AIDA

GLOBAL METALFORMING SOLUTIONS

AIDA-TECH

REVERSE TONNAGE

AIDA-Tech Volume Nine

REVERSE TONNAGE

(a.k.a.) SNAP THROUGH

The Not So Silent Press Killer

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Have you ever walked into a metal stamping facility and heard an operation that sounded like a shotgun blast every time the press passed through the bottom of its stroke? If so, you were witnessing the destruction of a press caused by reverse tonnage.

WHAT IS REVERSE TONNAGE?

Reverse tonnage, often referred to as “snap through”, is the undesirable result of cutting operations. When a punch breaks through the metal during a cutting or perforating operation, a negative force results. This is the moment in time when a press has built up enough force to exceed the shear strength of the material and the material fractures. The sudden release of stored up energy occurs in less than 20 milliseconds and the press components that are designed to function in compression are placed in tension while those that are normally in tension end up in compression.

WHAT CAUSES REVERSE TONNAGE?

The reverse tonnage is caused by cutting and blanking operations. The factors that determine the level of reverse tonnage are as follows:

- Material type, hardness and thickness
- Punch to die clearances and sharpness
- Amount of punch stepping or shearing of the punches and die
- Punch velocity when it contacts the material
- Amount of deflection in the press and die components
- Bearing clearances in the press

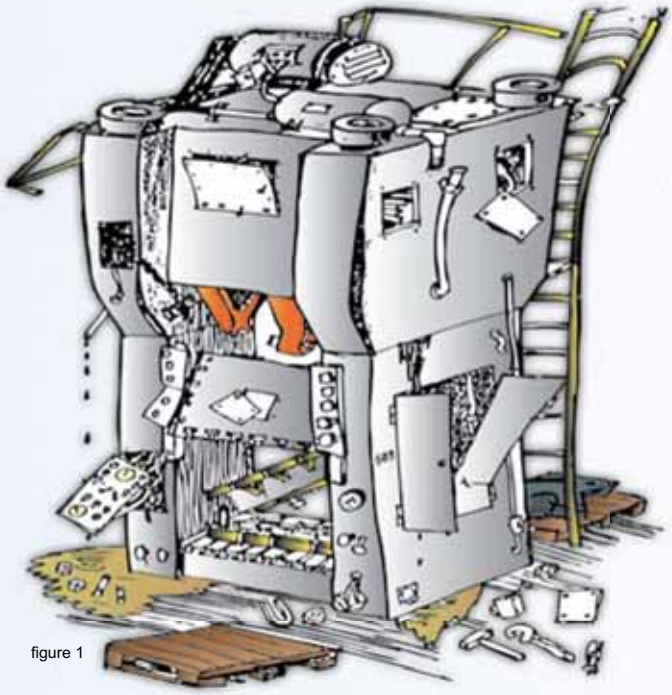


figure 1

Though this illustration is an exaggeration, it depicts many of the problems that occur on a press that is experiencing high reverse tonnage.

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WHAT ARE THE SYMPTOMS OF HIGH REVERSE TONNAGE?

Some of the symptoms of reverse tonnage are as follows:

- Very high noise level
- Loose bolts, air and hydraulic lines
- Recurring air and hydraulic leaks
- Electrical malfunctions
- Fatigue failure of press components, especially in the slide connection area but also main frame parts
- Premature wear of punches and die components
- Foundation issues
- Fatigue in operators feet, ankles, knees, hips and even resulting in back problems

HOW DOES REVERSE TONNAGE NEGATIVELY AFFECT A PRESS?

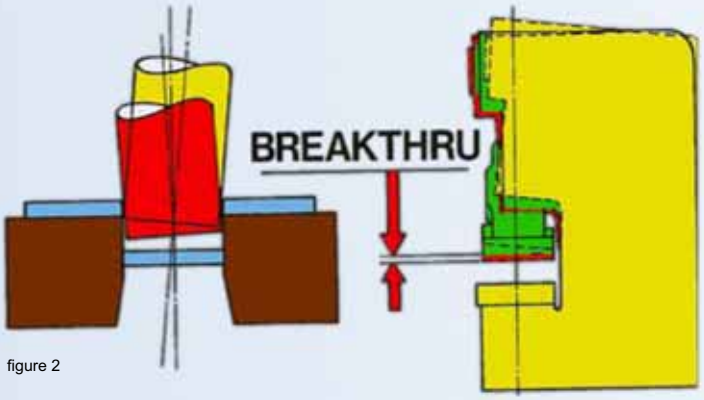
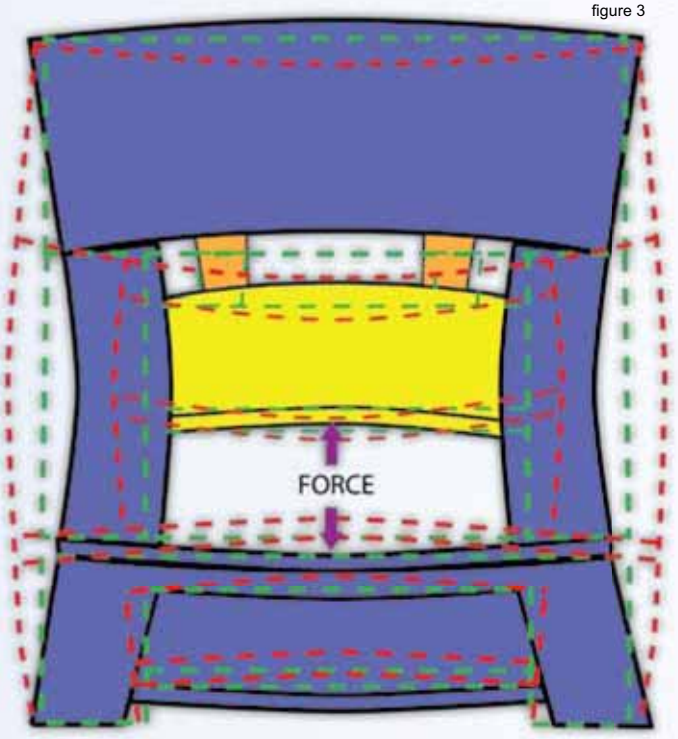


figure 2

In a gap press the frame opens up when load is applied. When the material fractures the frame snaps back but closes beyond its “at rest” position, as indicated by the red outline in the above illustration. High frequency oscillations of the press structure continue until all energy is dissipated. This violent action is occurring while the punch is in the die cavity and engaged with the material as shown in figure two. The punches not only oscillate vertically but also experience significant lateral movement that will not only cause premature wear but often breakage.

Excessive reverse tonnage can cause damage to major press parts such as the frame or suspension point components. This damage does not usually appear after a single press stroke but manifests itself over many cycles. High shock, vibration and component deflection levels cause fatigue in the press and tooling components resulting in failure.

figure 3



A straightside press reacts in much the same way as a gap frame press except that deflection of its components does not have the angular component present in the gap press frame. The blue structure in figure three illustrates a straight-side press under load. When the material fractures the frame response is illustrated by the red outline and is well past the “at rest” position illustrated in green. As with the gap frame press, the frame oscillates many times before reaching a stable condition. This flexing of the frame and suspension point parts is what causes material fatigue because it occurs over and over with every press stroke.

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WHAT IS AN ACCEPTABLE LEVEL OF REVERSE TONNAGE?

The conventional industry standard is to have presses designed to accept a reverse tonnage load that does not exceed 10% of the maximum forward capacity of the press. As an example, a 100-ton press will have a reverse load capacity of 10 tons. There are presses available that are designed to accept higher reverse tonnage loading. Twenty percent of the press capacity is not unusual and there are presses available that are rated up to 50% of the maximum forward capacity. The basis for this rating is dependant on the overall clearances, suspension point design and deflection characteristics of the press. To properly compare different press models requires close analysis of the guaranteed specifications and designs provided by different manufacturers.

HOW DO WE IDENTIFY THE AMOUNTS OF REVERSE LOAD IN OUR STAMPING OPERATIONS?

The only practical way to determine reverse load levels is to install tonnage monitors on the press. The monitor must have the capability to display load signatures that include reverse as well as forward tonnage. As can be seen in figure four below, the load signature of a progressive die will normally show an operation that is within the press reverse tonnage capacity.

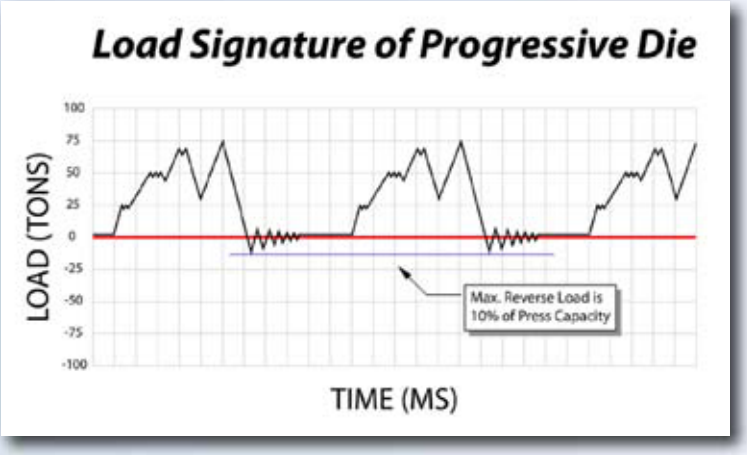


figure 4

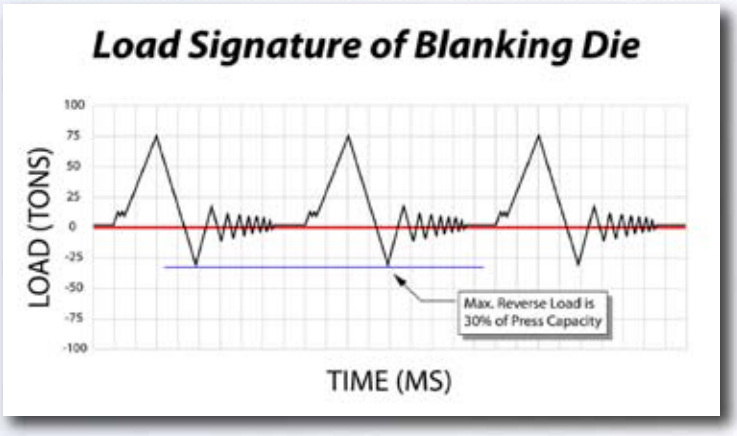


figure 5

The load signature shown in figure five above is for a blanking die. This signature is very simple to read when compared to a progressive die signature but the reverse load clearly exceeds the capacity of any standard press. Also note the oscillations of the press frame until the energy is dissipated. These oscillations increase in amplitude and duration as the reverse tonnage goes up. The oscillations represent the shock and vibration that are the greatest enemy of press and die life.

These vibration levels can be checked using an accelerometer that is placed at different locations on the press bed and then on the lower die set. Different structures have different levels of vibration that is acceptable. This is also true for presses, making it necessary to work with the manufacturer of the machine to determine what is acceptable. Also, even though the vibration level might be acceptable for the press it can still be too high for operators and the surrounding environment.

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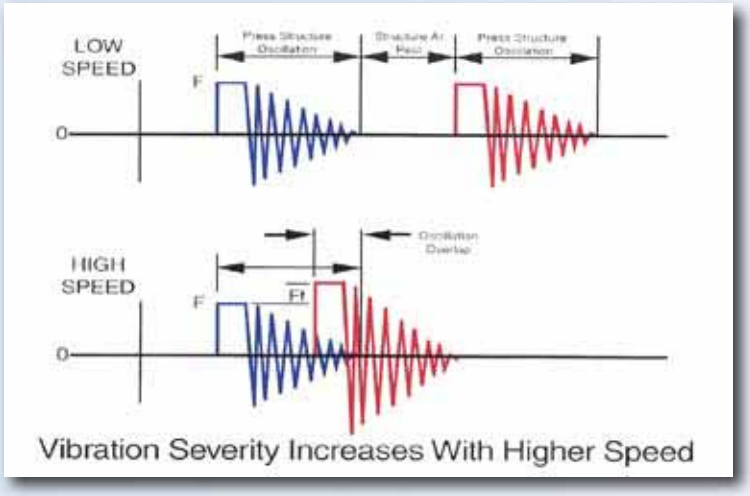


figure 6

Figure six above illustrates the negative impact that higher speeds can have on vibration levels. At higher speeds frame oscillations may not have dissipated before the punch comes down again and contacts the material. This causes a vibration oscillation overlap that will then cause the new vibrations to have even greater amplitude and become even more destructive.

WHAT STEPS CAN BE TAKEN TO REDUCE THE REVERSE TONNAGE IN BLANKING OPERATIONS?

Following are some measures that can be taken to reduce the effects of reverse tonnage:

1. **Change raw material to a softer and thinner type**

   - This is generally not possible because of the end-use requirement of the part being produced

2. **Limit the applied tonnage**

   - Keep punches and dies sharp
   - Use a punch to die clearance that provides the lowest force requirement to accomplish the cutting and perforating, however burr and flatness requirements on the finished part will at times dictate what the clearance must be.
   - Consider stepping punches, as shown in figure seven to reduce the load by 50% or more

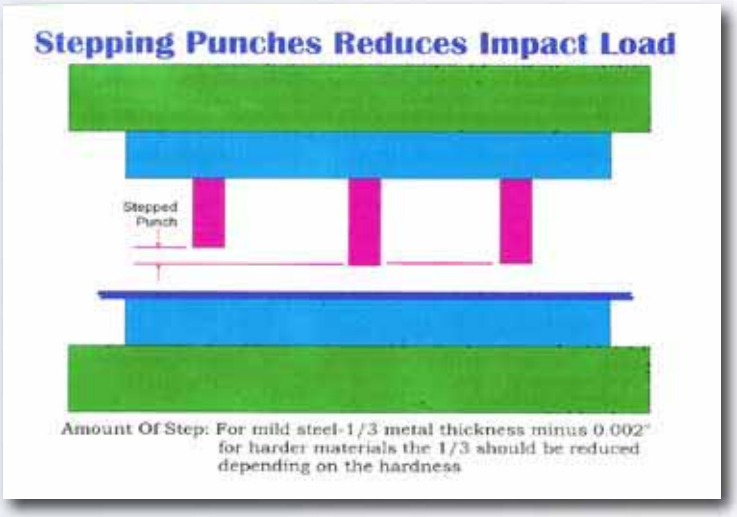


figure 7

Caution must be used with stepping punches in a progressive blanking die with many stations so that off-center loads are not created. The off-center loading, as shown in figure eight, can cause the upper die to move laterally in the direction of the first load and cause damage to punches and die sections.

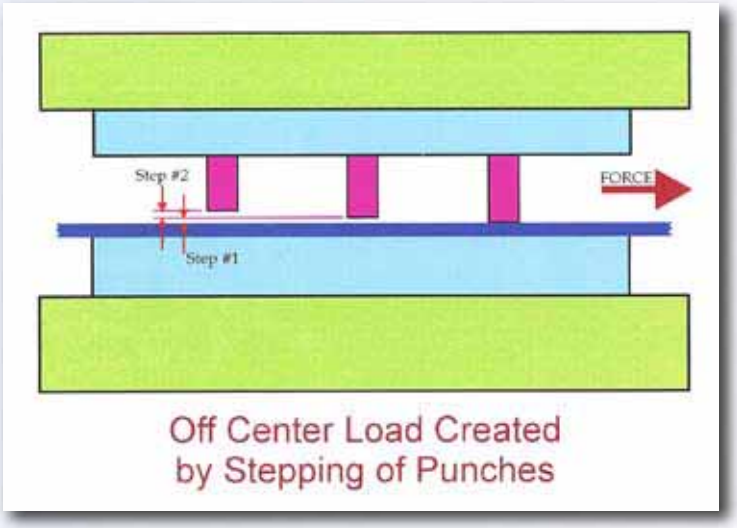


figure 8

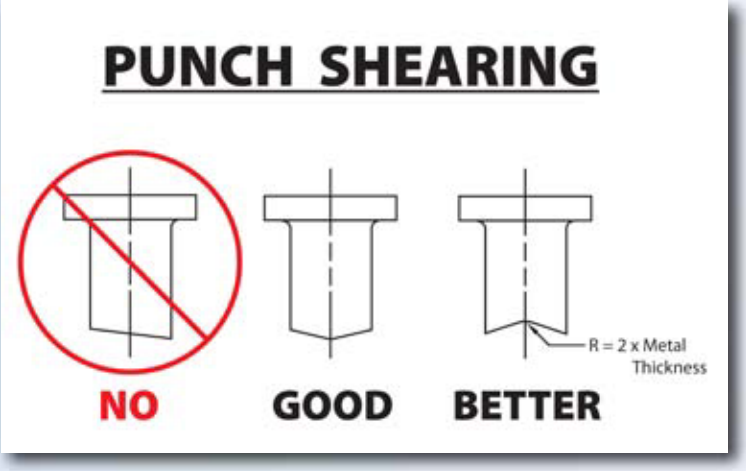


figure 9

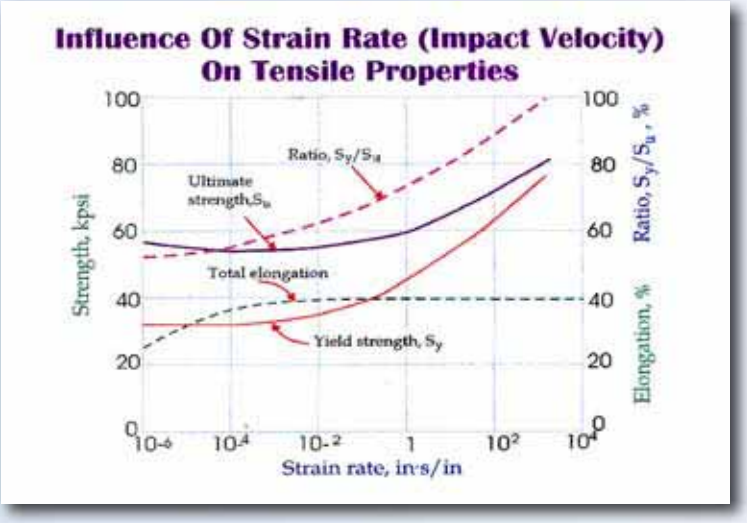


figure 10

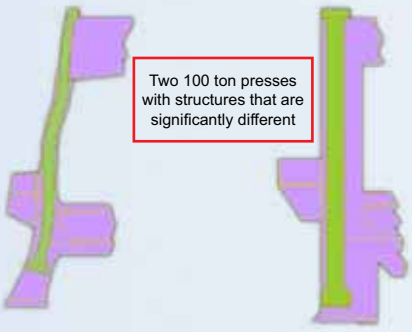


figure 11

- Consider grinding shear on the punches or die sections, as shown in figure nine, to reduce the forward load by as much as 33%.

Punches should be sheared if the slug is to be scrap, however, if the punch is for blanking and the part must remain flat then shear should be ground on the die section. Also, remember that grinding all the shear in one direction will create a lateral force on the punch that could cause excessive wear or chipping.

3. **Reduce the punch velocity**

- The velocity of the punch, as it contacts the material, plays a significant role in the effects of reverse tonnage. As the punch velocity increases so does the reverse tonnage as well as the shock and vibration. Figure ten, left, shows that as the strain rate (punch velocity) increases the shear strength of the material also goes up. As an example, blanking tonnage can more than double as press speed is increased from 100 to 400 strokes per minute.

- Slowing the press down (usually not acceptable), reducing the press stoke length or using a special link motion drive are all practical methods that can be adopted to reduce punch velocity.

4. **Reduce the press deflection**

- Deflection of the press and die components has a direct relationship to reverse tonnage. Reducing the overall deflection can be accomplished by placing the die in a significantly higher tonnage capacity press or by using a press that is designed specifically for blanking and perforating work.

- Using a higher tonnage capacity press has obvious drawbacks and is usually not the method that most stamping operations will use. However, as shown in figure eleven, component deflection can be limited by placing sufficient structure in the proper areas of the machine. The proper structure along with slide suspension points that

are designed specifically for blanking operations, will yield a machine that has a very high reverse tonnage capacity. Die structure and design are also important when trying to limit deflection. A thin die set placed on wide spaced parallels will produce a high level of deflection. If possible, blanking die sets should be mounted flat on the press bolster plate and parallels should be eliminated. However, this is not always possible so die sets and parallels should be substantial with the parallels mounted as close to the work area as possible.

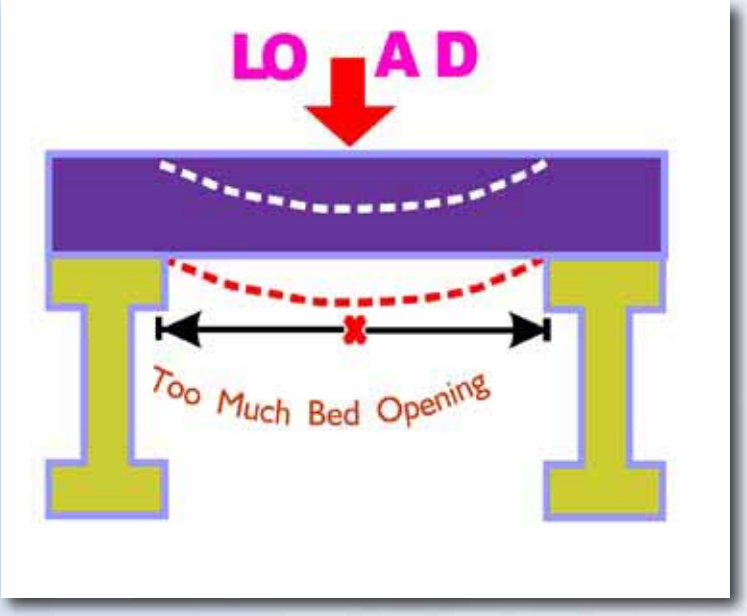


figure 12

Looking at figure twelve, we can see another issue related to deflection. Here we see a small, high tonnage die installed in a large bed press with the result being excessive deflection of the press components. Conventional presses have deflection ratings that are based on the load being equally distributed over two thirds of the bolster area. Placing a concentrated load in the large bed press causes the reverse tonnage to increase due to the increased deflection.

5. **Reduce the overall clearance in the press**

- As with deflection, overall bearing clearance is a significant contributor to the negative effects of reverse tonnage.

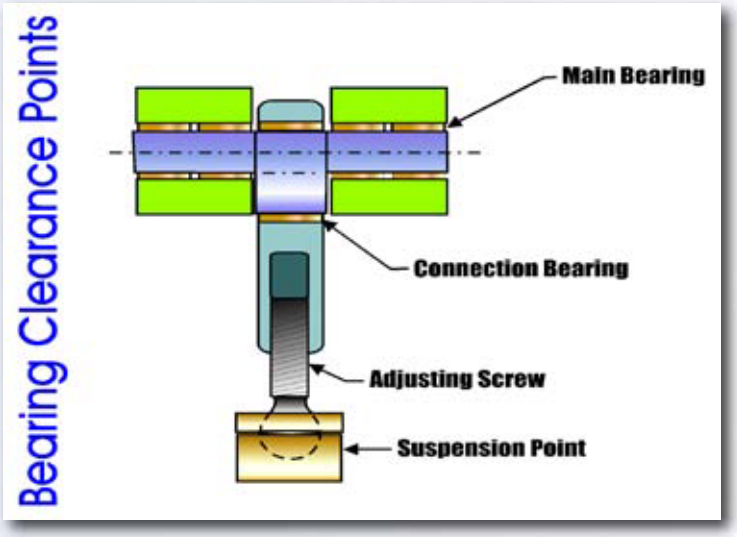


figure 13

Bearing clearance and deflection produce the over-travel of a punch into the die cavity once the material fractures. This over-travel is extremely detrimental to die life and part quality, as well as increasing shock and vibration in the press. Conventional presses tend to have a large amount of total bearing clearance so, if possible, it is wise to use a press specifically designed for blanking operations with bearings that have little or zero clearance.

6. **Use shock dampers**

- Hydraulic shock dampers, as shown in figure fourteen, have long been used on hydraulic presses to limit reverse tonnage. More recently, mechanical press users are reaping the benefits of this technology.

The hydraulic shock damper is effective up to a speed of nearly 100 strokes per minute and press capacity of 50 tons and larger (there is no upper limit). Shock dampers are designed to provide an upward counter pressure at the moment of material breakthrough. This resistance is generated by internal orifices that restrict the flow of oil out of the cylinder resulting in a cushioning effect.

Benefits of the shock damper include:

- Protects the press – reduces maintenance cost related to fatigue.
- Stamping at full press capacity – it is common to blank at up to 90% of the press tonnage capacity.
- Increase in die life – implementation of dampers dramatically increases die life.
- Reduction in foundation vibration – reports have shown a reduction in floor vibration of nearly 40%
- Noise dampening – noise levels drop significantly when dampers are employed.



figure 14

Actual Applications
400 ton capacity mechanical press

Without damper system

First stroke --------- 234 forward tons with 100 tons / 25% reverse load

Second stroke ----- 233 forward tons with 101 tons / 25% reverse load

With damper system

First stroke -------- 356 forward tons with 1 ton / 0.0025% reverse load

Second stroke ---- 359 forward tons with 1 ton / 0.0025% reverse load

1700 ton capacity mechanical

Without damper system

First stroke ------- 571 forward tons with 223 tons / 13.1% reverse load

Second stroke -- 588 forward tons with 215 tons / 12.6% reverse load

With damper system

First stroke ------- 769 forward tons with 38 tons / 2.2% reverse load

Second stroke ---- 775 forward tons with 36 tons / 2.1% reverse load

figure 15

Although the forward tonnage increases with the use of shock dampers, the reverse tonnage reduction will increase die life, improve part quality and save the press from serious damage. These examples show operations that were or would have caused serious problems. The installation of shock dampers nearly eliminated the reverse tonnage and the resulting damage.

Figure sixteen shows a typical installation of four shock dampers on a straightside press. From this we can see that the dampers consume bolster area that cannot be used as die space. So the slight increase in forward tonnage and the loss of usable die space are the two negative factors that must be considered when installing shock dampers.



figure 16

CONCLUSION

Reverse tonnage (snap through) in cutting, perforating and blanking operations is a problem that must be addressed. High, unabated reverse tonnage and the shock and vibration that accompany it can destroy dies and presses, crumble floors, crack foundations, shake building structures or even cause health problems for operators and other personnel working in the area. It can also have a negative impact on residences and other businesses in the immediate area.

Fortunately, the selection of the press and its specifications, as well as the use of shock dampers, can reduce or eliminate the problems associated with high reverse tonnage. By simply understanding and then dealing with reverse tonnage, production part quality will improve, die life will go up, press maintenance costs will go down and operation personnel will have fewer health problems.



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