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RESPONSE OF A RECESSED PRESSURE TRANSDUCER
WITH A MILLISECOND PRESSURE STEP INPUT

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RESPONSE OF A RECESSED PRESSURE TRANSDUCER WITH A MILLISECOND PRESSURE STEP INPUT

ABSTRACT

All too often, dynamic pressure measurements are made with the sensitive part of the transducer, the diaphragm, recessed and away from the pressure source. If the transducer has been recessed far enough from the pressure source, an invalid pressure measurement will result. To explore the effect of recessing, the Reynolds* pneumatic accelerator was used to produce a pressure step with a rise time from 0.5 to 2 ms.

INTRODUCTION

To obtain valid pressure data a diaphragm should always be mounted flush at the point where the pressure measurement is to be made. However, this is not always possible. Thus, any cavity or connecting tubing will degrade the transducer's performance and lead to erroneous data.

In Ref. 1 a shock tube was used to produce a pressure step with a relatively fast rise time in the microsecond and nanosecond regimes. To see if the same effect is present with a slower pressure pulse, the Reynolds pneumatic accelerator was used to produce a pressure pulse with a rise time of 0.5 to 2 ms with essentially no dwell time.

TEST SET UP

The accelerator operates as follows: A mass is propelled down a barrel by air pressure (Fig. 1). As the mass moves down the barrel, air is pushed out the two vents near the end of the barrel until the mass reaches and closes the vents. Then, if the end of the barrel is closed by a transducer adaptor, air will be trapped and compressed to a high pressure.

*Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Atomic Energy Commission to the exclusion of others that may be suitable.

Fig. 1. Reynolds pneumatic accelerator with pressure transducer.

The amount of compression depends on the velocity of the mass and the volume of air being compressed. The velocity of the mass is changed by air pressure applied to the mass, and the volume is changed by moving the transducer adaptor closer or farther from the vents. By experimenting with these two parameters various pressures and rise times can be obtained.

To recess the transducer, circular flat plates of different thicknesses(L) were placed in front of the transducer (Fig 2). This plate had a hole (D) through the center that was either equal to, or one-half of, the transducer diaphragm diameter. The two diameters used were 0.22 in. and 0.11 in. wide. The 0.22-in. diameter was equal to that of the Kistler pressure transducer model 603A. This transducer was used for all the tests.

For each test an input plate of a different thickness was attached to the transducer adaptor, in effect, recessing the transducer.

Three different input pressures were used for the test: 500, 1000, and 2250 psi. The compression area and the air pressure applied to the mass remained the same for each test (Fig. 2). This gave the same input pressure for each test, regardless of the pressure transducer recessing.

RESULTS

Figures 3 through 8 show the effects of the recessing at three input pressures and two diameters. The first oscilloscope trace in each figure shows the pressure transducer flush; the rest of the traces show the various degrees of recessing.

Summary of Figs. 3 and 4

At 500 psi the effect of recessing seems to be negligible for a pressure pulse with a rise time of about 2 ms. Valid data can be obtained with the transducer recessed up to 1 in. Only a small distortion is seen in the pressure trace in Fig. 4f.

Fig. 2. Schematic showing how plate recesses transducer.

Fig. 3. Scope traces: 500 psi input pressure, $D = 0.22$ in.

Fig. 4. Scope traces: 500 psi input pressure, $D = 0.11$ in.

Fig. 5. Scope traces: 1000 psi input pressure, $D = 0.22$ in.

Fig. 6. Scope traces: 1000 psi input pressure, $D = 0.11$ in.

Fig. 7. Scope traces: 2250 psi input pressure, $D = 0.22$ in.

Fig. 8. Scope traces: 2250 psi input pressure, D = 0.11 in.

Summary of Figs. 5 and 6

At 1000 psi the effect of recessing becomes a little more apparent as the rise time decreases. At an L/D ratio greater than two (Figs. 5e and 6d) the pressure trace begins to become distorted and the results questionable. As the L/D ratio increases, the pressure measurement loses validity.

Summary of Figs. 7 and 8

At 2250 psi the effect of recessing is apparent, and for an L/D ratio greater than two the indicated pressure is significantly less than that obtained in the flush position. The rise time here has decreased to 0.5 ms, and an additional effect is seen. In Figs. 7c and 8c increased pressure is indicated when the oscilloscope trace is compared to the transducer in the flush position. This increase is possibly due to the shorter rise time and the large area ratio between the barrel and the diameter of the hole recessing the transducer (3.0 in. for the barrel vs 0.22 or 0.11 in. for the hole). This same effect is apparent when the pressure step has a rise time in the microsecond and nanosecond region.¹

CONCLUSION

After looking at the six figures it is apparent that recessing does affect the pressure measurement. The amount of the pressure measurement effect seems to be a function of the L/D ratio as well as a function of the rise time of the pressure step. For an L/D ratio larger than two, the pressure measurement is questionable.

There are some tests when recessing cannot be avoided; therefore, a good rule is to keep the hole diameter as large or larger than the transducer diaphragm and to limit the amount of recess to a depth of one diameter.

1. W.M. Shay, The Dynamic Effects of a Pressure Transducer Due to Recessing, Lawrence Livermore Laboratory, Rept. UCRL-51156 (1971).

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