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DAMPING AND CANCELLATION DEVICES TO REDUCE PUNCH PRESS NOISE

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Many sources of noise may be present during the operation of a typical industrial power press: clutch noise, tooling impacts, bearing rattles and also noise from ancillary sources such as workpiece vibration, feed mechanisms and air exhausts and component blow off nozzles. The basic, and usually dominant, source, however, during a material cutting operation (piercing, blanking or cropping) is that related to the sudden release of the strain energy stored in the press structure which occurs as the workpiece material fractures.

The press structure, having finite stiffness, acts like an enormous spring; it is loaded relatively slowly as the punch contacts the workpiece which deforms first elastically then plastically and begins to shear (see fig. 1). As material shearing continues, the material cross-sectional area is progressively reduced until a point is reached where the remaining material can no longer support the applied load. The material then suddenly fractures and the structure snaps back unrestrained and oscillates transiently around its equilibrium position until all the energy has been dissipated. The transient vibration radiates noise and can also lead to high rates of press wear due to the backlash impacts which occur in the drive linkage. It has been shown (1, 2) that the noise energy radiated from a press can be directly related to the rate of change of the force which is applied to the structure.

Noise and Vibration Control

An effective form of noise control is to smooth the unrestrained structural unloading and release the stored strain energy slowly. Figure 2 shows a smoothed force history and its effects of frame strain and noise. Noise radiation was reduced by 10 dB.

There are basically two ways by which the structural unloading rate can be smoothed; by initially applying a smoother forcing function and by reducing the structural response. A smoother forcing function can be achieved by tooling modifications which inhibit the sudden material fracture and give progressive cutting or shearing of the material. The use of sheared punches or piercing with reduced punch/die clearances, for example, are effective in this respect. In practice, however, these methods are often unacceptable because of adverse effects on component quality, production rates, tooling costs, etc. Reduction of the structural response is a relatively new idea in relation to power presses and involves the use of an additive damping or cancellation device to resist the sudden springback of the frame. Conventional damping treatments would be of little use in this situation (except for certain types of presses constructed from thin panels) as the inherent structural damping levels are already high; $\eta \approx 3 \times 10^{-2}$ - typical of bolted/fabricated machinery of this type.

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Press Damping and Cancellation Systems

To date a number of systems to arrest the rapid springback of the press structure have been tried by various manufacturers and researchers - with only limited success being reported. The problem is that to be effective the device must catch the structure immediately after the material fractures, leaving the working part of the stroke unaffected. Disastrous consequences may result if the structure is blocked too early as the press could be seriously overloaded.

In its simplest form a damping or cancellation device acts passively, systems tested have been both mechanical blocking systems or hydraulic 'shock' absorbers. The system is set in parallel with the tooling to be contacted by the ram as it is driven downwards. Height setting with this type of system is extremely critical as contact with the device must be made at the instant of material fracture. This critical height setting requirement renders this type of system impractical for industrial use unless the press capacity is sufficient to cope with the sum of both the tooling and damping loads.

A semi-active system overcomes the critical height setting problem and typically consists of a hydraulic cylinder continuously in contact with the moving ram (during the working part of the cycle). During the material load and shearing phase the system is soft and offers minimum resistance to the motion of the ram. Upon material fracture the system must change immediately from soft to hard to oppose the structural springback. A number of methods have been tried to effect this system change, usually by the use of a flow sensitive valve or electrically controlled solenoid valve to either block the flow or switch the system over to a higher pressure. The system must have a very rapid response, however, as structural unloading rates are typically in the order of 0.5 to 2 ms.

Experimental Work

Experimental work at the ISVR has been conducted on an ex-industrial 25 tonne 'C' frame press, shown in fig. 3. In the course of this present investigation, two experimental damping systems have been fitted to this press: a mechanical system consisting of a rubber buffer opposing the punch load (fig. 4) and a hydraulic damping system (fig. 5).

Each system was mounted beneath the press bed and acted via a pin directly under the punch. This is the ideal location as far as the operation of a damping or cancelling device is concerned being directly at the point of application of the forces. It is, unfortunately, a rather unsuitable location in practice as the activating pin prevents the ejection of the blank through the die. To be practical such a system would have to be modified to operate via pins to some other part of the press structure or tooling.

Both systems were effective at damping the press vibration and reducing noise, as shown in figs. 6 and 7, but the rubber buffer system, being purely passive, led to substantially increased press loading if contacted too early. This very simple system did, however, give a valuable insight into the problems and parameters involved with these types of devices.

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The hydraulic damping system consisted basically of a cylinder exhausting through a surge type of flow control valve. The cylinder was in contact with, and opposing, the punch movement throughout the material cutting process. The system was designed to offer minimum flow resistance whilst the material was being cut but to resist the sudden surge of flow associated with the structural springback. By adjusting the flow through the control valve the system could be set to operate effectively and smooth the structural unloading rate with only a minimal increase in total press load.

Parallel investigations are also being performed on a 200 tonne straight-sided press at CETIM in France.

Conclusions

The experimental damping system fitted to the ISVR press even in its initial very basic form has shown that substantial reductions of noise (~ 10 dB) can be attained. Further development and experimental work is required, however, especially in relation to the positioning of the damping system on the press and to ensure excessive press loading does not occur.

References

1. EVENSON, H.A. A fundamental relationship between force waveform and the sound radiated from a power press during blanking and piercing. J. Sound Vib. (1980) 68(3), 451-463.
2. BURROWS, J.M. 1978 The influence of tooling parameters on punch press noise. M.Sc. Thesis, ISVR, University of Southampton.

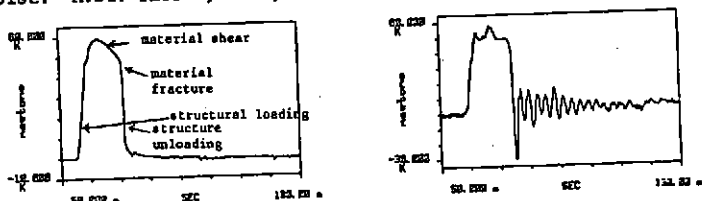


Fig. 1 Normal blanking operation

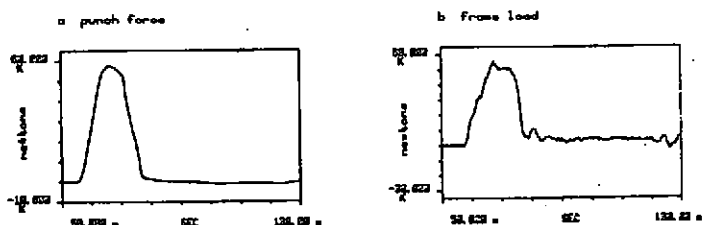


Fig. 2 Smoothed blanking operation

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Fig. 3
Experimental
press at ISVR

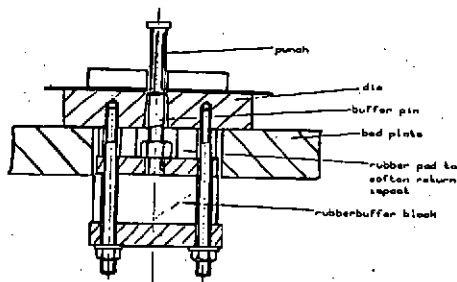
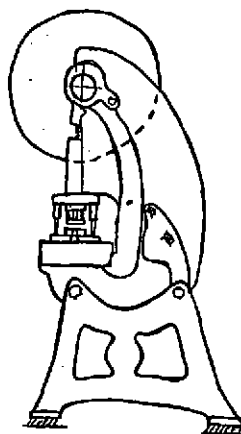
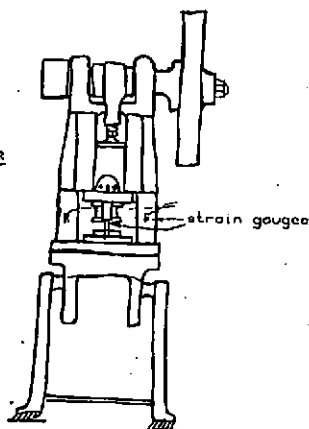


Fig. 4 Rubber buffer

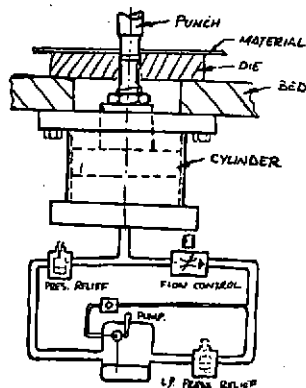


Fig. 5. Experimental hydraulic damping system

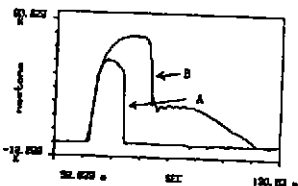


Fig. 6 Punch force:
A - normal operation
B - with rubber buffer



Fig. 7 Punch force:
A - normal operation
B - with hydraulic damper