AIDA TECH
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Volume One

Off-Center Loading in Multi-Stage Tooling

What it is and what to do about it.

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Progressive and transfer dies are certainly not new to the metal forming industry and their use is constantly growing. These multi stage dies are becoming increasingly more complex as the quality and enhanced performance demands for the parts being produced continues to grow. To accommodate the demand for more complex parts, the dies used to produce them require more operating stations, which increases their length. The result of this increased complexity and length is that it becomes nearly impossible to center the loads of all the working stations within the die set.

Tooling engineers not only have the burden of generating a die design that will produce a quality part but must also keep the cost of the die to a reasonable minimum. Any effort to center the loads within the die set will most likely result in an increase in the cost of the die. This means that the tooling manufacturer may not be awarded the contract for the building of the die.

Even more disturbing is the fact that most tooling engineers, process engineers and set-up personnel are not aware of the negative effects of off-center loading on part quality and die life because nowhere in their education or training has this problem been properly addressed. Because of this lack of knowledge, dies are designed, manufactured and installed in presses with no consideration given to centering the load.

THE PROBLEM:

To better understand the negative effects of off-center loading, we must first understand how to determine what it is and how to place a value on it. If we look at Figure #1, we see the layout of a six station progressive die. The feed progression is 8 inches with three operations performed on

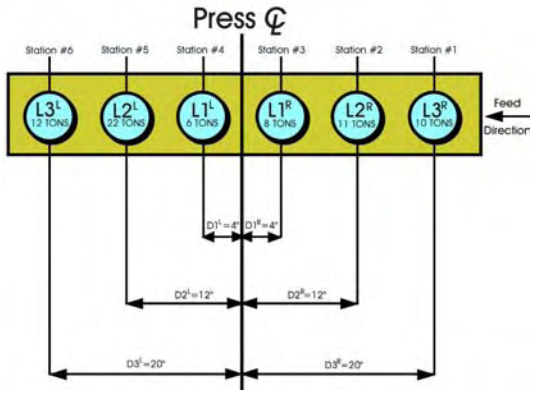

Figure #1

one side of the die centerline and three on the other. The calculations that determine the total amount of off-center load are shown in Figure #2. This die has 164 inch tons of off-center load located to the left side of the centerline. Now that we have identified what off-center loading is, let's look at the effect it has on a stamping operation. When the set-up person places the die in a press, it is common that the centerline of the die set matches the press centerline.

$L3^R \times D3^R =$	200 IN. Tons
$L2^R \times D2^R =$	132 IN. Tons
$L1^R \times D1^R =$	32 IN. Tons
Right Side Total	364 IN. Tons
$L1^L \times D1^L =$	24 IN. Tons
$L2^L \times D2^L =$	264 IN. Tons
$L3^L \times D3^L =$	240 IN. Tons
Left Side Total	528 IN. Tons

Off Center Load=
528 IN. Tons - 364 IN. Tons=
164 IN. Tons

Figure #2

Once this location is established, the die is clamped to the press bolster plate and slide face and the operation begins. Using the above example, we now know that 164 inch-tons of off-center load force will be applied to the press slide with the result illustrated in Figure #3.

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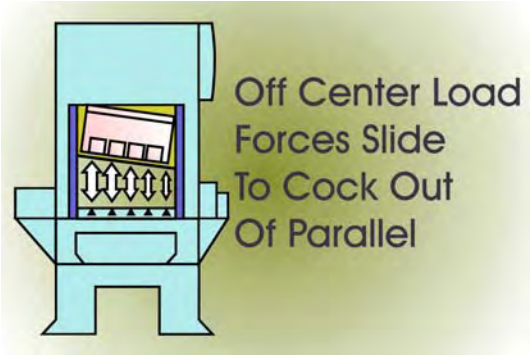

Figure #3

The press slide tips and moves laterally in the direction of the greatest force, which in our example will be to the left. This movement occurs while the punches are engaged with the die section, which creates high wear on these mating components. This wear increases die maintenance costs and can reduce the dimensional consistency of the parts being produced.

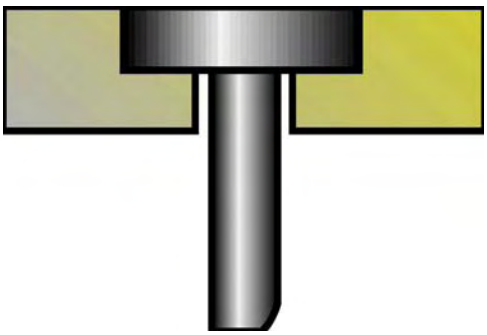

Figure #4

One method that can be used to determine if die wear is being created by off-center loads is to look at the perforating or blanking punches. If these punches are rounded off on one side as illustrated in Figure #4 or the punch and die section chip repeatedly in the same spot as shown in Figure #5, then the damage has probably been caused by the press slide movement that results from the off-center loading.

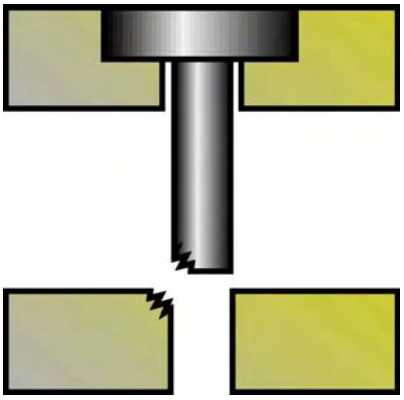

Figure #5

THE SOLUTIONS:

There are many possible solutions to the problem of off-center loading. The application of these solutions will depend on a variety of factors involved in the production of metal stampings. Ideally, the tooling engineer will be aware of the off-center load problem and will incorporate load balancing in the die design. However, it is virtually impossible to design a multiple stage die with the load perfectly centered on the die set. Press selection can also play a big part in reducing the effects of high off-center loads, especially if the press and dies will be purchased new. We will look at those press features that help to reduce slide tipping and lateral movement. However, most metal stampings are produced on presses and dies that are already in existence so we must to be able to make adjustments to this equipment that will improve the system performance.

1) SHIFT THE DIE ON THE PRESS BOLSTER

When multi-stage tooling has been reviewed and the off-center load identified, the simplest method to eliminate the problem is to slide the die set on the press bolster so that the highest load is moved towards the press centerline as illustrated in Figure #6. The distance that the die is shifted on the press bolster will depend on the amount of

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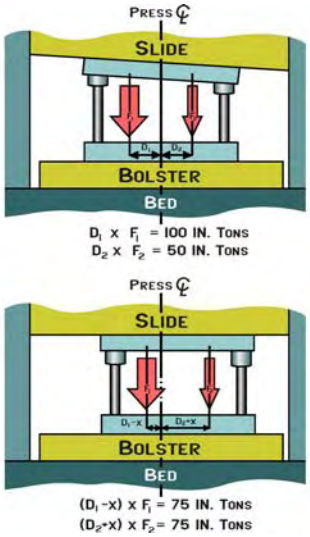

Figure #6

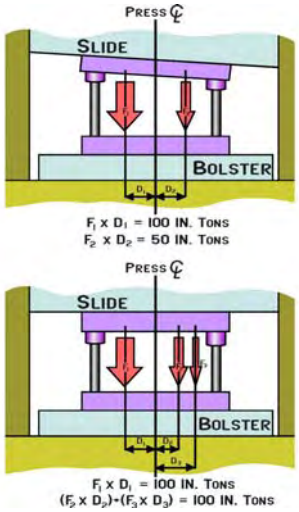

Figure #7

off-center load. Electronic tonnage monitors allow for very accurate positioning of the die to balance the load. The die is simply moved until the load readouts for the right and left sides of the press are matched. If the press is not equipped with tonnage monitors (as all presses should be), then we must rely on our calculations to properly locate the die. Remember to always center the **load** in the press and not the die set.

2) INTRODUCE A FALSE LOAD

Shifting the die on the bolster is a very simple solution for load balancing. However, not all presses have large enough bed area to allow sufficient shifting of the die to achieve a balanced load situation. In these situations we want to look at introducing a false load in the die to produce a balanced condition. As shown in Figure #7, the false load (F3) is installed opposite the highest load to eliminate the off-center load condition. Caution must be taken when adding the false load so that the press capacity is not exceeded. In many cases, it will be necessary to combine die shifting and the addition of a false load to achieve a balanced condition.

3) STEPPING PUNCHES

Another method that can be used to balance the off center loads, especially in dies with a large amount of perforating and cutting punches, is punch stepping. Figure #8 illustrates the amount of step for running mild steel. Stepping of the punches doesn't eliminate the force required to do the work but it does change the time at which the force is applied which can be used to balance off- center loading. Another benefit of punch stepping is that the impact load is reduced and shock and vibration go down as a result.

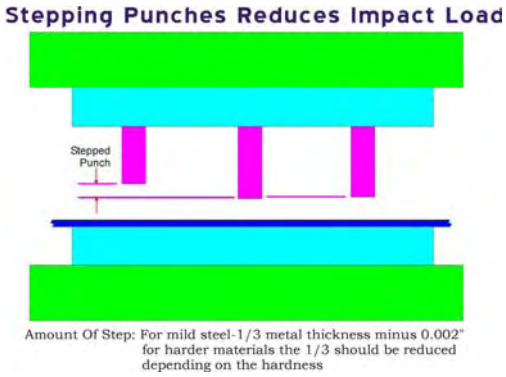

Figure #8

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HOW CAN PRESS SELECTION HELP ?

It's not often that we have the opportunity to buy a new press specifically designed to run one die. We generally are presented the problem of fitting a new die to an existing press. Therefore, we need to understand the press characteristics that will assist us in reducing the negative effects of off-center loading.

The most commonly used press in the world is the gap frame type machine with a single point connection between the crankshaft and the slide. This type of press provides good performance as long as the load in the die is centered directly under the connecting rod. Single operation dies make it easy to center the load under the connecting rod and this type of operation is most commonly performed on gap frame presses. However, as shown earlier, multiple stage tooling can make it very difficult to center the load, especially in a press with restricted bolster and slide areas which is normal on a single point gap machine.



Figure #9

As Figure #9 shows, high off-center loads on single point gap presses can produce disastrous results. The condition can become even worse because the slide is coming out of its guides as it approaches the bottom of the press stroke.

To improve the performance of this die, we must consider placing it in a press with two suspension points between the crankshaft and the press slide. By keeping the load between the connection centerlines, we will get increased resistance to slide tipping and lateral movement created by the off-center loads in the die. This point is illustrated in Figure #10.

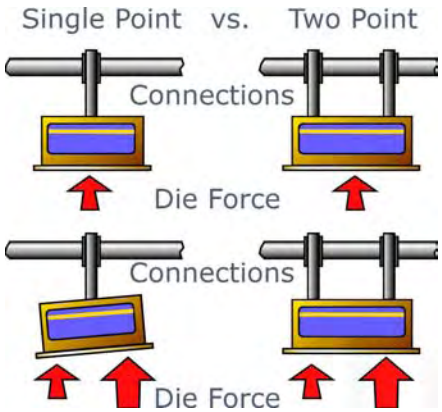

Figure #10

Let's assume that we have now decided to install our multiple stage tooling in a two suspension point press with the idea of improving the overall operation. We must now look at the spacing of the connections in relationship to the bed and slide areas. If the connecting rods are spaced closely together on a press with a large bed area (refer to Figure #11) then the possibility exists where loads in the die can be applied outside the centerlines of the connecting rods.

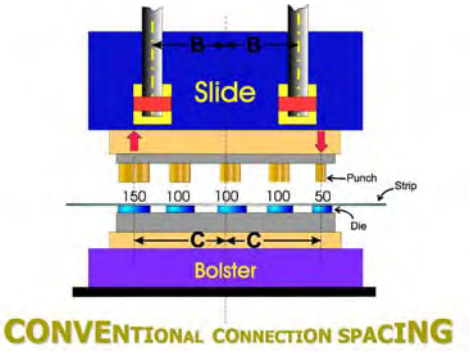

Figure #11

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This occurrence will result in excessive slide tipping and lateral movement and will provide unsatisfactory results.

Selecting a press that has wide spaced connecting rods (refer to Figure #12), will result in superior performance.

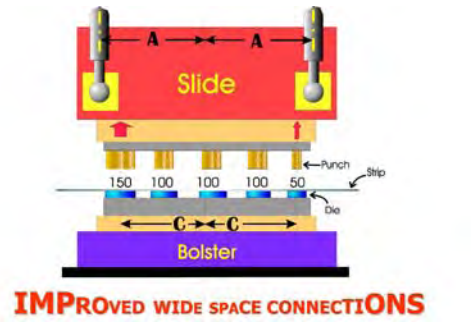

Figure #12

Another area of the press structure that has a direct relationship to is the overall bearing clearance and the clearance in the slide guide system. Figure #13 illustrates the bearing clearance points in most mechanical presses.

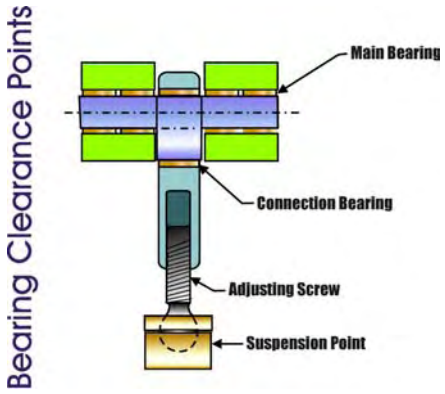

Figure #13

The lower the overall bearing clearance, the better it will resist the slide tipping and lateral movement. The slide guide system, as shown in Figure #14, must also be of low clearance as it is

the primary means of controlling slide movement. The press manufacturer will be able to give the values for total bearing and slide guide clearance. These values must be checked



Figure #14

and maintained on a regular basis or press and system performance will suffer.

Not all presses are manufactured to the same standards so it is imperative to know the characteristics of all presses. The ideal press would have wide spaced connections and low clearances. The chart in Figure #15 shows us the difference between two new presses as related to off-center load allowance. The press described by the top line has wide spaced connections and low bearing and slide guide clearances and provides excellent resistance to off-center loads while the press described by the bottom line does not. Remember, there are differences between press manufacturers and it behooves us to understand those differences if we hope to achieve the ultimate in productivity and quality.

Some manufacturers will try to compensate for design inadequacies in their press by installing devices attached to the slide that are meant to maintain slide parallelism by adjusting internal pressures through the working portion of the press stroke. This sounds great but seldom works and is difficult to maintain. We must remember that there is no substitute for good design.

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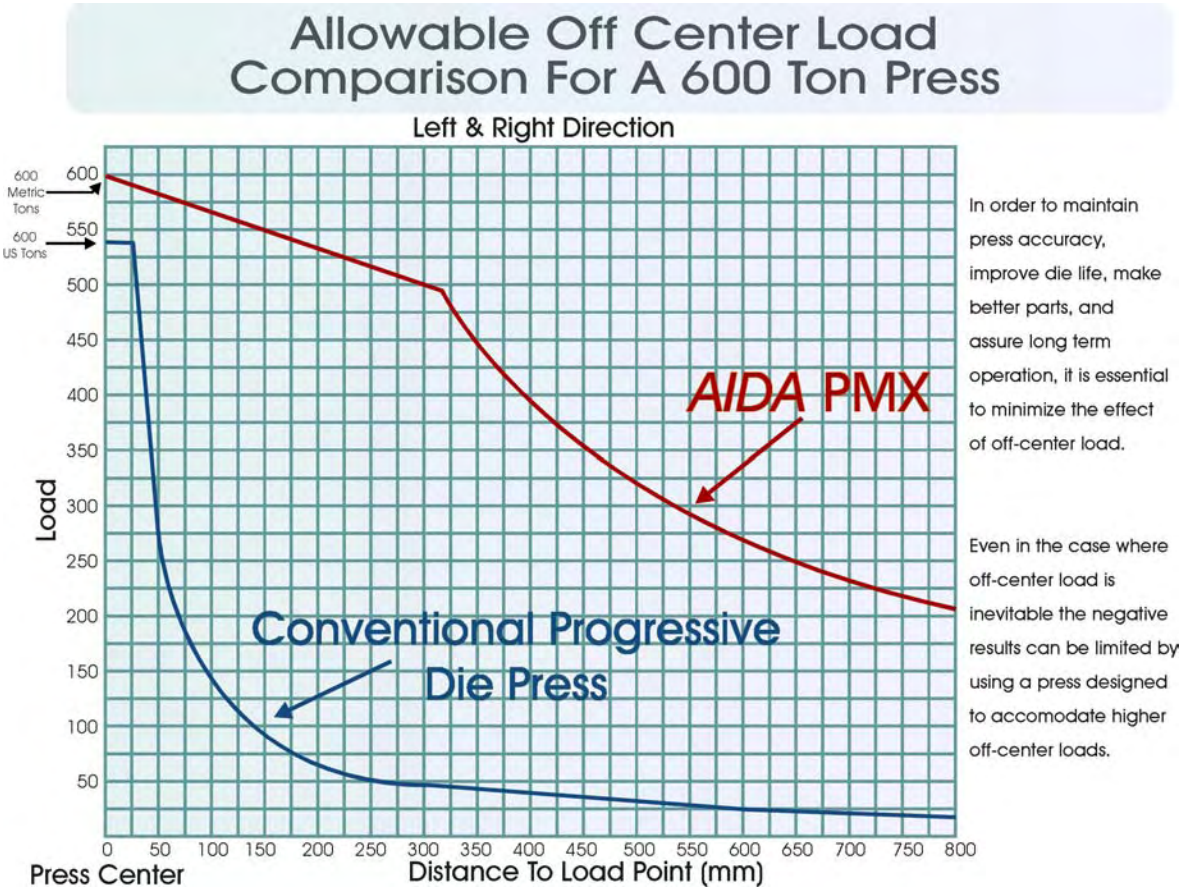
SUMMARY

We have examined many methods that can be used to reduce or eliminate the negative effects of off-center loads. Select those methods that will work in your individual production environment. This will depend on the types of dies and presses that you have as well as the education and skill levels of the personnel involved.

Always remember **"center the load and not the die set".**



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