General

Power presses are used for punching or stamping, forming or drawing and embossing operations. Press brakes are used for bending operations. Shears are used to cut material to size. In most cases, the material being worked is steel.

These machines usually utilize a slider-crank linkage to transfer kinetic energy from a rotating flywheel to a reciprocating ram. They are rated by the force $\mathbf{F_r}$, the ram can exert at a given distance **d** above the bottom of the stroke. This distance is called the drive capacity. The product of the drive capacity and rated force determines the maximum energy which should be removed from the flywheel to perform the necessary work.

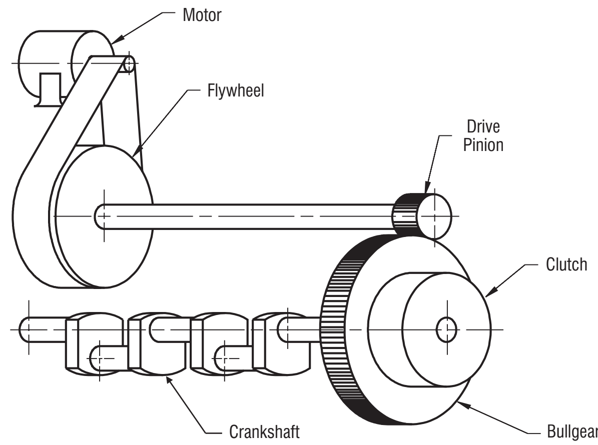
As energy is removed from the flywheel, and work is performed, the flywheel slows down. The machine's motor replaces the expended flywheel energy before the next work stroke by bringing the flywheel back up to its operating speed.

A clutch and brake is usually required for one or all of the following reasons:

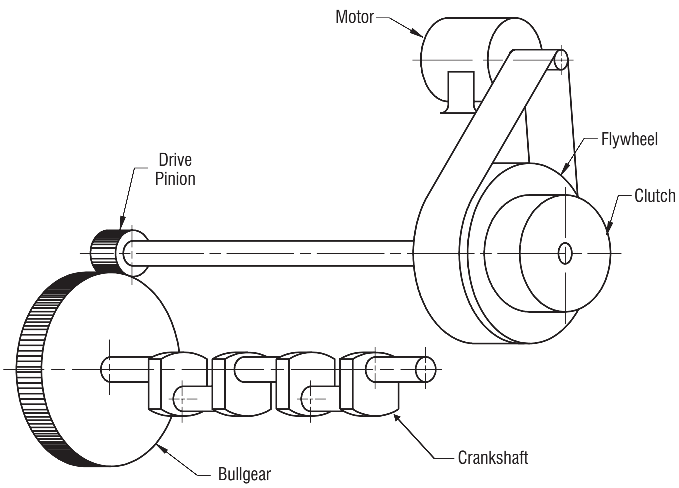
- For die or blade setup.
- For feeding and removing work pieces from the machine.
- For emergency stopping.

Because these machines are inherently dangerous, the brakes are spring-set, pressure released types.

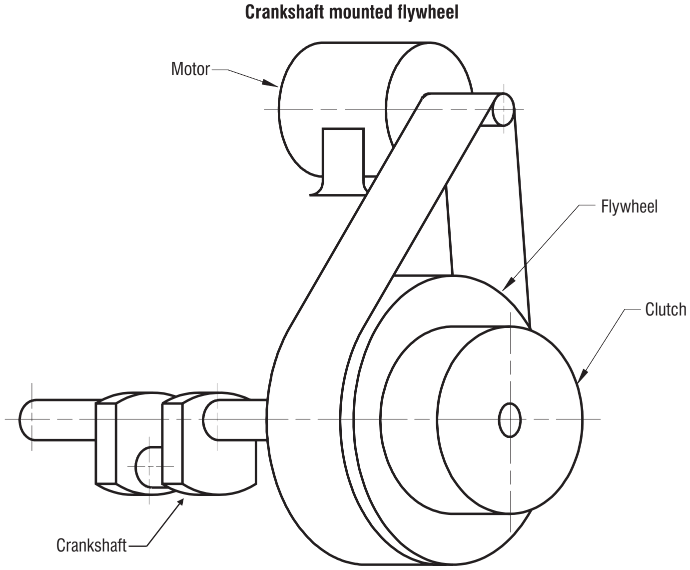
Single geared, single drive clutch mounted on bullgear



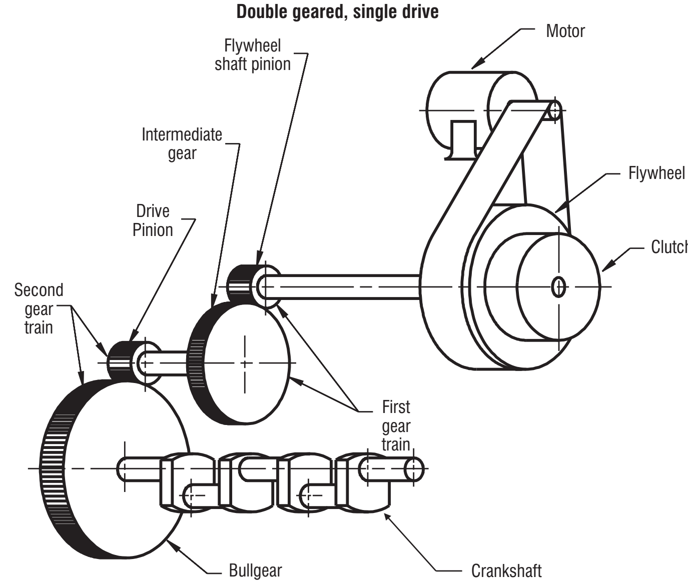
Single geared, single drive clutch mounted on flywheel



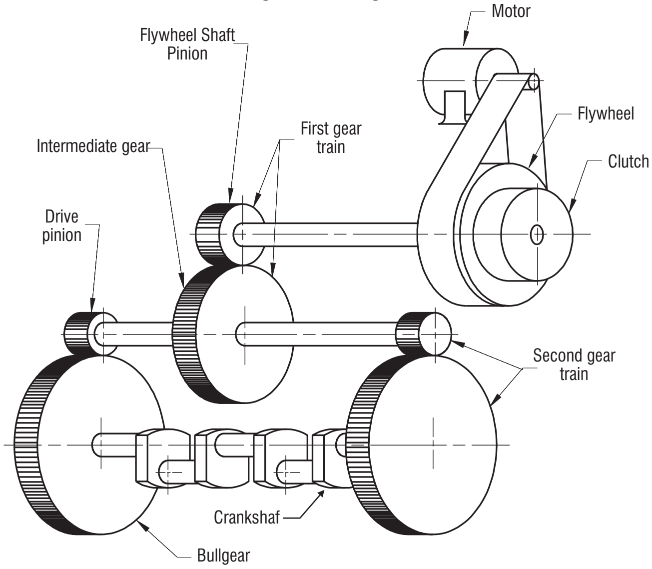
Crankshaft mounted flywheel



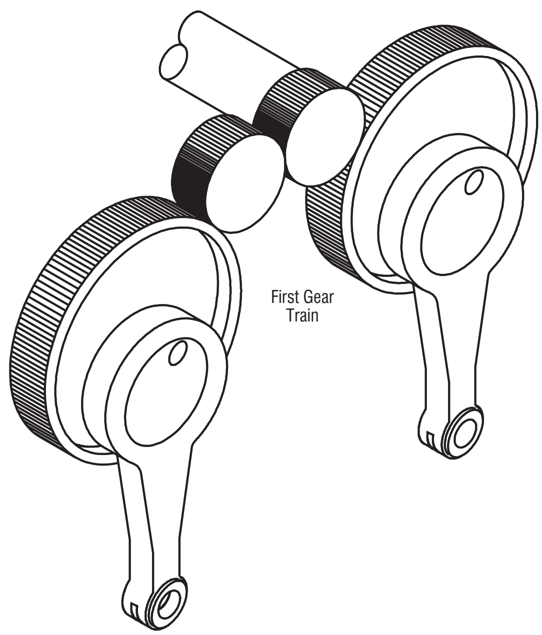
Double geared, single drive



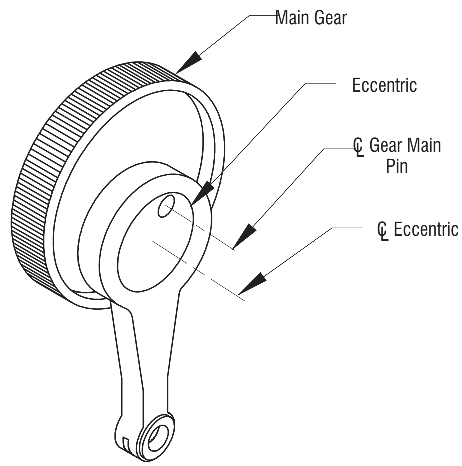
Double geared, twin gear



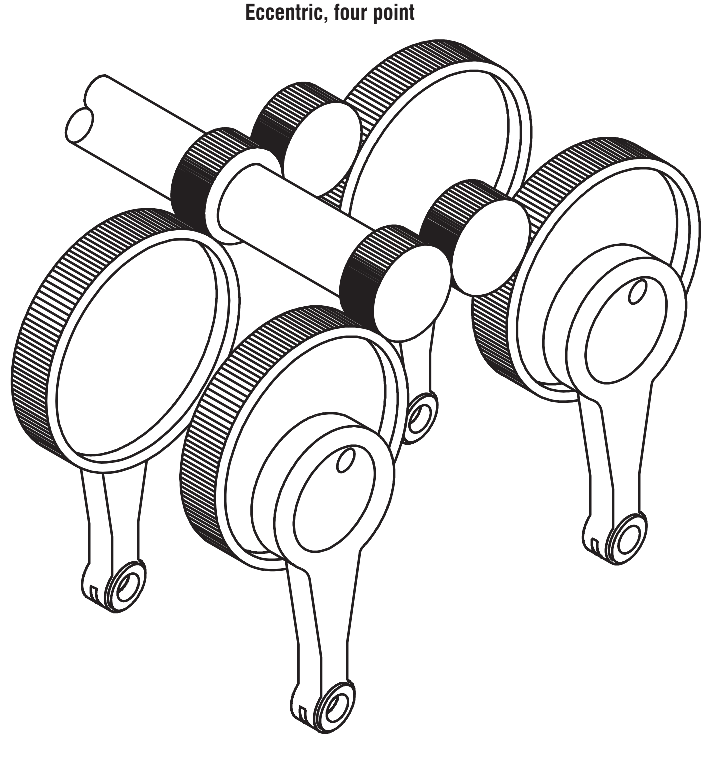
Eccentric, two point



Eccentric, single point



Eccentric, four point



Drive Capacities

Power presses

Mechanically, the drive capacity is dependent upon the drive train between the crank and flywheel shafts. Commonly used drive trains are illustrated on the preceeding pages. The distance is a minimum for crankshaft mounted flywheels and a maximum for twin geared drives. If not specifically stated, the values given in the following table may be used.

Drive Capacities d		
for Open Back Inclinable (OBI) and Horn Presses		
Rated Tonnage	**c/s Flywheel Drive**	**Geared Drive**
32 and less	0.03 in (0,8 mm)	0.13 in (3,3 mm)
over 32 to 110	0.06 in (1,5 mm)	0.25 in (6,4 mm)
over 110		0.25 in (6,4 mm)
For Single-Action, Single and Multiple Point Geared Presses		
Single drive	0.25 in (6,4 mm)	
Eccentric drive	0.50 in (13 mm)	
Twin drive	0.50 in (13 mm)	

Press brakes

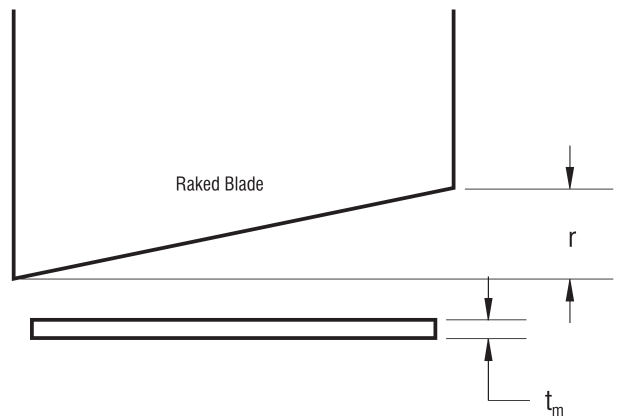
The drive capacity for short stroke machines, if not specified, can be approximated from the width **V** of the vee die opening. Use the following approximations:

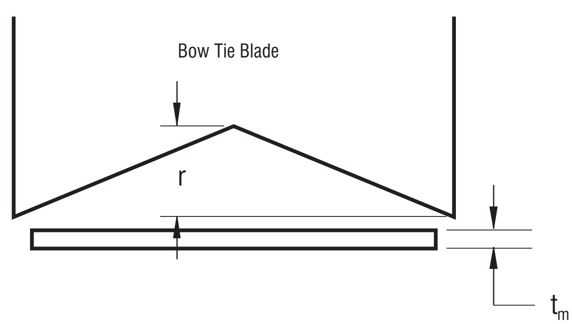
For stroke less than 3 in (76 mm) $d = 0.28V$

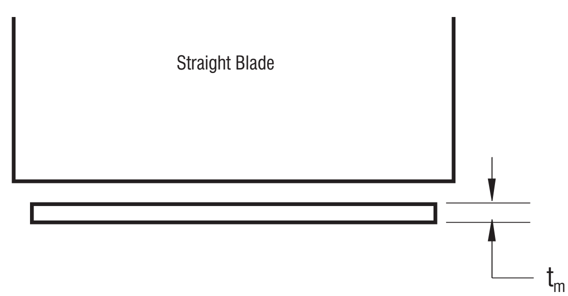
For larger strokes $d = 1$ in (25 mm)

Shears

The tonnage and drive capacity needed to cut a given material depends upon the type of blade used. The diagrams illustrate the differences between straight, raked and bow tie blades and gives the drive capacities. Usually, the shear blade is allowed to overtravel the work piece thickness $\mathbf{t_m}$ by a small distance **e** to provide a clean cut.

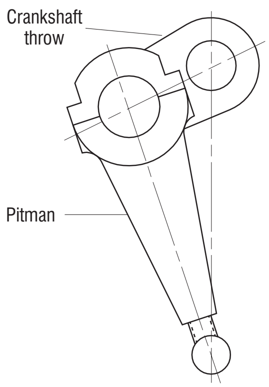


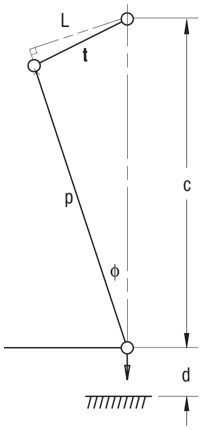




Crankshaft Torque

The slider-crank linkage is shown below.





The crank link **t** length is equal to the crankshaft throw (one-half of the stroke distance) or in the case of an eccentric drive, the eccentric offset. The link **p** connecting the crankshaft throw to the ram is called the pitman.

Knowing the lengths of the throw and pitman, the pitman angle **Ø** can be calculated at any point in the stroke from:

$$\cos \phi = \frac{p^2 + c^2 - t^2}{2 \cdot p \cdot c}$$

$$c = p + t - d$$

The torque lever arm **L** varies throughout the stroke of the machine. At any point in the stroke, the lever arm can be calculated from:

$$L = c \cdot \sin Ø$$

The force $\mathbf{F_p}$ which the pitman must transmit can be calculated from:

$$F_p = F_r / \cos Ø$$

$$F_r = 2000 \cdot \text{Rated Tonnage of Press}$$

The crankshaft torque **M** is:

$$M = F_p \cdot L = Fr \cdot c \cdot \tan Ø$$

The torque required at the machine's drive capacity is used in the clutch selection procedure.

Clutch Torque

Clutch torque $\mathbf{M_c}$ calculations can be simplified by the use of the effective lever arm $\mathbf{L_e}$ graphs and the following formula. The graphs assume the pitman length is twice the stroke. Longer pitmans will slightly reduce the effective lever arm.

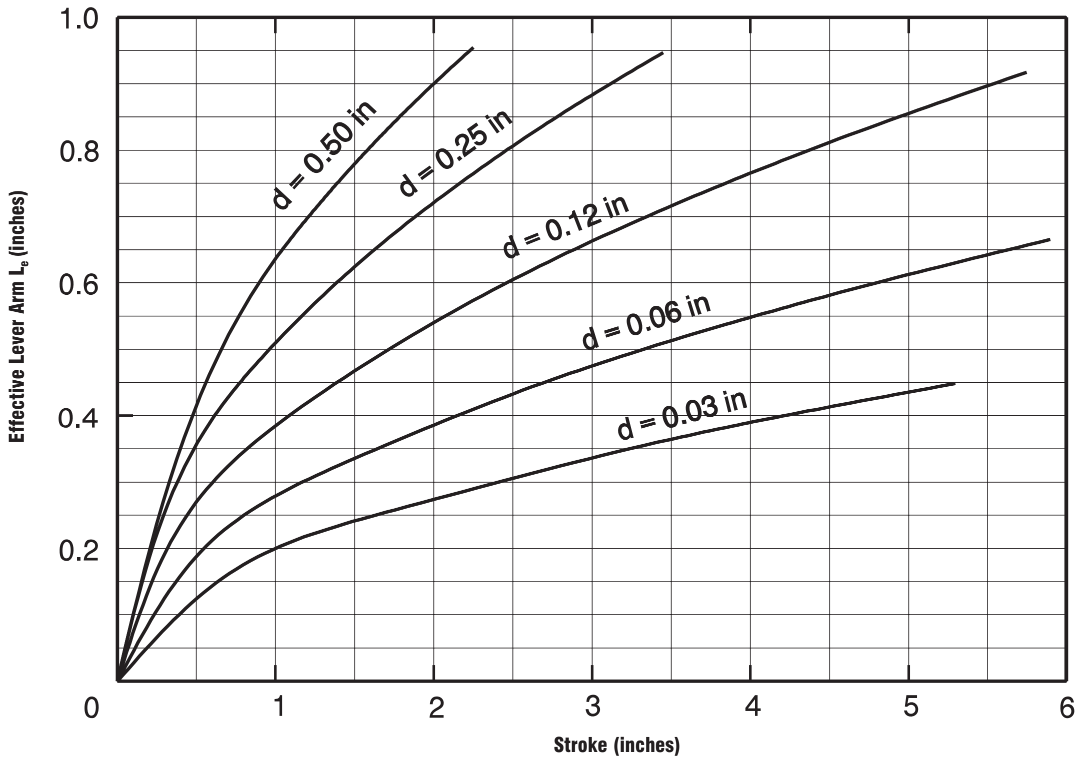
$$M_c = \frac{F_r \cdot L_e}{R} \cdot SF$$

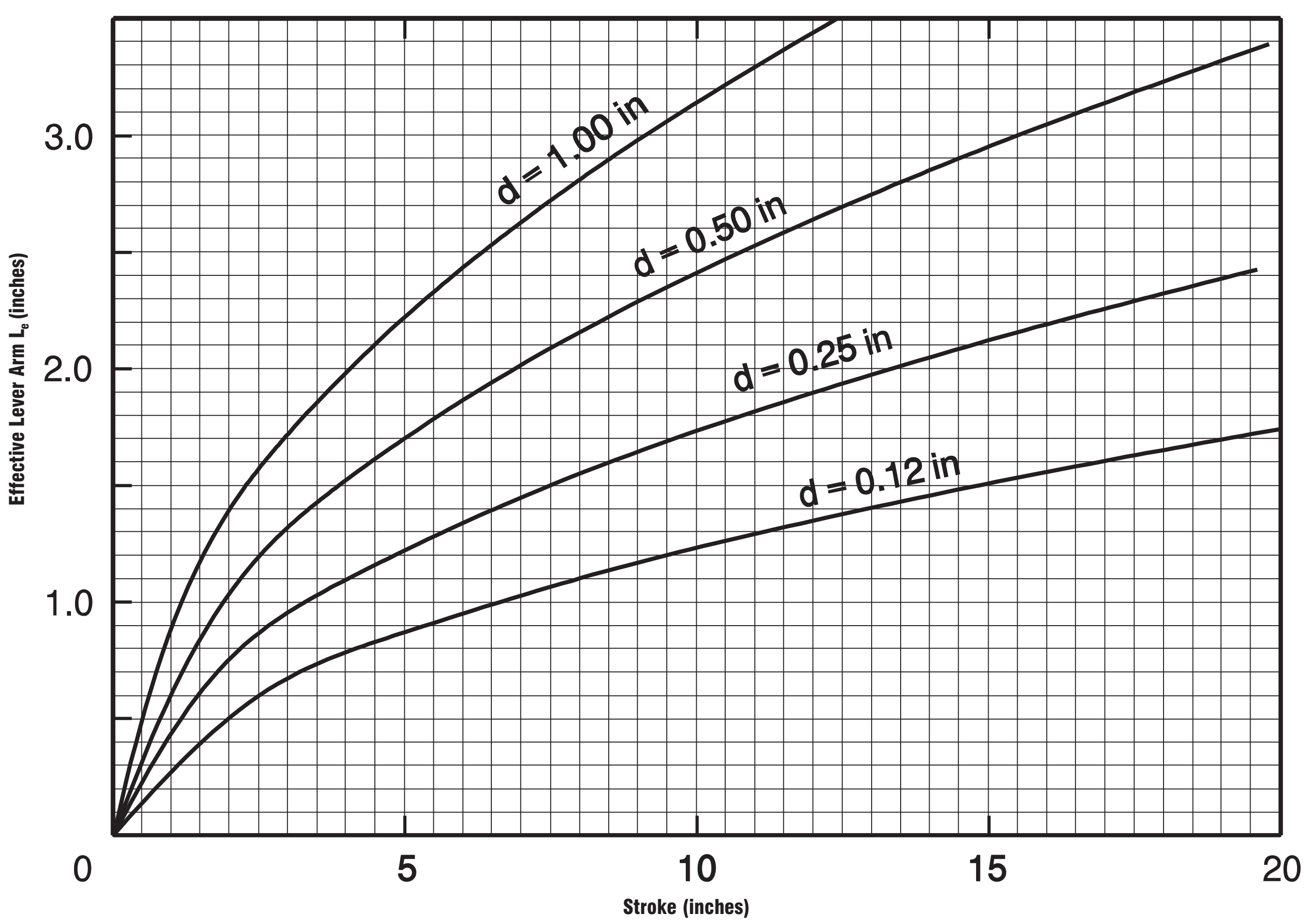
R: reduction between clutch shaft and crankshaft.

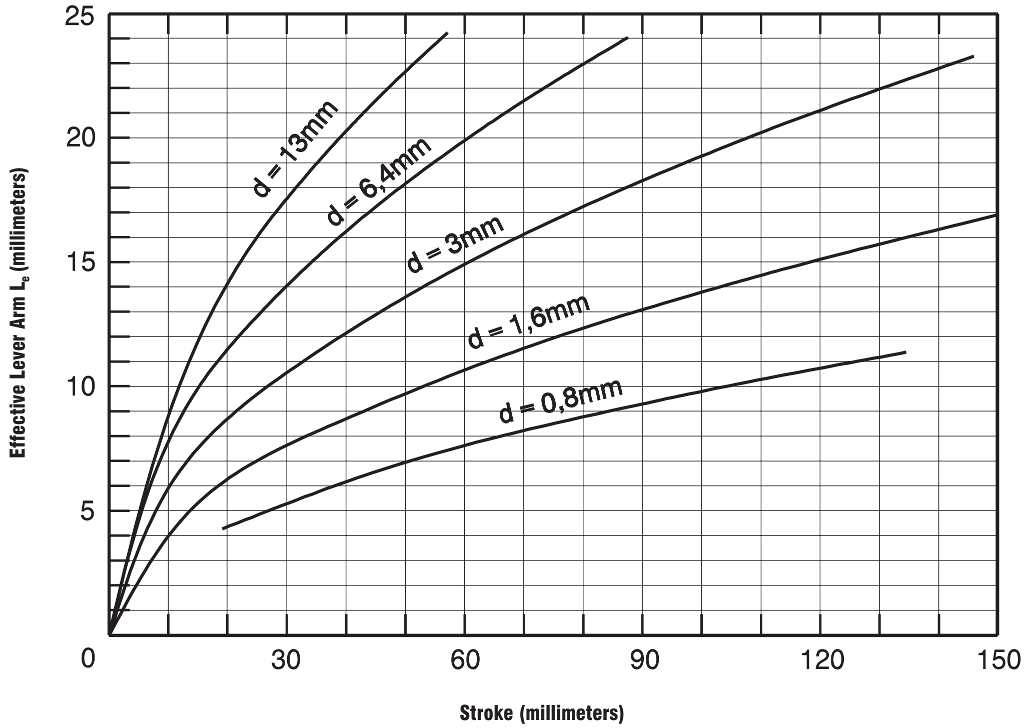
SF: service factor from following table.

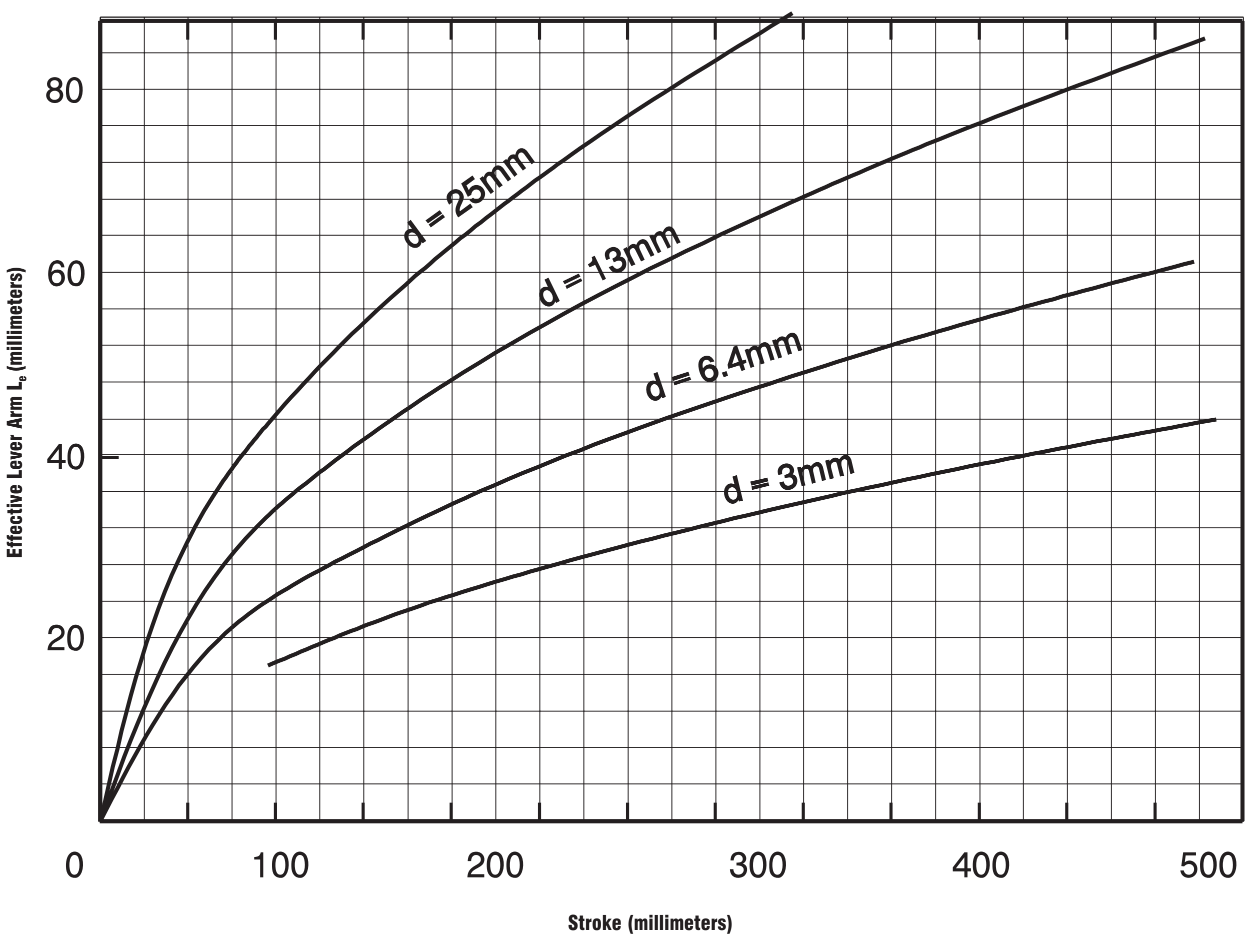
Brake Capacity

Type of Drive	SF
Crankshaft mounted flywheel	0.8
Single drive, single reduction	1.0
Single drive, double reduction, single throw	1.1
Single drive, double reduction, double throw	1.2
Twin drive, single reduction	1.3
Twin drive, double reduction	1.5


1.0
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
Effective Lever Arm L_e (inches)
Stroke (inches)
d = 0.50 in
d = 0.25 in
d = 0.12 in
d = 0.06 in
d = 0.03 in


3.0
2.0
1.0
0
5
10
15
20
Effective Lever Arm L_e (inches)
Stroke (inches)
d = 1.00 in
d = 0.50 in
d = 0.25 in
d = 0.12 in


25
20
15
10
5
0
30
60
90
120
150
d = 13mm
d = 6,4mm
d = 3mm
d = 1,6mm
d = 0,8mm
Effective Lever Arm L_e (millimeters)
Stroke (millimeters)


80
60
40
20
0
100
200
300
400
500
d = 25mm
d = 13mm
d = 6.4mm
d = 3mm
Effective Lever Arm L_e (millimeters)
Stroke (millimeters)

The selected brake must satisfy the following conditions:

It must have sufficient torque to stop the ram within a given crankshaft angle.

It must have sufficient torque to hold the ram and die on the back stroke.

It must have sufficient thermal capacity to handle the single stroke rate of the machine.

Formulas are given in Section Y which allow calculation of brake torque Mb knowing the stopping angle, inertia to be stopped and the brake shaft speed n. A brake selection is made using Mb.

Holding torque Mh is calculated from:

Mh = F· t/R

F: total weight or mass of ram including attached tooling.

The reverse torque of the brake selected is compared to Mh to determine if it has sufficient capacity.

Cyclic thermal power Pc is calculated from formula 23, Section Y. The allowable thermal loading on the friction area of Airflex types CS, CTE and DB brakes is 0.012 HP/in² (0.0014 kW/cm²).

Example

Press rating - 60 tons

Type of drive - crankshaft mounting

Drive capacity d - 0.06 in

Stroke - 3 in

Pitman length p - 8 in

Crankshaft speed - 100 rpm

Single stroke rate - 30 cpm

Ram and die weight F - 200 pounds

Wk^2 less clutch and brake - 10 lb·ft²

Stopping angle ϕ_d - 15°

Flywheel Wk^2 - 900 lb·ft²

Calculations

c = t+p-d = 0.5·3 + 8 - 0.06 = 9.44 in

$$\cos f = \frac{p^2 + c^2 - t^2}{2 \cdot p \cdot c} = \frac{8^2 + 9.44^2 - 1.5^2}{2 \cdot 8 \cdot 9.44}$$

$= 0.9988$

$Ø = 2.78°$

$L = 9.44 \cdot \sin Ø = 0.46$ in

$M = F_r \cdot c \cdot \tan Ø$

$= 60 \cdot 2000 \cdot 9.44 \cdot \tan 2.78$

$= 55000$ lb·in

$M_c = 55000 \cdot 0.8 = 44000$ lb·in

Select FSPA109 (20CB500 clutch and 15CS300 brake):

clutch torque = 53600 lb·in

forward brake torque = 22000 lb·in

reverse brake torque = 3500 lb·in

flywheel Wk^2 = 942 lb·ft²

Wk^2 drum and hub = 61 lb·ft²

Total Wk^2 to be stopped = 10 + 61 = 71 lb·ft²

Stopping Time:

$$t_d = \frac{Wk^2 \cdot n}{25.58 \cdot M_b} = \frac{71 \cdot 100}{25.58 \cdot 22000}$$

$= 0.012$ sec

Stopping Angle:

$f_d = 3 \cdot n \cdot td = 3 \cdot 100 \cdot 0.012$

$= 3.6°$

$M_h = F \cdot t$

$= 200 \cdot 1.5$

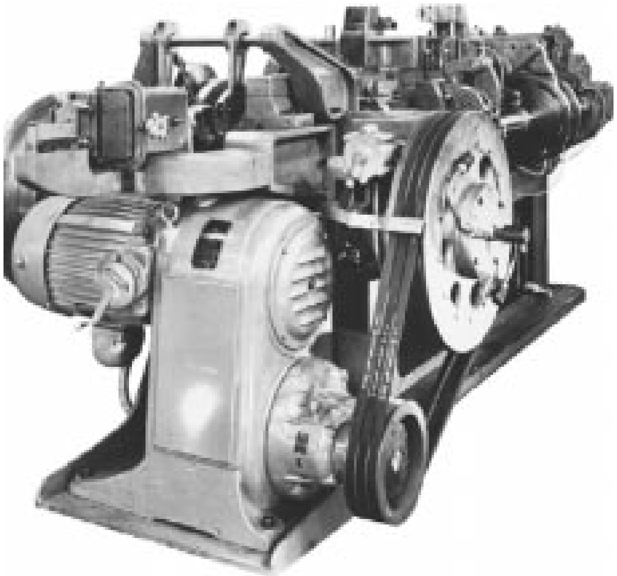
$= 300$ lb·in

$$W_r = \frac{Wk^2 \cdot n^2}{5873} = \frac{71 \cdot 100^2}{5873} = 121 \text{ ft·lb}$$

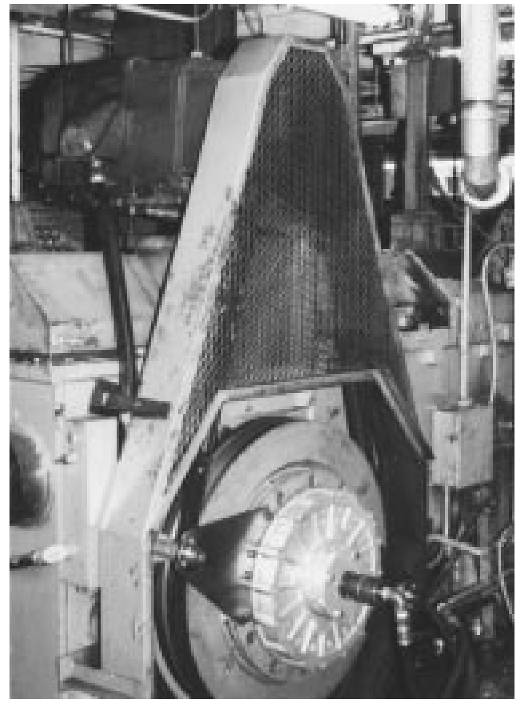
$$P_c = \frac{W_r \cdot cpm}{33000} = \frac{121 \cdot 30}{33000} = 0.11 HP$$

$$\frac{Pc}{A} = \frac{0.11}{89} = 0.0012\ HP/in^2$$

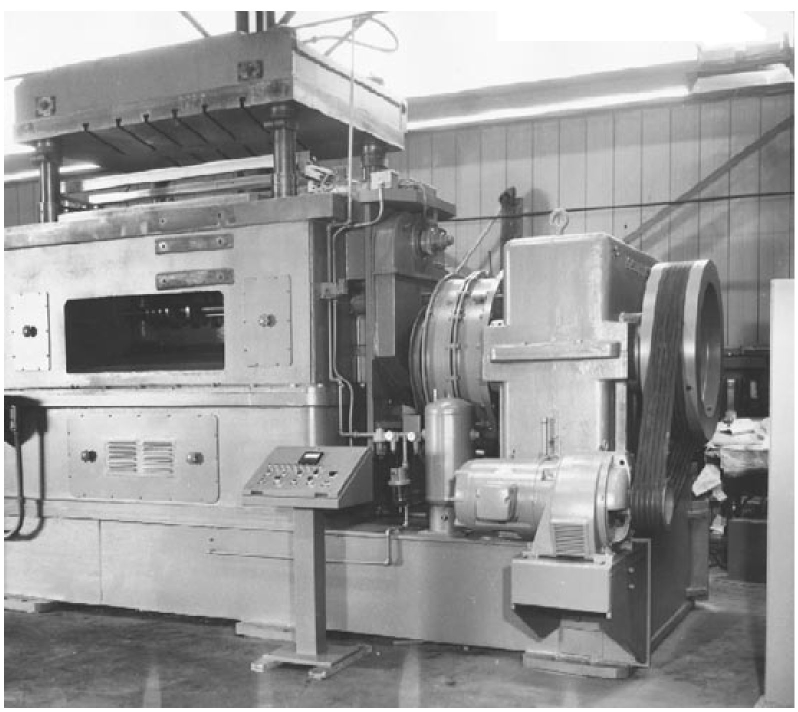
Both thermal capacity and holding torque requirements are within the 15CS300 parameters.



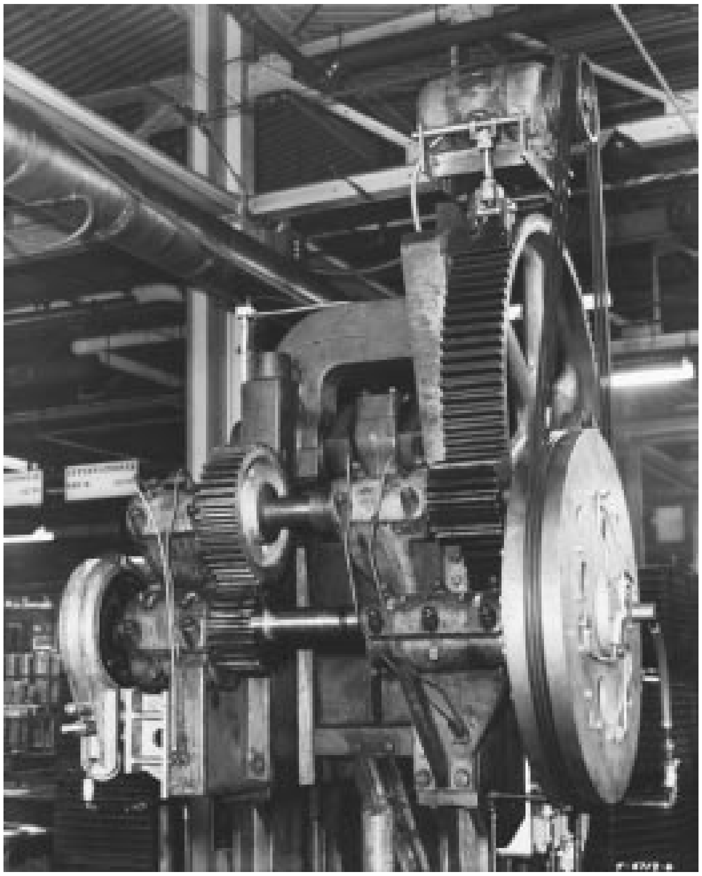
Typical FSPA application on multi-slide machine.



21DCB clutch/brake on can making machine.

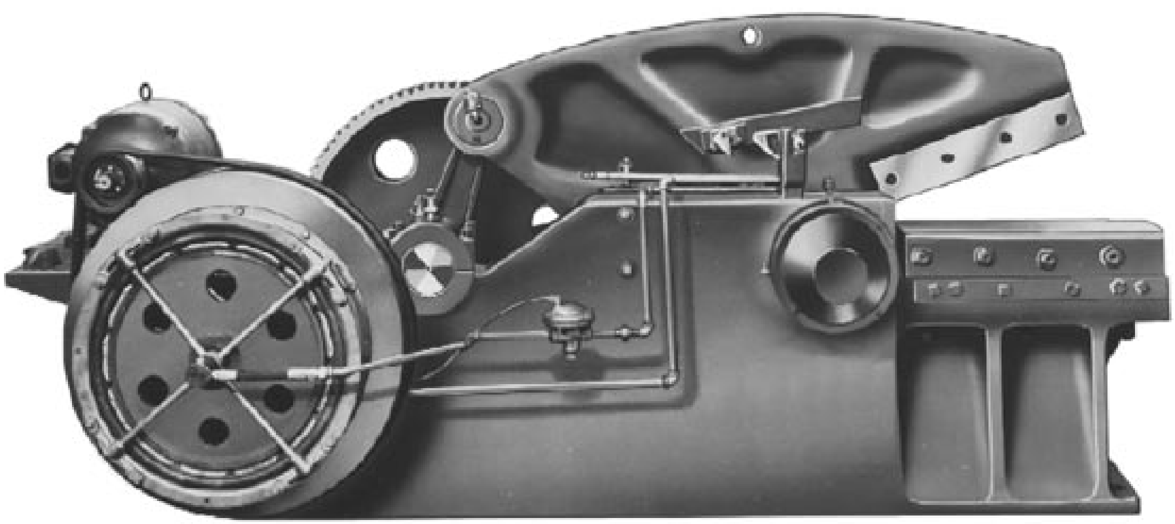


Dual 33VC650 clutch and 24CTE500 brake on a 150 ton, 12 inch stroke under-drive press.



Split FSPA application with flywheel/clutch at right side of press
and CTE brake at the left side.

46VC1200 clutch in an air bridge mounting on crankshaft bullgear
- 600 ton press, 6 inch stroke.



CB air bridge clutch application on a scrap shear.