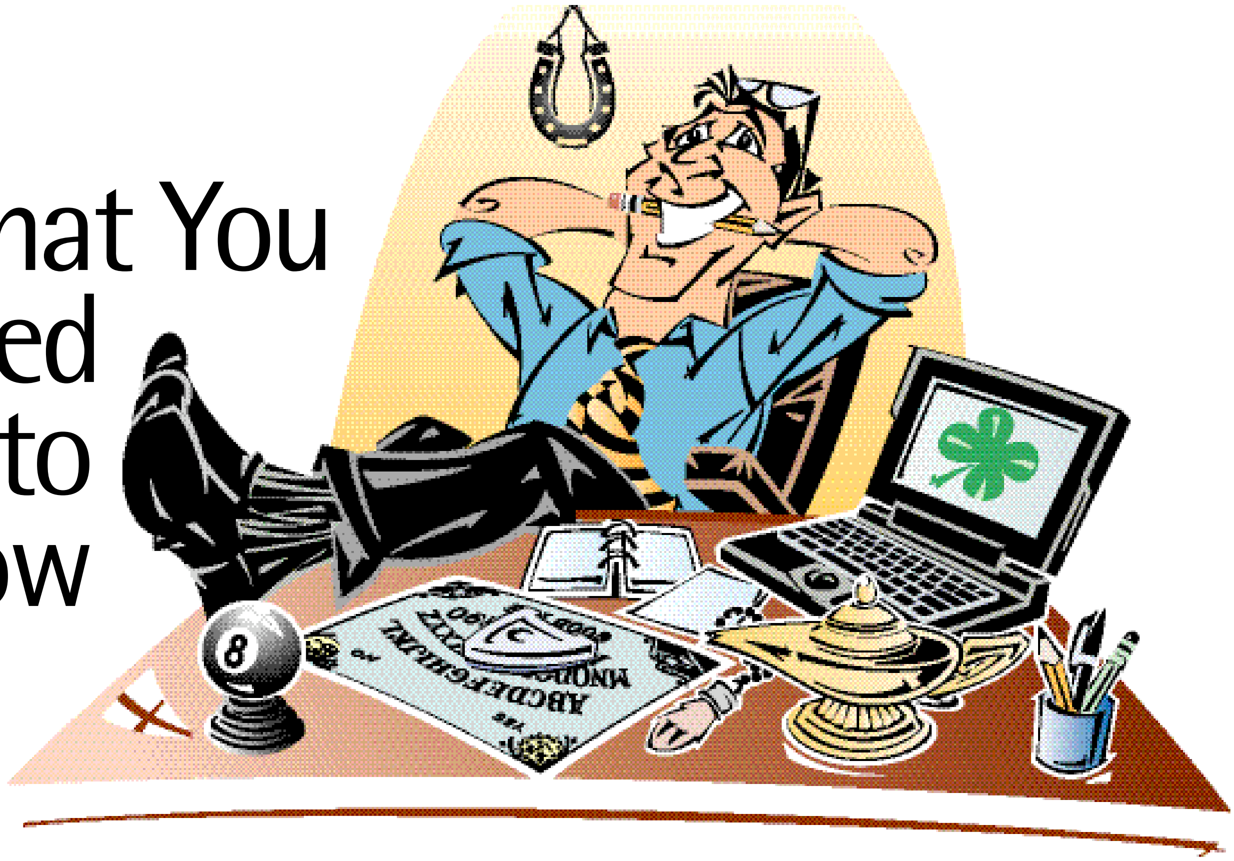
What You Need to Know to Quote Capital Equipment



Required tonnage makes a nice starting point for evaluating a press purchase, but consider many other key variables to help pinpoint the press you need. Study tooling needs first.

BY TODD WENZEL

For most metalformers, the purchase of a stamping press begins with an evaluation of press suppliers. Companies also will visit other stamping houses to see prospective equipment in action. Vendors then visit to present proposals.

A less common but more efficient approach is to start the process by evaluating the tooling you need to run. The tooling a manufacturer plans to use will dictate the type of press needed. This careful consideration is a metalformer's only opportunity to fit the press to the tools.

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Metalformers also can use the following items to further fine-tune their equipment choices: tonnage, load distribution, energy, die size, stroke-length requirement, die clearances, critical part dimensions, material type and annual volume. Understanding these elements can help metalformers pinpoint the type of press they need. Collecting this information quickens the press-selection process and optimizes capital investment.

Answer the Tonnage Question

The first element, tonnage, is where most people start. It is the force in tons required to do the work in the die that produces a finished part. The types of production processes a metalformer plans to use dictate tonnage requirements.

When calculating the amount of tonnage required to produce a part, different elements become part of the formula. The four primary points to consider when thinking about tonnage: total tonnage to be exerted at once; how high in the stroke the tonnage must be exerted; tonnage distribution; and, finally, an estimation of the reverse tonnage. The total tonnage a press can exert without damaging the machine is determined by the frame and drive components. These elements are designed to withstand full press tonnage in the forward direction with all materials operating within their infinite fatigue range.

In a drawing process, the tonnage needed depends on cup diameter and height, and workpiece-material type, thickness and tensile strength. For blanking, we use part diameter and thickness as well as material thickness and shear strength to calculate tonnage. For multiple-stage dies (progressive or transfer), metalformers must perform tonnage calculations for each operation. Items such as stripper pads and die cushions also increase the amount of required press tonnage to produce a part, and must be accounted for in the calculation.

Timing is Everything

Calculating the total tonnage only marks the beginning of the press-selection process. One important aspect of tonnage often overlooked is the height above the bottom of the stroke where the tonnage must be exerted—you must know the timing of the die in order to properly spec a press. A job that requires 200 tons of force at ⅛ in. above stroke bottom is entirely different from a job that requires the same 200 tons at 3 in. off bottom. The press designs needed to accommodate these two jobs are radically different.

Also consider tonnage distribution over the press bed. Manufacturers rate presses for maximum tonnage with the load evenly distributed across two-thirds of the bed. So, for example, a press rated for 600 tons with a 12-ft. bed must evenly distribute that 600 tons across at least 8 ft. of the bed. Concentrating the load unevenly, or in too small of an area, will damage the press over time and, more importantly, diminish tool life and part accuracy.

Press suppliers offer data on a press's ability to withstand load, including off-center loads. A good rule of thumb: Design dies to perform the work between or below the connections of the press. For this reason, presses offer designs with one connection for small high-tonnage loads; two connections for loads evenly balanced back to front but off-center left to right; and four connections for parts that require uneven tonnages in both directions.

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Another important, and sometimes neglected, aspect of load distribution relates to how high in the stroke the press exerts tonnage. Don't just calculate required tonnage at each station and figure that a similar load occurs on the other half of the tool. You also must time the process in order to balance loads at the same point in the vertical plane.

Finally, in blanking and piercing operations, determine the amount of reverse tonnage expected. Reverse tonnage occurs after the punch breaks through the workpiece material. Just before breakthrough, the ram and connections compress, the bed, bolster and drive shaft deflect and the rest of the press frame stretches. This stretch/compression of press components develops tonnage in the forward direction to perform work on the part. When the material breaks, this forward tonnage suddenly becomes unopposed and components deflected from their original shape suddenly attempt to return to their original shape, quickly accelerating the ram in a downward direction. The clearances in the drive train reverse and the ram jerks to a halt when all of the bearing clearances are taken up in the opposite direction. This sends a shock through the press frame and deflects press components in the opposite direction. Reverse tonnage is the primary component of many press-maintenance problems, and is an important element to consider before purchasing a press.

Torque, Leverage and Energy

The height above the bottom of the stroke at which the tonnage can be exerted is a function of clutch torque combined with the mechanical advantage of the drive. Due to increased leverage as the connecting rod straightens, mechanical presses can exert more tonnage as the ram moves closer to stroke bottom. Manufacturers rate presses at a distance above bottom where the press can exert full tonnage without the clutch slipping.

The ability of a press to exert tonnage increases dramatically as it nears 180 deg. of the stroke (bottom dead center), and it will be able to exert many times the tonnage that the press frame is designed for unless the press has a hydraulic overload to protect it. Conversely, as the connecting rod gets closer to 90 deg. of stroke, the amount of tonnage the press can exert, without causing the clutch to slip, lessens.

Energy is a second consideration, particularly important if the metalformer plans to perform drawing operations. Energy is press tonnage times the distance over which the press will exert that tonnage, expressed in the United States as in.-tons.

Consider the tonnage information just discussed. The total force-distance

How Much Tonnage and Energy Do You Need?

An example: To calculate tonnage/energy/distribution, consider a hypothetical die with five stations, 60 in. left to right.

- Station one requires 20 tons beginning 0.250 in. above bottom dead center (BDC), and will exert that force for 0.015 in. of the press stroke.
- Station two requires 20 tons beginning 0.125 in. above BDC, and will exert that force for 0.015 in. of the press stroke.
- Station three requires 40 tons beginning 2 in. above BDC, and will exert that force for 2 in. of the press stroke.
- Station four requires 20 tons beginning 0.125 in. above BDC, and will exert that force for 0.015 in. of the press stroke.
- Station five requires 30 tons beginning 0.250 in. above BDC, and will exert that force for 0.015 in. of the press stroke.

The most tonnage the press frame will see at any one instant is at 0.250 in. above BDC, when stations one, three and five exert their tonnage. The tonnage on the frame and drive train at that instant will be 90 tons. Note that stations two and four do not begin to exert tonnage until 0.125 in. above BDC, when stations one and five have finished exerting tonnage.

At 0.250 in. above BDC the press must be able to exert 90 tons without slipping the clutch. Note that this calculation assumes a sharp die. More tonnage will be required as the stations dull—leave a comfortable margin of tonnage capacity to account for this.

At 2 in. above BDC, the press must be able to exert 40 tons without slipping the clutch.

At 0.250 in. above BDC the load is out of balance because station five is exerting 30 tons while the opposing station, number one, exerts only 20 tons. The press selected must be able to resist this unbalanced load without undue wear or part inaccuracy.

Force x Distance = Energy

Station 1: 20 tons x 0.015 in. = 0.3 in.-tons of energy

Station 2: 20 tons x 0.015 in. = 0.3 in.-tons of energy

Station 3: 40 tons x 2 in. = 80 in.-tons of energy

Station 4: 20 tons x 0.015 in. = 0.3 in.-tons of energy

Station 5: 30 tons x 0.015 in. = 0.45 in.-tons of energy

Total energy used during one stroke to produce the part: 81.35 in.-tons

At the slowest stroke rate that the die will run, the press must be able to exert and recover more than the 81.35 in.-tons between strokes. Again, as the tooling wears the press will need to deliver more tonnage and therefore more energy at each station to complete the part.

The die will see 90 tons and will distribute that load across 60 in. of the bolster. Since presses are designed to allow maximum even load distributed across at least two-thirds of the press bed, the bed should be 92 in. or less left to right for this die to meet that criteria in a 100-ton press.

product of all of the stations must be combined to determine how many in.-tons of energy will be needed to form the part.

A mechanical press stores energy in the flywheel. Every time the press strokes, the flywheel slows down as energy transfers from it to the workpiece. When the flywheel slows, the motor draws electrical energy and attempts to return the flywheel to its original running speed.

The work-energy capacity of a mechanical press offers a measurement of how many in.-tons of energy can be drawn during one stroke and fully recovered before the next stroke begins. This work-energy capacity relates directly to the flywheel's rotational speed, mass and mass distribution in relation to the rim's distance from the hub and the motor horsepower.

It is extremely important that any press being considered in a drawing application has the energy capacity dearly stated on a quotation, as well as the strokes per minute at which the press has that amount of energy. Blanking and forming operations will require very little energy because the force is exerted over a very small distance. Drawing operations require a lot of energy because they must exert tonnage over a large distance.

Bed Size and Shut Height

The size of the dies to be used will dictate the required bed space and shut height of the press. Metalformers must balance the flexibility that a large bed provides with the optimum load distribution typically offered with a press bed doser in size to the tool. Besides creating concentrated load problems, running small dies in large beds also can create problems for operators as they attempt to move the workpiece through the tool, especially in progressive-die applications.

One aspect of die size often overlooked is upper die weight. The press has a counterbalance system designed to provide enough additional lift on the slide to counteract the weight of the upper half of the tool. This keeps bearings tight during the downstroke. Every machine has a maximum upper-die weight capacity—improper counterbalance adjustment can lead to early clutch/brake wear, early bearing failure and increased energy use.

When considering stroke-length requirement, stampers should look at the types of parts to be produced. Drawn parts require at least three, and preferably four, times as much stroke length as part height to allow for ease of automation and to allow the tonnage to be exerted with a standard-sized clutch. Stampers looking for greater versatility must examine stroke length in terms of the balance needed between the shortest possible stroke with the fastest cycle rate versus the longest possible stroke length, which can accommodate a wide range of part heights but at a sacrifice in press speed.

Material Considerations, Clearances and Lot Size

Required die clearance also affects press selection. Dies producing parts from very thin materials have small punch-to-die clearances. This means using a press with accuracy requirements not available in most gap-type machines. Extremely tight die clearances require extremely high-precision presses and demand straightside-press designs.

Critical part dimensions not only dictate the type of press model but also point the metalformer toward other features that help achieve tighter tolerances and greater part accuracy. These features include low deflection, high resistance to off-center loads, low stack-up tolerances, and special drives such as link and knuckle-motion.

Workpiece-material type will affect the type of press needed, and whether features such as link motion or servo technology may be required for successful production. Link motion and servo technology find application for forming thinner yet stronger materials and exotic materials such as titanium-magnesium alloys and high-tensile-strength steels. For extensive blanking operations on high-tensile materials, press tonnage often is based entirely on the resistance needed to withstand the expected reverse tonnage.

Finally, metalformers must look at the annual volumes they expect to produce. High-volume batches may require a faster straightside press over a gap press. For very high annual volumes, purchase more accurate presses, as the higher original investment pays dividends in press uptime, tool life and overall efficiency. While many consider the strokes rate at which a press can operate, in high-volume operations it is more important to consider minutes per hour that the press will actually operate. Metalformers also may require certain levels of automation, and annual volume will determine whether a part must be hand transferred, fed progressively or automatically transferred through the die.

These guidelines are intended as a checklist. A basic understanding of the elements discussed can help companies consider capital-equipment purchases from different perspectives. In addition to making more-informed purchase decisions, a thorough examination of these elements helps manufacturers meet short-term needs while identifying equipment flexible enough to serve future job requirements—a key ingredient to profitable operation in today's lean economy. **MF**