct replacement for two point mechanical presses in critical work such as progressive die operation. Taking any advertising claim at face value can result in highly unsatisfactory tooling operation. The ability of a sensing system to acquire data and redirect oil through servo valving faster than the several milliseconds during which a snap-through release occurs is extremely difficult to achieve.

Upgrading Existing Presses

Older presses can often be upgraded for smoother, more reliable operation and reduced tooling wear. In some cases, rebuilding a work or damaged press can pay rapid dividends in reduced tooling repair costs and better part quality.

Electrical controls, which may no longer meet safety requirements, can be replaced. Usually, the most satisfactory way to retrofit the press is to install a complete new control package especially designed for the application. Such systems are available from several suppliers.

Die Cushion Retrofitting and Maintenance

When a single-action press is used for drawing operations, the manner in which the blankholder pressure is applied to control the flow of the metal blank is important. The application of pressure to a blankholder is one of the features of a double-action press. Single-action presses lack this feature and therefore require supplementary blankholding equipment.

Dies are sometimes built with a blankholder using compression springs, air cylinders or high-pressure nitrogen cylinders to supply the holding pressure. This greatly increases the cost of the die. A press cushion can serve every die with this requirement, lowering the cost of tooling.

Pneumatic Die Cushion

This type of die cushion is supplied with shop air pressure. A pneumatic-die-cushion design normally uses either one or two pistons and cylinders. The recommended capacity of a die cushion is about 15% to 20% of the rated press tonnage. The size of the press-bed opening limits the size, type and capacity of the cushion.

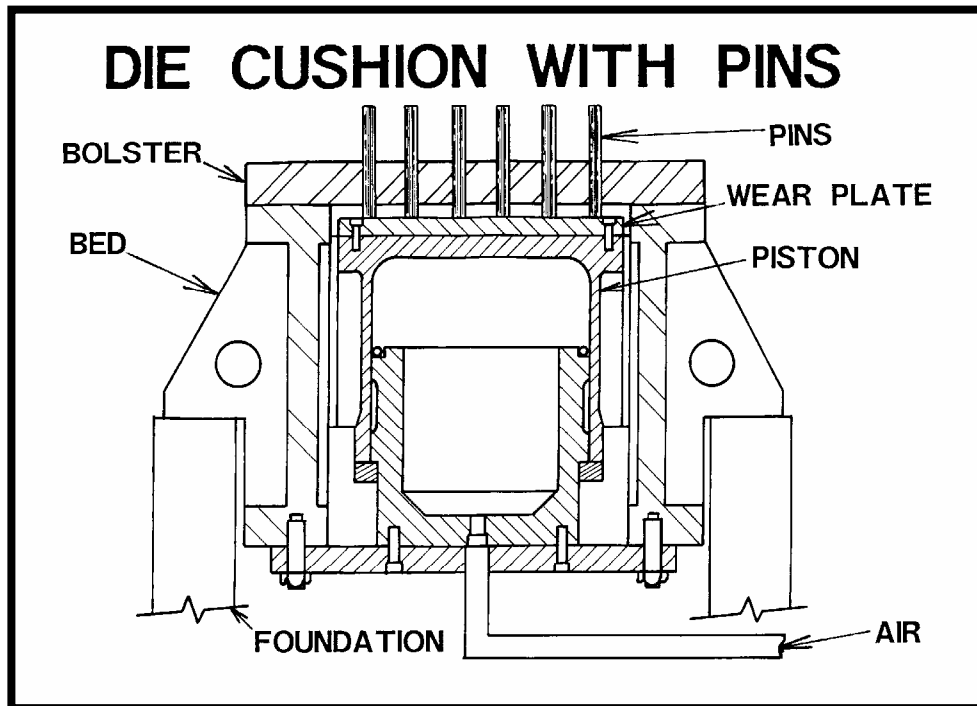


Figure 15. Sectional view through a press bed and bolster illustrating a pneumatic die cushion. *Smith & Associates*

A schematic arrangement of a pneumatic die cushion is shown in Figure 15. This illustration shows an inverted-type cushion in which the downward movement of the blankholder, through pressure pins, forces the cylinder against a cushion of air inside the cylinder, and moves the air back into the surge tank (not shown). The external components such as the surge tank, regulator and pressure gage are essentially identical in function to a press counterbalance system. On the upstroke, the air in the surge tank returns to the cylinder. Other designs function without surge tanks.

It is very important to load the cushion evenly to avoid premature wear and cushion failure. The die designer should incorporate equalizing pins in the lower shoe if required to accomplish loading equalization. Often the upper heel blocks can actuate these. In some cases, special pin drivers made of structural tubing may be attached to the slide to actuate equalizing pins. Operator safety must be considered when doing this operation because additional pinch points are created.

To avoid press and die problems, it is of extreme importance that the correct length pins be used. In drawing and other critical operations, a pin that is 0.060 in. (1.5 mm) longer than the others can easily cause a wrinkled or fractured part. When problems are encountered, and the pressure setting is found correct, the pins should be carefully measured with a micrometer or vernier caliper. This step will determine if they are of the same length.

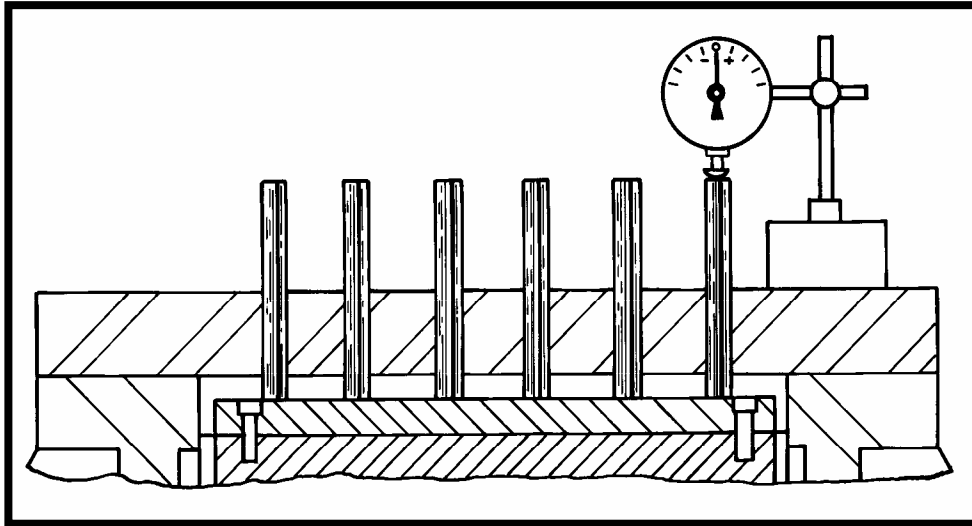


Figure 16. Troubleshooting a die cushion system with a dial indicator.
Smith & Associates

If the pins are the same lengths, they can be re-inserted into the bolster pin holes and checked with a dial indicator as shown in Figure 16. If a variation in length is found, it is probably caused by unevenly worn depressions in the top of the piston wear plate or the cushion is damaged. Regrinding can repair the wear-plate.

The bolster pin holes will become larger with use. If this occurs, hardened bushings can be fabricated and used to repair the worn holes. Generally, this is a permanent solution. The die can also be a source of difficulty. With extended use, the pins can wear uneven depressions in the underside of draw-rings, pads and subplates.

Hydraulic Die Cushions

Hydraulic die cushions have the advantage of taking up less space than air cushions. They also can be equipped with fixed or servo-actuated relief valves. Programmable controllers and servo valves provide controllable resistance throughout their travel. Paul Pfundtner, President of Red Stag Automation, Inc. is one of several persons who have provided leadership in engineering this feature into new and used presses.

Centering the Load in the Press

Maintaining correct die clearances is a basic requirement for producing high quality stampings. If the load is not centered in the press, critical die clearances will be changed.

Off center loading actually results in an out-of-level condition much like that caused by setting a die on a slug. This is because the press must deflect in order to develop tonnage. If the load is centered the deflection is uniform and the slide remains parallel to the bolster. If the load is not centered, the greatest deflection occurs in the side of the press with the greatest load resulting in an out-of-parallel condition. This condition can cause rapid press wear as well as die damage and part quality problems.

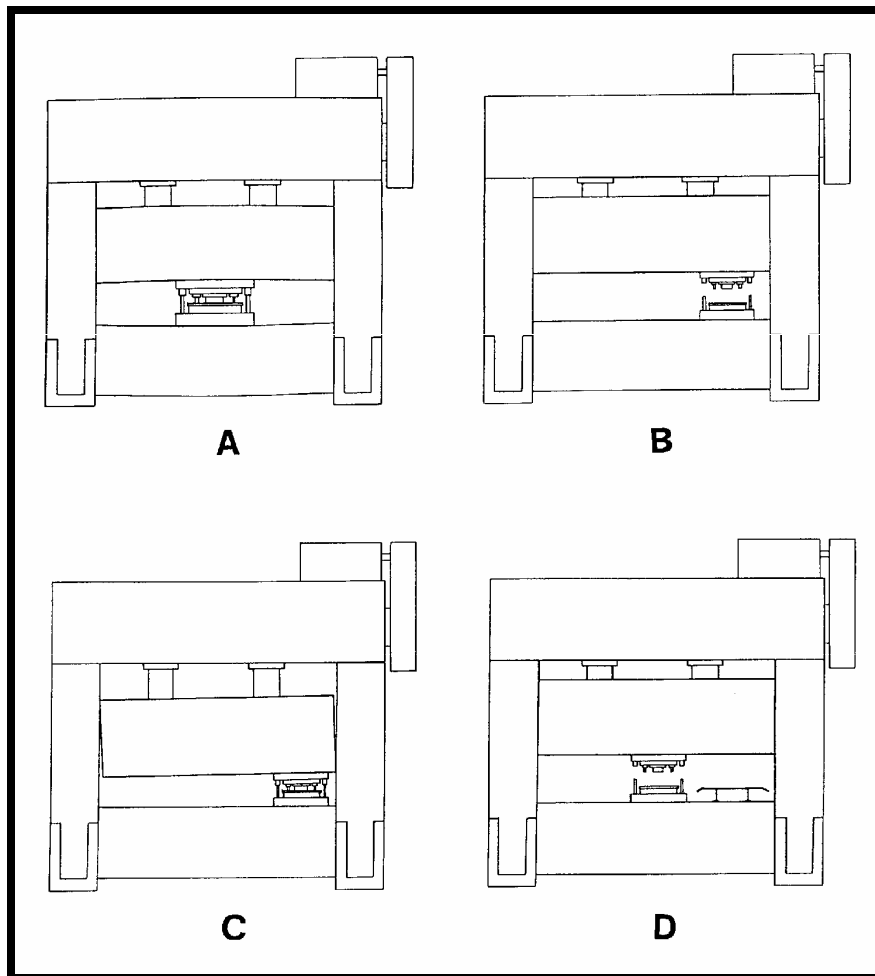


Figure 17. An exaggerated view (A) of the press deflection that is a normal result of developing the tonnage needed to do presswork. The die is offset to one side of the press (B) for operator or set-up convenience. This creates unequal loading results in an out-of-parallel condition (C) when the press deflects. To correct off-center loading of a press, a simple production aid or stock guide (D) may be all that is required. *Smith & Associates*

In the case of cutting dies, too little clearance between the punch and die will result in excessive cutting pressures, which will break down the cutting edges quickly. Too much clearance will result in excessive burrs. Ram tipping will also result. This will cause rapid wear of the gib liners and other important press parts.

Figure 17A illustrates an exaggerated view of the press deflection that is a normal result of developing the tonnage. Just as a spring must change shape or deflect to develop pressure, a press must deflect to develop tonnage.

The illustration shows a small die centered in a large straightside press. Not all of the press tonnage capacity is safely usable. As a rule, at least 70% of the press bed should be occupied with a centrally placed die shoe if full press tonnage is to be developed.

Developing full tonnage with a small die can result in damage to the press slide and bed due to excessive localized deflection.

Reasons for Offsetting Dies

The most common reason for offsetting dies from the center of the press is for the loading convenience of the operator. Offsetting the die may satisfy ergonomic considerations. The operator does not have to reach or bend as far to place and remove parts from the die. Productivity and operator comfort goes hand-in-hand.

Another reason dies may be offset in the press is the lack of a proper coil stock guide. Figure 17B illustrates a die offset to one side of the press to move closer to the coil feeder.

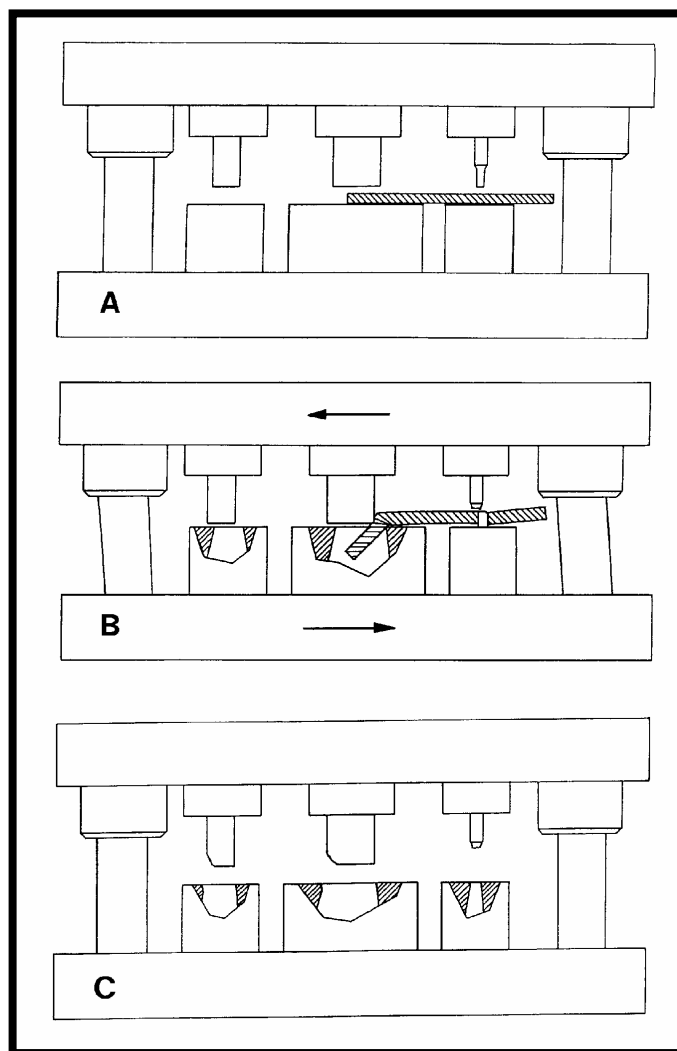


Figure 18. Out-of-location stock can cause die damage: (A) out-of-location stock in a die; (B) a partial cut results in the stock being flanged into a die opening causing the die shoes to be displaced sideways; (C) the damage that results. *Smith & Associates*

The Effect of Unbalanced Loading

Figure 17C illustrates the result of unequal loading. The result is an out-of-parallel condition when press deflection occurs.

The short-term effect is press misalignment under pressure that is much the same in its effect as that of a slug under the die shoe. The quality of work and number of pieces produced between die sharpening will be less than would be the case if the load were centered.

The long-term effect is uneven press wear. Bearings will not wear evenly, resulting in an out-of-parallel condition in the future. The gibbing will be subjected to high-localized pressures resulting in rapid uneven wear and scoring.

Solutions to Off-center Die Placement

A good solution usually requires a careful analysis of all factors. Common sense solutions may include asking the following questions:

1. Is a smaller press available so the operator won't need to reach as far to place the blank?
2. Can a production aid be constructed to permit the part to slide into correct location by gravity or automatic movement?
3. Is it possible to operate two dies in the same press to correctly balance the loading?
4. Is the placement of nitrogen cylinders on one side of the press to balance the load a practical solution?
5. Is there a good reason for offset loading such as moving a progressive die to one side to balance the force?

Figure 17D illustrates a simple stock guide used to correct the problem.

Avoid Mishit Damage

Many dies are designed with balanced cutting action. This is done in order to avoid side thrust, which can change die clearances. If the part design or stock layout will not permit balanced cutting action, very large guide pins or heel blocks are required to limit the side-movement to an amount that is acceptable.

Mis-positioned stock can damage the die. The unbalanced loading can be so severe that the stock is flanged rather than cut. Figure 18 illustrates how this happens.

Out-of-location stock (A) is flanged into a large cutting die opening due to the unbalanced cutting action resulting from mislocated stock (B). Because the cutting

clearance is only 10% of the stock thickness, the side displacement is so great that the punch and die cutting edges hit upon die closure and are damaged (C).

It is very important that everyone be made aware of how this type of damage occurs and how it may be avoided. Honest reporting of any damage of this type is important also. The damage shown in Figure 18C could be reported as a broken punch. Replacing the small punch in the press would not fix the damage to the other stations. Press time should not be wasted. A die damaged this badly should be taken to the dieroom for extensive repair.

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