Seven Steps for Selecting an Extrusion Press

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ABSTRACT --- Very few new extrusion presses are purchased each year, so
most managers and engineers in the extrusion industry do not have experience in
specifying or selecting a new press. Purchasing a new press is a major
responsibility because the press installed today will be in service for 50 years or
more. Therefore, it is important that the press specified will perform efficiently
and reliably, with minimum maintenance and operating cost throughout its entire
lifespan. When proposals from various press suppliers are evaluated, it is
necessary to compare construction details and features point-by-point for each
press. Where differences are identified, the press suppliers should be asked to
explain and justify their particular specification. Then the purchaser’s own
engineering evaluation may be made from the different explanations. For this
presentation, the decision process has been divided into seven steps. Taking
them in a logical order, it is possible to choose the size and type of press and
decide the features that are best suited for the purchaser’s needs. These
principles may also be applied when buying a used press or modernizing an older
one.

STEP 1. WHAT TYPE OF PRESS: DIRECT, INDIRECT, PIERCING, OR MANDREL?

This first decision is based on the market situation. Most new presses are direct without piercing or
mandrel.

Indirect presses have the die placed at the front end of the hollow stem, which moves relative to the
container; but there is no relative displacement between the billet and the container. Since there is no
friction between the billet surface and the container, the extrusion load is 20 to 30 percent less. The
reduced load permits extruding smaller sections, or else reducing billet temperature and, thus, use of higher
speeds. Profile temperature is more uniform throughout the cycle. Impurities on the billet surface do not
end up inside the profile; however, it is necessary to machine or scalp the billets to prevent surface defects
from affecting the surfaces of the profiles. Another disadvantage is the limitations on profile size imposed
by the size of the hollow stem.[1]

Production of true seamless tubing requires either a piercing mandrel to make a hole in a solid billet, or
a hollow billet and mandrel. With either system, a true seamless hollow profile is possible with better
structural properties than may be achieved with conventional presses. Investment for this process is high
and production efficiency is poor, so it is limited to a few very specialized producers throughout the
market.[2]

For most extruders, the choice will be a conventional direct extrusion press.

STEP 2. WHAT CIRCLE SIZE, TONS, AND BILLET LENGTH?

Circle Size

The first question is the most difficult: What is the maximum circle size and weight-per-length range
of the products to be produced? What is the target market, not only today, but over the economic life of the
press? The past history of orders should be considered, but only as a guide since future markets may not
follow the same pattern. This decision requires the input of Sales, Production, and Top Management, but in the end it will be only a guess. In general, presses purchased in recent years have tended to be bigger, partly because of improvements in the ability to extrude more strands (more holes in the die). For one projection see, “The Extrusion Press Line for 2024: A Forecast,” by the author.[3]

Billet diameter is usually chosen to be at least 1 inch larger than the diameter of the largest profile or group of profiles to be produced. It is always possible to extrude profiles equal to or even larger than billet diameter by using spreader dies; but the technology is more complicated, die costs are higher, and there are limits to using them. It is better to use a larger billet diameter if possible.

Press Tons

After deciding on circle size, it is recommended to select a specific pressure within the target range of 60 to 80 kg/mm² or 85,000 to 115,000 lb/in². Specific pressure is calculated by dividing the press tonnage by the area of the container opening (usually based on billet diameter plus three percent). Many presses are operated outside the range of recommended specific pressure—for example, for very simple shapes. Your own experience may give you confidence to select a press outside of the recommended range. In general, however, you may be risking some loss of productivity due to slower upset and breakthrough.

To calculate Specific Pressure on the die face in **English units**:  

\[ P_s = \frac{\text{Press tonnage}}{\text{container area}} \]

\[ P_s = \frac{\text{Press tonnage} \times 2000}{\pi \times (\text{container ID})^2 / 4} \]

where \( P_s \) is in pounds/square inch and container ID is in inches (typically three percent larger than billet diameter).
<table>
<thead>
<tr>
<th>Billet Diameter (inches)</th>
<th>6”</th>
<th>7”</th>
<th>8”</th>
<th>9”</th>
<th>10”</th>
<th>12”</th>
<th>14”</th>
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<tbody>
<tr>
<td>Container I.D. (inches)</td>
<td>6.18</td>
<td>7.21</td>
<td>8.24</td>
<td>9.27</td>
<td>10.3</td>
<td>12.36</td>
<td>14.42</td>
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<tr>
<td>Container Area (square inches)</td>
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<td>40.83</td>
<td>53.33</td>
<td>67.49</td>
<td>83.32</td>
<td>119.99</td>
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<table>
<thead>
<tr>
<th>Press Tons ↓</th>
<th>Press Specific Pressure on Die Face (pounds/square inch)</th>
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<tbody>
<tr>
<td>900</td>
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<tr>
<td>1200</td>
<td>80,010</td>
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<td>1400</td>
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<td>594,803</td>
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<tr>
<td>7000</td>
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Notes:

1. Many experts recommend operating with Specific Pressure (die face pressure) in the range of 85,000 to 115,000 pounds/square inch.
2. Many North American extruders operate in the range 70,000 to 80,000 psi.
3. The optimum range of Specific Pressure will also depend on extrusion practices and the type of profile or bar being extruded.

To calculate Specific Pressure on the die face in **Metric units**:

\[
P_s = \frac{\text{Press tonnage} \div \text{container area}}{1000}
\]

\[
P_s = \frac{\text{Press tonnage} \times 1000}{\pi (\text{container ID})^2 / 4}
\]

where \( P_s \) is in kilograms/square millimeter and container ID is in millimeters (typically 3% larger than billet diameter).
### Billet Diameter (inches)
- 6”
- 7”
- 8”
- 9”
- 10”
- 12”
- 14”

### Billet Diameter (mm)
- 152
- 178
- 203
- 228
- 254
- 305
- 356

### Container ID (mm)
- 160
- 185
- 210
- 236
- 262
- 314
- 365

### Container Area (mm²)
- 20106
- 26880
- 34636
- 43744
- 53913
- 77437
- 104635

### Press MTons ↓

<table>
<thead>
<tr>
<th>Press MTons</th>
<th>Press Specific Pressure on Die Face (kilograms/square millimeter)</th>
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<td>6000</td>
<td>352.84</td>
</tr>
<tr>
<td>7000</td>
<td>402.84</td>
</tr>
</tbody>
</table>

### Notes:
1. Many experts recommend operating with Specific Pressure (die face pressure) in the range of 60 to 80 kilograms/square millimeter.
2. Many North American extruders operate in the range 50 to 60 kg/mm².
3. The optimum range of Specific Pressure will also depend on extrusion practices and the type of profile or bar being extruded.

### Billet Length

Typical billet lengths have increased greatly in the past 20 years or so, resulting in greater production flexibility and productivity. Some typical maximum billet lengths for common press sizes:
### Billet Diameter (inches / mm) | Press US tons | Press M tons | Billet Length (mm) | Billet Length (inches)
--- | --- | --- | --- | ---
6” – 152mm | 1350 – 1800 | 1200 – 1600 | 750 – 850mm | 30” – 34”
7” – 178mm | 1800 – 2200 | 1600 – 2000 | 850 – 1000mm | 34” – 40”
8” – 203mm | 2400 – 2750 | 2200 – 2500 | 850 – 1250mm | 34” – 50”
9” – 229mm | 2750 – 3100 | 2500 – 2800 | 1000 – 1350mm | 40” – 53”
10” – 254 mm | 3000 – 3600 | 2800 – 3100 | 1250 – 1400mm | 50” – 53”
12” – 305mm | 4200 – 5000 | 3850 – 4600 | 1350 – 1400mm | 53” – 55”
14” – 356mm | 5200 + | 4700 + | 1500 mm + | 60” +

It is usually advisable to select the maximum billet length according to plant requirements.

### STEP 3. WHAT DIE STACK DIMENSIONS?

The length of the tooling stack determines the deflection of the die under load and, therefore, the ability to control profile dimensions and tolerances. Deflection is reduced by the third power of the stack depth. On the other hand, a larger tool stack increases tooling costs. The best strategy is to consult with tooling experts and press suppliers to define a complete tooling system that balances tool stack rigidity with cost factors.

Published recommendations for die stack dimensions are very limited. Alan Castle proposed the following:[4]

#### Press Size 1600 Tons

- Total depth of die stack: 400 mm (15.75 inches)
- Die and backer thickness: 115 mm (4.5 inches—in practice, typically 101 and 128 = 4.0 and 5.0 inches)
- Die plate thickness: 25, 30, 40, and 50 mm (1.0, 1.2, 1.6, and 2.0 inches).

#### Press Size 2000 Tons

- Total depth of die stack: 450 mm (17.7 inches)
- Die and backer thickness: 135 mm (5.3 inches)
- Die plate thickness: 25, 30, 40, and 50 mm.

In practice, the total depth of die and backer may have to be increased (e.g., if large hollows are produced on porthole dies where the leg lengths are excessive). A typical range of die and backer depths used in practice on a 2000-ton press is:

- Solid Sections: 100, 160, 190 mm (4.0, 6.3, 7.5 inches)
- Porthole Dies: 120, 160, 190 mm (4.7, 6.3, 7.5 inches).

### STEP 4. WHAT ARRANGEMENT: SHORT-STROKE, FRONT-LOAD, OR CONVENTIONAL?

Today’s market has moved overwhelmingly toward short-stroke (moveable stem) and compact (front loading) presses, especially in Europe. These three press types are illustrated in Figure 1:
Both the short-stroke and compact types reduce dead cycle in a logical manner by reducing the distance which the main ram must travel in relation to maximum billet length. Since this travel is slow and must occur in both directions, the savings in dead-cycle time are significant, usually about four seconds compared to a conventional press with the same billet length and hydraulic system. These press types are also much more rigid in structure, with shorter tie-rods and less overall deflection of the die platen. Either type requires less space and less foundation than a conventional press.

The short-stroke press reduces ram travel by moving the stem sideways (or downwards) immediately after it exits the container.
With the compact or front-loading press, the container moves back over the stem, and then both travel back to make room for loading the billet; the billet is loaded in front of the container and the container swallows the billet as it closes against the die.

**STEP 5. WHAT PRESS MANUFACTURER?**

When selecting vendors to make proposals for a new press, the choice is never based on purely objective considerations. Most buyers take into account past experience, reputation, references, and service and support; these often are more important than price, because of the importance of reliability and cost of operation.

Press suppliers range from top-tier, high-tech (and higher cost) companies to Third World, low-tech (and lower cost) manufacturers. The top-tier presses offer the highest efficiency, productivity, and reliability, with short dead cycles, top quality structural components, greater rigidity, better alignment, and top quality hydraulic and control systems. However, top-tier presses are not necessarily the correct choice for everyone. Analysis has to take into account the following questions:

- The effects of reliability versus downtime: Is this the only press in the company, or are there others available to support customers in case this one breaks down?
- Is investment capital available for the high-quality and higher-cost options?
- Will the markets support the added fixed costs of a higher-quality press plant?
- What about the cost and availability of skilled labor? How do these affect the economic picture?
- Will the press remain modern and competitive for future years, or will technological advances soon make it obsolete?

**STEP 6. WHAT DESIGN DETAILS?**

**Component Construction: Cast or Forged?**

In the early days of aluminum extrusion, many of the main press components (platens, main cylinders, container housings) were supplied in cast iron or cast steel. In recent years, most of these components are being built of forged steel instead, for reasons well explained by Mr. J.O. Nøkleby of Det Norsk Veritas in Chapter 4: “Inspecting & Repairing Major Components” in The Extrusion Press Maintenance Manual.[5]

In general, forgings are more easily and more reliably tested against flaws and, therefore, may be certified for quality by the press supplier. Many sophisticated purchasers of new presses require certification of the forgings before machining and testing of major components by ultrasound and magnetic particle inspection (MPI) after machining. Component design must also be verified by finite element analysis (FEA).

**Platen Thickness**

The press front platen should be as thick as possible within practical limits. Rigidity of the platen for die support increases geometrically with the thickness. Platen deflection should be less than 0.010 to 0.015 inches (0.254 to 0.381 mm) under full load in order to minimize die deflection.
Pre-Stressed Tie Rods

Fatigue failure of tie rods, common in earlier press designs, may be virtually eliminated by installing sleeves over the tie rods and pre-stressing them over their whole length. Details of the sleeve design and pre-stress procedures are critical to the application.

Press Dead Cycle

The extrusion capacity lost to dead-cycle time is a major factor in press performance. Fortunately, dead-cycle times have been reduced dramatically in recent years, thanks to PLC controls, improved hydraulic systems, conversion to short-stroke and compact press designs, and other innovations. While very short dead-cycle times may be quoted by press suppliers, it is extremely important to always use the same definition of dead cycle when making comparisons of different presses. Items which may or may not be included in a supplier’s calculation include decompression, billet upset, and burp cycle. Be sure that all suppliers are referring to the same definition of dead-cycle. The best way to get correct information is to require a cycle bar chart with all component movements diagrammed on a time scale.

Hydraulic System

This area of the specification involves many issues:

Hydraulic Supplier. Hydraulic components should be supplied by your preferred vendor, based on your past experience and maintenance program. Spare parts in common with existing presses will be one issue to consider. Second, consider the responsiveness of different vendors when on-site service and training are required. The press supplier should be willing to use the vendor-supplied components you prefer. Your preferred hydraulic vendor may also be helpful in specifying the system details for the new press.

Number of Main Pumps. Consider increasing the number of main hydraulic pumps in order to improve performance and reduce dead-cycle time.

Location of Pumps. The pumps may be located on the tank over the press, on the floor behind the press, or even in a pit or separate room. Location affects noise level, maintenance access, and system performance.

Oil filters and Cooling. Proper filtration is critical to component life and performance (see Chapter 5: “Hydraulic Equipment” in The Extrusion Press Maintenance Manual). Be sure that the design of filters, heat exchangers, and temperature control takes into account the actual conditions and climate of your plant.

Manifolding, Piping, and Miscellaneous Components. Specify the use of manifolds to reduce oil leaks. Careful selection and placement of valves and other components can reduce system shock and oil leaks and permit reduced dead-cycle time.

PLC Controls

All modern presses are controlled by PLC controls, but it is still important to define which features will be included in the control scheme of your new press. Some issues include the following:

Supplier. Whether Allen-Bradley, Siemens, Modicon, or other—specify the brand of PLC that you prefer, based on performance, technical support, and familiarity of your maintenance technicians.

Features and Integration. Today’s PLCs may be integrated with company-wide computer systems to offer collection and recall of data as well as online order entry. Touch-screen displays inform the operator of data trends as well as the past history of each die. The range of options is great and still growing; make sure your new press takes advantage of the potential.

Diagnostics. Fault displays can notify you of potential breakdowns before they occur. For example, some new presses allow continuous measurement of container alignment. Networking allows remote display of
press condition and faults at a screen in the maintenance shop, or even on the maintenance person’s home
computer (through cable or dial-up networking). The press or software supplier may even diagnose and
resolve problems from halfway around the world.

**Container Guiding**

Most modern presses use container guiding systems which may be adjusted from outside the press
frame—no center guides. Guide surfaces should be in the horizontal and vertical planes—no \( X \) guiding.

**Container Heating and Cooling**

Newer presses, especially larger sizes, offer multi-zone heating control and multiple points for
measurement of container temperature. It is preferred to separate the container into upper and lower zones,
as the top tends to get hotter than the bottom. Some suppliers also offer container cooling in order to be
able to reduce the temperature when it exceeds a pre-set limit (usually in the center or rear of the billet).

**Die Changer Type**

Layout considerations are key to this choice. The rotostation changer extends farther away from the
press, but is more compact in the direction along the press axis. The unistation or shuttle-type is longer
along the press axis but does not stick out as far. The unistation may have a slight advantage in
accessibility for ease of maintenance.

**Billet Loader Type**

For swing-arm-type loaders, the two-piece loader is generally considered obsolete, in favor of a one-
piece with a telescoping support. Compact and short-stroke presses typically use an overhead or robot-type
loader to transport the billet from the shear to the press centerline.

**Butt Shear**

Design should include a butt-knocker. Some suppliers offer proprietary designs, which may improve
contact with the shearing surface while avoiding damage to the die face.

**Quick-Change Container and Stem**

Where more than one billet size is to be used, it is recommended to specify a quick-change design for
the container and stem. Various designs are available to permit change-over in the minimum possible time.

**Other Specialty Features**

Proprietary press features offered by various press suppliers include the following:

- *No-burp extrusion*, where the container is held open during billet upset in order to eliminate or
  minimize the “burp” cycle

- *Die locking*, to hold the die face fixed in both the horizontal and vertical directions while the butt is
  sheared, in order to insure a uniform, smooth-sheared surface

- *Profile shearing between the die and backer*, to reduce the quantity of aluminum wasted at each die
  change.
STEP 7. WHAT SPARE PARTS AND DRAWINGS?

Spare Parts

The initial project appropriation should include about five percent for purchase of spare parts. Spare parts should be negotiated at the same time as the press purchase and made a part of the purchase contract. The purchase contract should include the right to specify the make and model of purchased component parts such as hydraulic, electrical, and electronic components to insure local availability as well as compatibility with existing spare parts inventory.

Similarly, the purchase contract should specify the detailed drawings, particularly of the press tooling that will be supplied as part of the purchase. This step will allow flexibility and economy in purchasing replacement tooling and other components in future years.

CONCLUSION

An extrusion press that is well-chosen and well-specified will serve its owners well and be profitable for decades to come, long after the people making the selection have finished their careers. Therefore, the selection process deserves the investment of time necessary to master each of the seven steps and, thus, to make a wise choice.

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2 Ibid
6 Ibid., Chapter 5: “Hydraulic Equipment.”