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RESUME OF RESEARCH ON NOISE GENERATED IN IMPACT FORMING MACHINES AT THE UNIVERSITY OF BIRMINGHAM, 1971 - 1978

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Introduction

The present paper surveys the major projects on impact noise generated in forming machines supervised/directed by the authors during the period 1971-1978. The ultimate aims of these projects are the development of computer aided techniques for the acoustical and dynamic design and assessment of machines, the experimental verification of such techniques and their application to industrial conditions.

The present summary will confine itself very largely to fundamental aspects of the work, in particular to that relating to the mechanism by which noise is generated and emitted by the process and the machine structure and the computer aided predictions of these.

NOISE GENERATED BY FORMING PROCESS

Three different effects have been recognised and investigated:

1. Deceleration Effect: This effect has been measured in full-scale forging hammer tests, under conditions corresponding to coining operations (1). Hodgson (2) developed a technique for predicting the noise pulses due to deceleration of solid cylindrical tubs. Fig.1 shows the dimensionless sound pressure as a function of time, for three values of the duration of the non-dimensional deceleration pulse, and for three space co-ordinates of the measuring microphone, as multiples of the cylinder heights. The pulse intensity in any other position can be determined with the aid of a "coefficient of directivity", assigned to each space co-ordinate point. An extension of this theory, due to Francis (3) allows the prediction of the sound pressure caused by the deceleration of non-cylindrical bodies.

2. Air Ejection Effect: This was first investigated by Bannister and Trengrouse (4), and refined by a model evolved by Francis (3). A comparison of experimental results with these two models is shown in Fig.2. Francis' model can also cope with conditions in which the approaching surfaces deviate from the flat.

3. Billet Expansion Effect: This was first investigated by Hodgson and Bowcock (5) who evolved a theory for its prediction. Fig.3 shows a typical variation of the sound pulse in the initial and terminal stages of the billet deformation.

The question arises as to relative importance of these three effects in comparison with the noise generated by structural "ringing". Theoretical work predicts and experiments confirm (6) that, under the conditions considered, which correspond to the simple upsetting of cold billets by flat dies, the sound pressure level due to structural ringing is about 6 dB above that of the deceleration effect. However, theoretical and experimental work has so far confined itself to the simplest practical conditions. It is by no means certain that under realistic hot forming conditions - when hot billets are formed in partially closed cavities and flash is extruded from a rapidly narrowing gap at high speeds, and when "explosive" lubricants are used for easing the ejection of the component - the sound peaks, produced before ringing has commenced, may not be of very great importance.

NOISE GENERATED BY STRUCTURAL RINGING

Fundamental work on the ringing of structures aims at the prediction of their acoustic emission on the basis of design drawings and the development of a computer aided design procedure with which the structure can be improved, and optimised. Such a procedure involves the following stages: 1. Prediction of the structural modes of vibration; 2. Prediction of the modal content of an impulsive response of the type arising in forming operations; 3. Calculation of the sound field.

The first attempt for predicting the acoustic performance of hammer structures was carried out by representing a laboratory drop hammer by a multi-degree of freedom non-linear system (6). This permitted the calculation of the peak sound pressure and that of the acoustic energy for arbitrary operator positions. In addition, the model also gave insight into relation of the peak sound pressure and the process efficiency. Subsequent work on more general aspects of forming efficiency and its relation with the structural dynamics/acoustics has shown, and this has been confirmed in full scale tests, that there is a linear relationship between the sound pressure level and the forming load and that the rate of variation of the former as a function of the latter is a unique measure of the acoustic characteristics of the structure (8).

The lump constant parameter approximation of structures is of only limited usefulness and more recent work involves the use of a comprehensive finite element program for predicting the normal modes of the machine, the natural frequencies, the energy content of impulsive response, etc. (9). For instance, Fig.4 shows the model shapes of a particular structure and Fig.5 the relative energy content of these when excited by a specified impulsive load.

The latest development of this technique (3, 10) allows the prediction of the sound energy radiated, the distribution of the sound pressure level, either for a free field or by including the reflections from the foundation, a typical example being shown in Fig.6 for two planes of symmetry of a particular structure.

RELATED WORK

This covers an exploration of the forming efficiency as affected by the dynamics of the structure and the process parameters, is a problem of considerable complexity which is outside the scope of this paper (11). In some cases an improvement of machine dynamics can result in not only a better utilisation of forming energy but also a reduction of the sound energy radiated (12). This is generally achieved by a matching of impacting masses, or an elimination of backlash. In the end, however, well designed machines involving impact phenomena are bound to generate some noise and this can be reduced only by special means. Shields, not necessarily of the conventional type, but utilising inertial effects can be used for minimising vibrating surfaces exposed to the free air (6). The sound pressure level is affected also by atmospheric conditions, such as the presence of watermist in air (13). Finally, by reducing the severity of the impact, by reducing the deceleration of moving masses by cushioning with hydrostatic films, etc., the acoustic performance of machines can be greatly improved.

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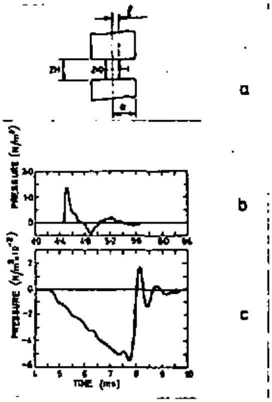


FIG. 1

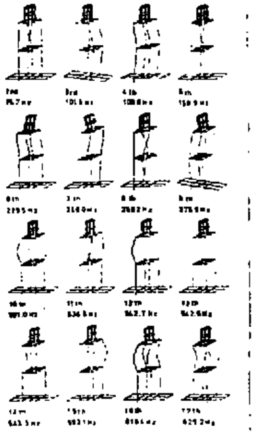


FIG. 4

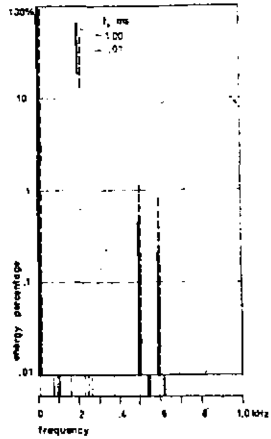


FIG. 5

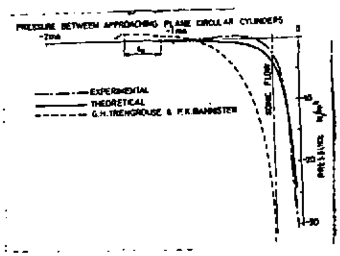
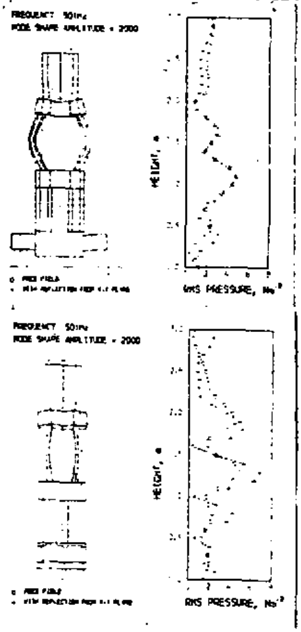


FIG. 2



(a)

(b)

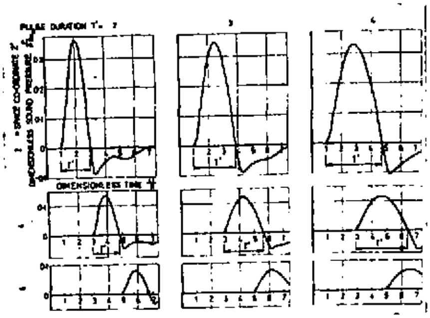


FIG. 3

FIG. 6