

# PUNCHING AND STAMPING

## How to compare production cost

**Fig. 1**  
Sheet metal products  
produced by punching  
from sheet, coil or by  
hard tooled stamping  
(casings for lighting  
appliances).



A short guide to identify the technology from among those available, for the lowest possible production cost, according to the number and type of parts to be produced.

The aim of process engineering is to identify the least expensive production cycle to make a product. A sheet metal product follows a cycle that starts from raw material, goes through shearing (punching, blanking or laser cutting) followed by forming (bending, stretch-forming or embossing, rollforming). The cutting technologies by punching and stamping (fig. 1) will be taken into consideration in these pages due to their similarities. The purpose is to identify the technology from among those available that, in a specific working situation (number and type of parts to be manufactured) completes the production at least cost.

We will then analyse these technologies to define the typical costs of each one, firstly identifying the three factors that added together give the production cost: raw material,

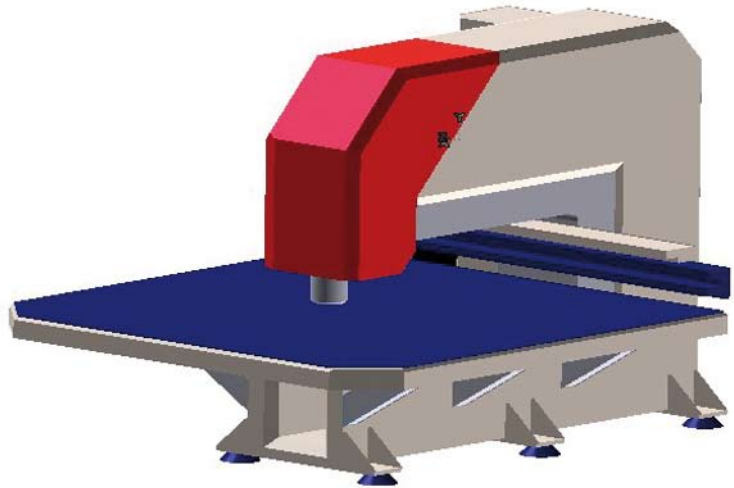
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tools and hourly cost of the machine, the last value being multiplied by the hours necessary for production.

To calculate the hourly cost of the machine, another four component factors will be analysed: labour cost connected to machine operation, maintenance cost, energy cost and lastly the cost of plant amortization. Lastly, the production costs either with sheet punching machines or coil punching machines will be compared. Likewise for the production costs with coil punching machine and press with die. This last part will also provide useful formulas, given the type of product and required quantity, for identifying the technology to obtain production at the lowest cost.

### THE TECHNOLOGIES

The technologies analysed for flatbed blanking of the workpiece are: punching from coil, punching from sheet metal and stamping with press. Punching with sheet feeding is the technology that allows maximum flexibility (fig. 2). Complex shapes may be obtained within the space of the sheet and the system is also suited to the manufacture of a single piece. There are machines with manual or automatic loading and unloading; in either case the machine must stop when the sheet is loaded and the finished product unloaded (fig. 3). Punching with coil feeding capability is a technology suited to medium and small quantity production. The machine loads the metal strip directly from the coil; the machine therefore always works in the automatic cycle with good flexibility (fig. 4). Stamping is the technology suited to mass production. In this case the speed is maximum, but flexibility is low: a die is made for each product and its cost must be amortised in production (fig. 5).



**Fig. 2**  
Sheet-fed  
punching machine

### PRODUCTION COST: THREE FACTORS

The guiding principle behind the choice of technology to be used is that of the lowest production cost.

This is given by adding up three factors.

The first is the cost of the raw material, which may be in sheets (for the sheet fed punching machines) or coil (for the coil punching machines and press stamping).

The cost for all the raw material necessary for completing production is considered.

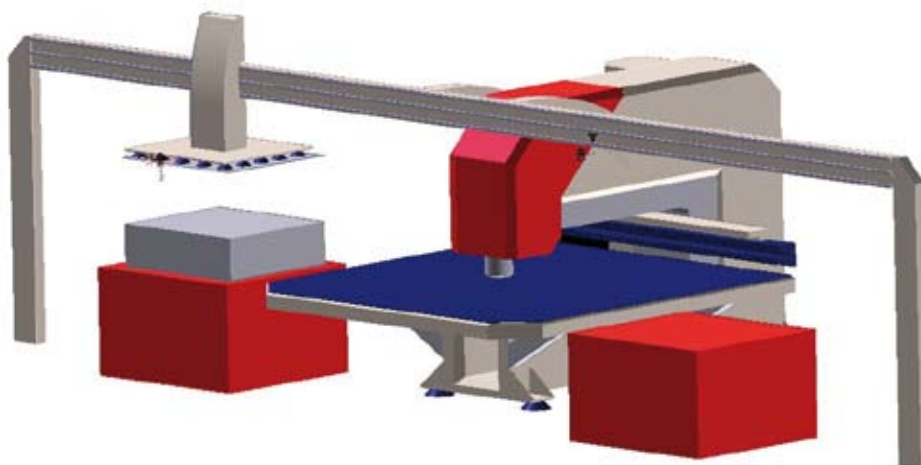
To this should be added the cost of the tools. The tools for the punch presses with sheet metal or for the coil punching machines are standard punches available from various manufacturers (e.g. thick turret punches).

The latter produce a standard shape (round or square holes and so on) or special shapes at every stroke of the punching machine.

The tool for the stamping press is made to measure for the product to be manufactured.

The standard punches undoubtedly have lower costs than the special press tools.

The last factor is the hourly cost of the machine, which is multiplied by the hours that the machine will require to complete



**Fig. 3**  
Sheet-fed  
punching machine  
with automatic  
loading and  
unloading.



**Fig. 4**  
Coil punching  
line with decoller,  
straightener and coil  
punching unit.

the production. All this is summed up by the formula: [production cost] = [raw material] + [tools] + [hourly cost] x [hours of production]. Fig. 6 gives the meaning of this formula in graphic form.

#### HOURLY COST: FOUR FACTORS

Four other factors must be added together to calculate the hourly cost of a machine. The first cost factor is the labour connected with the machine. When the machine needs continuous supervision, the cost of an operator dedicated to the machine must be taken into account (from 20 to 25,000 euro a year to be divided by 1800 hours per year). The second factor is the annual maintenance costs, which include the expendable materials, the hydraulic oil and the lubricants, the cost of technical assistance and spare parts. The cost of maintenance incurred for the machine in one year, divided by 1800 hours per year, gives this value. The third factor is the cost of the electricity consumed by the plant each hour. Lacking data regarding plant absorption of electricity, a prudent calculation could be half the installed power.

**Fig. 5**  
Stamping line  
with press.



The fourth factor is the cost of amortization of the machine. To calculate this hourly cost it is sufficient to divide the envisaged amortization rate for the machine during the year in progress and once again divide it by 1800 hours per year.

If the machine has been purchased by leasing, the annual instalment divided by 1800 hours may be considered instead of the cost of amortization. In this way, upon completion of machine amortization or upon expiry of the leasing contract, there will be a reduction in the hourly cost of the machine.

#### THE SPEED OF PRODUCTION

To complete the calculation of the production cost, it is necessary to multiply the hourly cost by the hours required for the machine to carry out the work.

Knowing the time-cycle of one piece (in hours/piece), this figure is multiplied by the total number of workpieces N.

In a sheet-fed punching machine the cycle time depends heavily on the type of machine, the route of the tool over the surface of the sheet metal and the number of tool changes required. To this punching time should then be added the time for loading the sheet and unloading the product (from 30 to 50 hundredths of a minute).

In the coil punching machine, the production time is obtained with empirical formulas as follows: [Production time] = [Number of operations per piece] x [Average time per operation] + [Length of piece in metres] x [Time per metre].

In this case the coil punching machine time is equal to the total production time, since the loading and unloading times do not exist.

Lastly, the production time in the stamping press is minimum: every press stroke produces one piece. Productivity therefore depends on the press speed (60, 80, 120 and more strokes a minute). In conclusion, the die press is the fastest production system, followed by the coil punching machine and lastly the sheet-fed punching machine. It has been pointed out in

the paragraph describing the technologies, that the sheet-fed punching machine is the most flexible system, followed by the coil punching machine and the stamping press line. At this point it is interesting to construct a productivity-flexibility diagram, which is given in fig. 7.

### COMPARISON OF TECHNOLOGIES

With a production N to be manufactured, it is necessary to find the technology to accomplish it at the lowest cost.

In the following paragraphs the numerical value of the cost of the raw material or the hourly cost will no longer be calculated.

The costs will instead be assessed in relation to other technologies to provide the required cost comparison. The concepts will be supported by numerical references; in this way the formulas given up to this point may then be applied to each individual working situation.

### COMPARISON BETWEEN SHEET PUNCHING AND COIL PUNCHING

At the current level of knowledge, punching from coil (fig. 8) is particularly indicated for making products with two sides corresponding to the sides of the coil (figs 9-11) and for medium and small production runs (from 200 pieces to 500,000 pieces per year in one shift). Furthermore, coil punching is ideal for the mass production of pieces that are "different from each other" if they belong to the same family (lot 1).

For example, window and door frames are mass produced as single pieces: the punching is similar, but the sizes (height and width of the door or window) differ from one product to the next.

Punching from sheet is used for manufacturing rectangular pieces (like the coil punching machine), but it may also produce highly complex shapes, nesting them in the sheet. Sheet-fed punching may also produce a single piece that is totally different from the others obtained from the same sheet. It is therefore also used for very small production runs (from 1 to 50 pieces). The two technologies will be compared for an average production run of pieces that can be made with both machines. Each of the factors making up the production cost will be analysed and the conclusions drawn, which will be valid in respect of the hypotheses already expressed.

#### Raw material

The sheet-fed punching machine works from commercial standard sized metal sheets or sheared to size. In the first case from 10% to

20 % waste must be considered due to the impossibility of fully using the surface of the sheet.

Working with blanks sheared to size, the percentage waste is minimum but the cost of the sheared blanks is higher than for the standard size.

The coil punching machine instead works strips from coils that come from service centres with the right width. The percentage waste in a coil is 1% at the most. Whereas the coil punching machine basically uses all the material of the coil, the sheet-fed punching machine generates a higher raw material cost due to greater waste or the higher cost of blanks sheared to size.

#### Tools

Regarding tool cost, it is estimated that both punching machines, using standard punches (e.g. standard thick turret tools), incur the same expense for tools.

#### Hourly cost

The last factor to be assessed is the hourly cost, which will be multiplied by the production time.

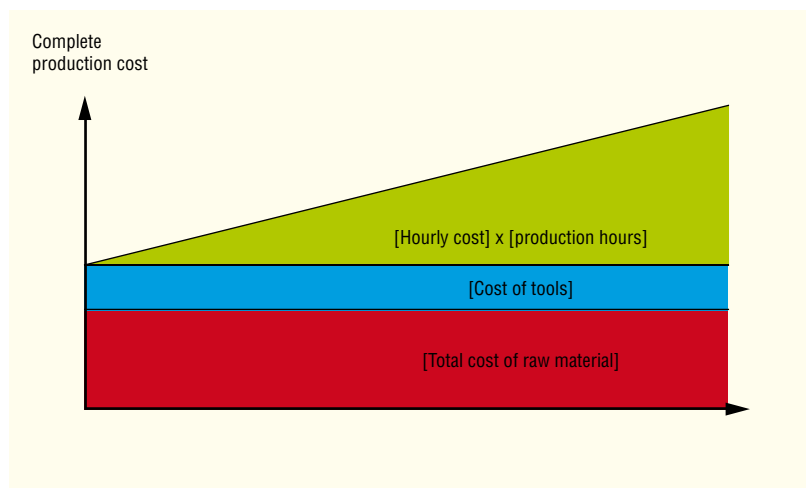
For calculation purposes the maintenance and electricity costs are considered equal in the two types of machines.

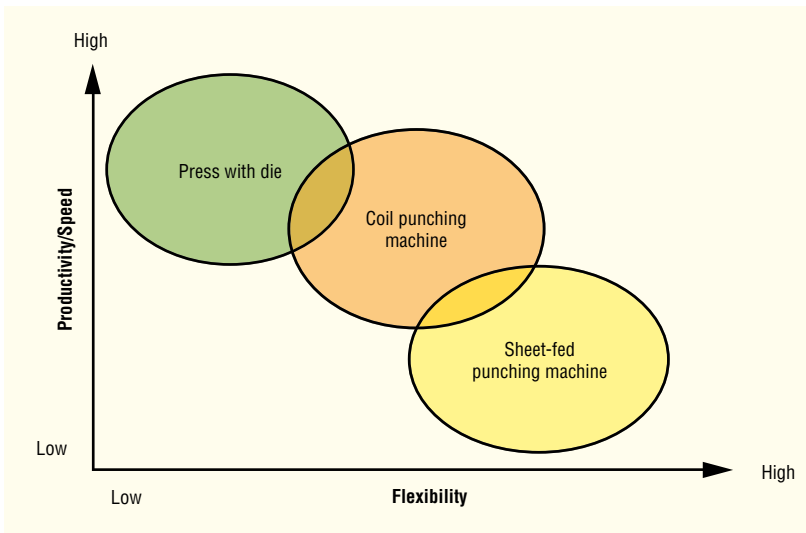
The labour cost depends on the type of system.

The sheet-fed punching machine requires the constant presence of at least one operator for the sheet loading and workpiece unloading operations. This cost may be eliminated by introducing a robotised loading and unloading system on the sheet-fed punching machine; in this case the system obviously requires a greater investment with consequent increase in the cost of amortization of the sheet-fed punching machine, as will be analysed.

A simple coil punching machine instead produces automatically without the constant presence of an operator, who just loads coils

**Fig. 6**  
Composition of the production cost in relation to the production hours.





**Fig. 7** Productivity-flexibility diagram and placement of the technologies in question.

and unloads pallets. The cost of amortization for coil punching machines and sheet-fed punching lines depends on the type of system that has been purchased. In this analysis we are considering the cost of amortization of a sheet-fed punching machine with manual loading and unloading at an equivalent cost of amortization of a coil punching machine. If the sheet-fed punch press has automatic loading and unloading, the hourly labour cost will be reduced, but the machine amortization cost will be higher.

There are also compact coil punching machines available that allow even less investment (figure 8) and therefore an even lower hourly amortization cost.

For the above reasons, in the various operating conditions, the coil punching machine has shown from 20% up to 30% lower hourly costs compared to the sheet-fed system.

*Production time*

The value of the hourly cost should be multiplied by the hours of production.

In the sheet-fed punching machine, as described in the paragraph on production speed, the time required for loading the sheet and unloading the piece must be added to the punch time.

This time goes from 30 to 50 hundredths of a minute, whether the operation is carried out manually or automatically.

In the coil punching machine, however, the machine time is equal to the product cycle time, which means that the coil punching machine is normally faster than the sheet-fed machine and therefore requires fewer hours to complete the production.

Generally speaking, the simpler the workpiece the more productive the coil punching machine compared to the sheet-fed punching machine.

*Conclusion*

Raw material and hourly costs are therefore lower for the coil punching machine, which also takes less time to complete the production.

The first and third addend of the sum [raw material] + [tools] + [hourly cost] x [hours of production] = [production cost] are less in the coil compared to the sheet-fed punching machine. It can therefore be concluded that for medium and small production runs and with suitable workpieces for production from coil, the latter is the technology that accomplishes the production at the lowest cost.

**Fig. 8** Coil punching machine for strips up to 1000 mm wide.





## COMPARISON BETWEEN PUNCHING FROM COIL AND STAMPING BY PRESS

With these two technologies available, given the high cost of press tools, the aim is to determine the discriminant number of pieces  $N$  below which it is more economic to work with the coil punching machine. For production runs greater than  $N$ , it will be more economic make a special press die. Also in this case each of the factors making up the production cost will be analysed and the conclusions drawn.

### *Raw material*

Both machines work from the coil and the raw material cost is therefore identical.

### *Tools*

The cost of special press tools is higher than the cost of punch press tools, which are standard and may be reused in various productions. The cost of setup time is included in the tool cost; it is considered as being equal in the two machines and negligible compared to the cost of the special press tool.

### *Hourly cost*

Both machines need the constant presence of an operator and the labour cost is therefore negligible. The annual maintenance and electricity costs are similar for the two machines. The cost of amortization of the two machines also here depends on the type of system. Basically the coil punching machine, with a slightly higher investment, offers great

medium and long-term savings in tools. That is why the cost of amortization and therefore the hourly cost of the stamping line will be considered as slightly lower compared to the coil punching machine.

### *Production time*

The stamping press, as has been seen, produces one piece at each press stroke. Productions of 40, 60, 80, 120 workpieces and more per minute are therefore normal. The coil punching machine requires from 0.5 to 1 second for each operation. The production of one workpiece may require, for example, from a few seconds to tens of seconds.

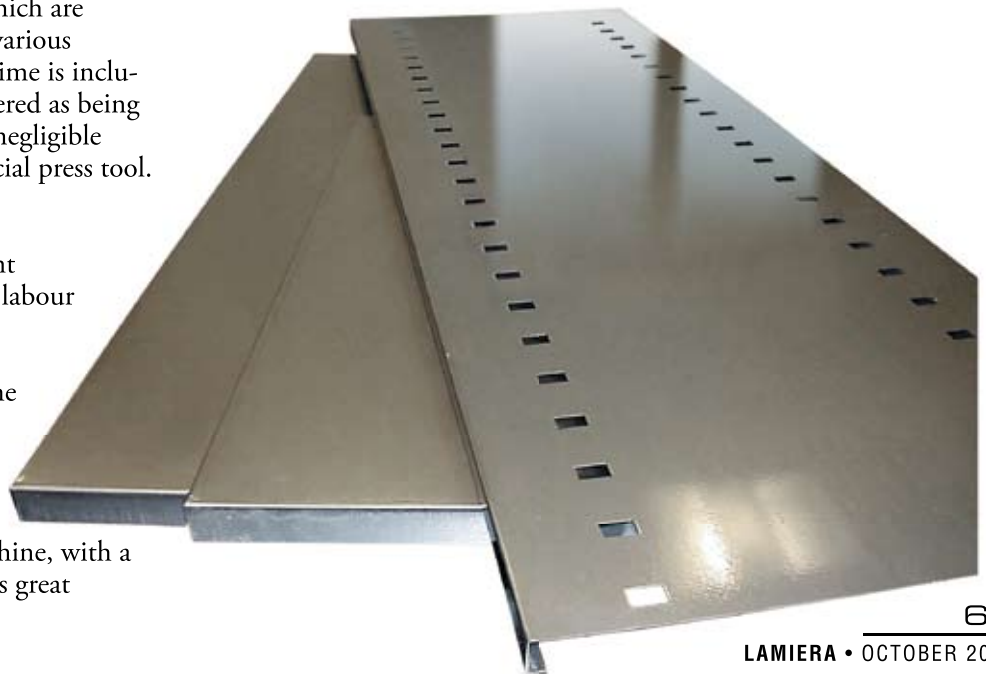
### *Conclusions*

To obtain the discriminant number of pieces  $N$ , which for the given definition indicates whether to produce with a coil punching machine or to make a special tool for stamping with the press, it is necessary to equalise the two production costs calculated from the equation: [production cost] = [raw material] + [tools] + [hourly cost] x [hours of production]. The raw material cost is the same and may therefore be eliminated from the calculation. Given the great difference between the cost for the punch press tools and the press die, the cost of the punch press tools are considered as practically nil compared to those of the special die.

Also given the greater speed of the die press over the punch press, the necessary hours of production when manufacturing with press and die are considered at first analysis as zero. The necessary hours of production for completing the production with the coil punching machine are equal to the number of pieces  $N$  multiplied by the hours required to make one piece (time-cycle). After a few passes, it can

**Fig. 9**  
Examples of products made by punching from coil (door panels).

**Fig. 10**  
Products punched from coil (metal furniture panels and shelves).



**Fig. 11**  
Products  
produced by  
punching from  
coil (safety  
door frames).

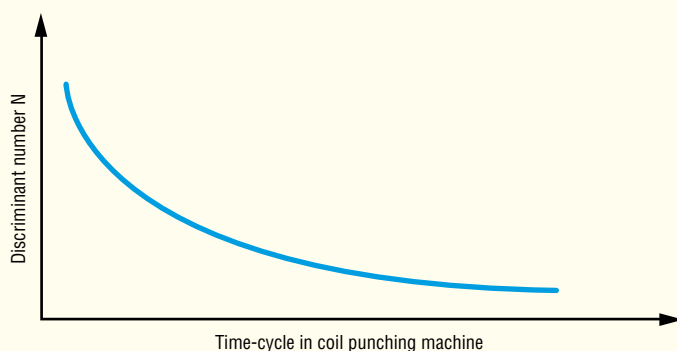


be calculated that  $N = [\text{Press tool cost}] / ([\text{coil punching hourly cost}] \times [\text{hours per piece in coil punching machine}])$ .

For example, suppose that it costs 8000 euro to make the tool. The hourly cost of the coil punching machine is 40 euro and the machine takes 20 seconds (equal to 0.0056 hours) to make the actual piece.

The discriminant number  $N$  will be equal to 35,700 pieces. For smaller production runs it will be more economic to produce with the coil punching machine. For larger production runs it will be more economic to make a die. It should be noted that the suggested formula, due to the approximations, is incomplete, as it lacks the cost of the punch press tools (which increases the formula denominator) and the cost of the hours of production with the press (which instead increases the numerator). Apart from the advantage of simplicity, this formula also offers a valid indication regarding the discriminant number  $N$  and leads to certain reflections. Consider the hourly cost of the punching machine and the cost of the press tool as constant. The graph of the trend of the discriminant  $N$  in relation to the punching machine time-cycle shows the trend as can be seen in fig. 12. The discriminant number  $N$  increases as the coil production time-cycle

**Fig. 12**  
Discriminant  
number  $N$  in  
relation to the  
coil production  
time.



decreases; in other words they are inversely proportional. Lastly, if the coil punching machine hourly cost and the coil production time-cycle are considered as constant in the formula, then the discriminant number  $N$  increases as the die cost increases.

## CONCLUSIONS

Firstly the structure of the production costs and the hourly cost of punching from sheet, punching from coil and stamping with press and die has been analysed.

Punching from sheet and from coil were then compared.

The result is that punching from sheet is indicated for manufacturing pieces with complex shapes or for very small production runs (from 1 to 50 pieces).

For simpler shaped pieces (rectangles, squares, notched and punched panels) and for medium and small productions (from 200 to 500,000 pieces), punching from coil is always preferable. Lastly punching from coil and stamping by press were compared.

The result is that stamping by press is to be preferred for large and volume mass production (millions of pieces), while, again, punching from coil is more indicated for medium and small production runs. In more general terms, a simple formula has been obtained that, given the tool cost, the hourly cost of the coil punching machine and its production time, gives the number of pieces  $N$  below which it is more economic to punch from the coil than to stamp by press.