

Vibration	Abnormal Vibration of Flexible Tube due to Pressure Pulsations in Piping	Reciprocating Machinery
Nonlinear		

Object Machine

Fuel piping system for Diesel engine

Observed
Phenomena

A bellows type flexible tube connecting a Diesel engine and its fuel piping was broken since vibrations with an amplitude of several cm generated, when the engine rotating speed reached a certain value

Cause Estimation

The following three causes were considered:

- (a) Resonance of flexible tube caused by exciting force of engine vibration
- (b) Flutter in an elastic tube represented by a cantilever elastic tube
- (c) Parametric excitation vibration that occurs due to periodic fluctuations of the rigidity of flexible tube caused by pulsations of inner pressure

Analysis and Data
Processing

Results of investigations have clarified the following points:

- (1) Abnormal vibration suddenly generated when the rotating speed of an engine reached a certain value. Its vibration amplitude was fairly constant.
→ Not resonance in item (a) above.
- (2) Flow velocity in the piping was the order of several cm/s.
→ The flow velocity generated is far from flutter velocity item (b) above.
- (3) In the piping, there is large pressure pulsations called "spill". This engine has six cylinders, therefore pressure pulsations with three times frequency of the engine rotating speed generated. The frequency of tube abnormal vibrations is 1/2 of t pressure pulsations frequency, and increases associated with the increasing engine speed.

From the above (1) to (3), the cause of this abnormal vibration is determined by the parametric excitation vibration in item (c) above.

Countermeasures
and Results

In order to mitigate pressure pulsations, the piping system was provided with an accumulator whose frequency was tuned to those of the pressure pulsations within the service rotating speed range.
Taking the above countermeasures, the pressure pulsations in the piping decreased to about 1/20, thus the abnormal vibrations eliminated completely.

Lesson

Vibrations may occur in unexpected places due to unexpected reasons, so that it is necessary to eliminate as far as possible any sources that may cause vibration, although they do not seem to be directly related thereto.

References

Nothing in particular.

Keywords

Flexible tube, parametric excitation vibration, pressure pulsation, flow induced vibration

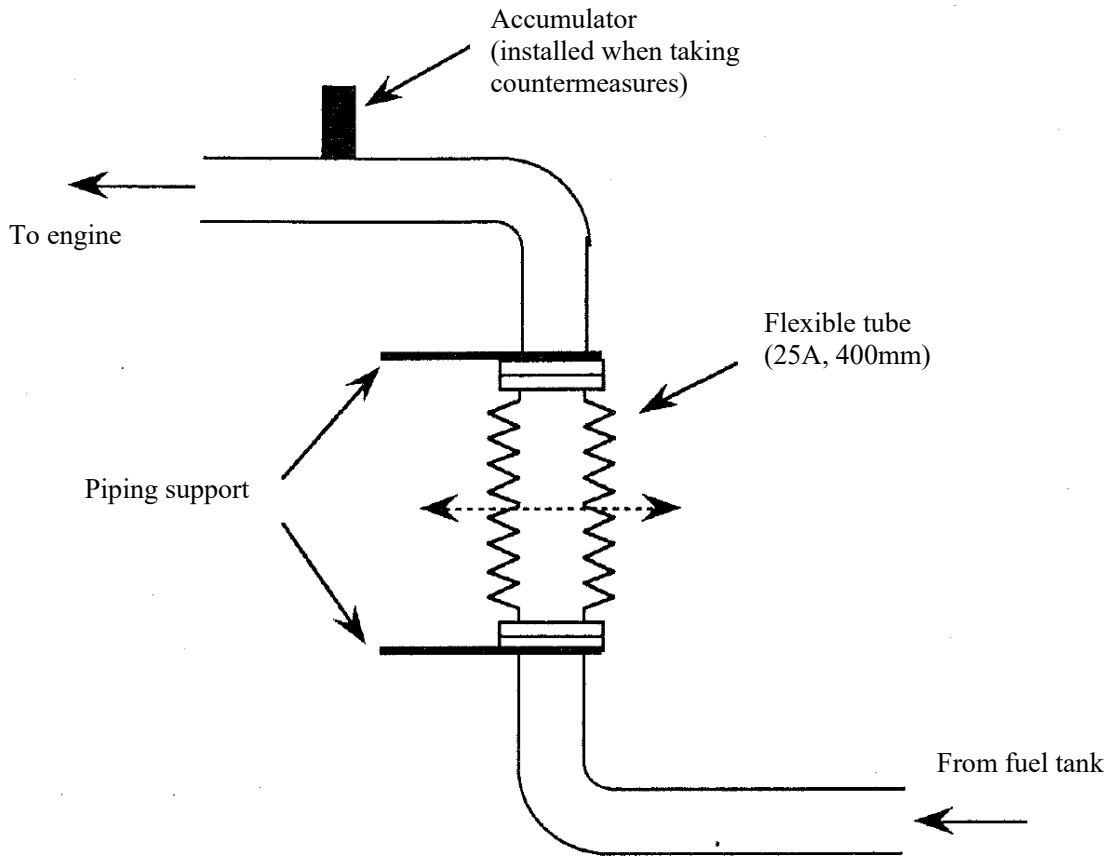
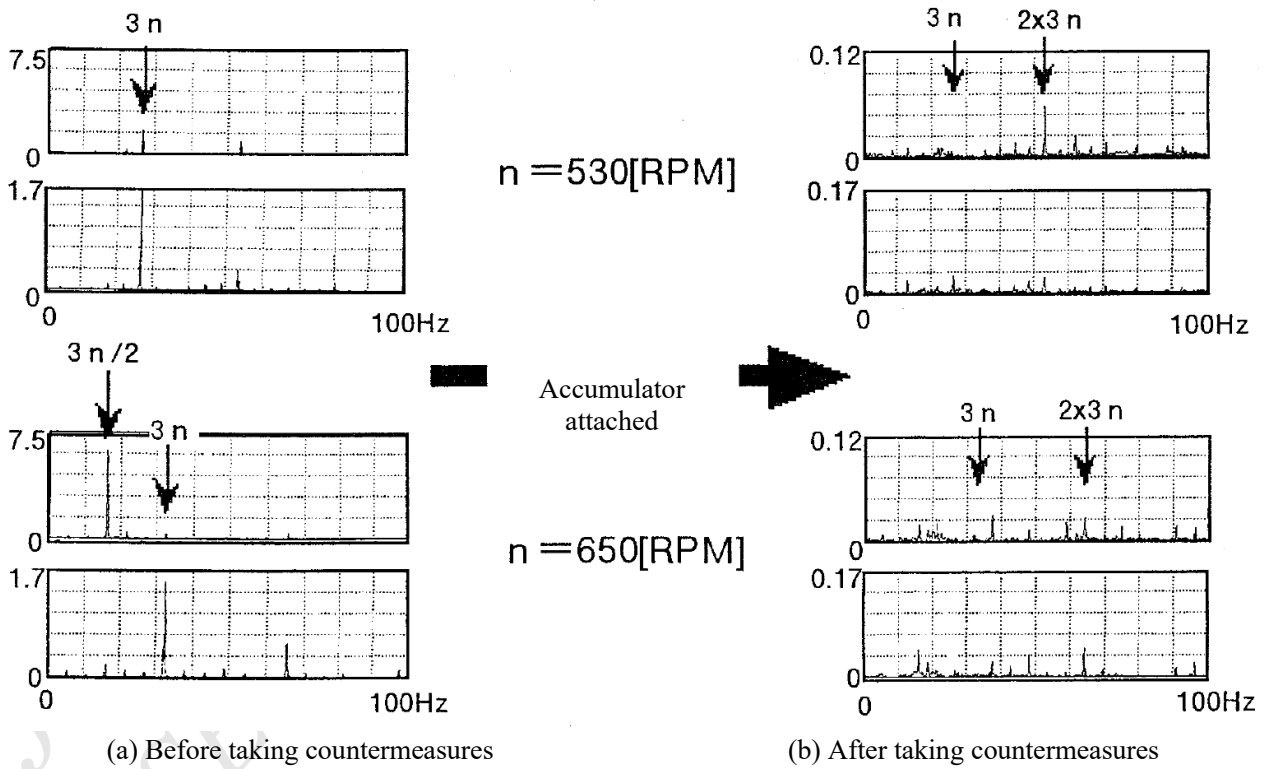


Fig.1 Schematic diagram of piping system



Upper column; vibration amplitude (half amplitude) [mm]
 Lower column; pressure pulsation (half amplitude) [kgf/cm²]

Fig.2 Vibration and pressure pulsations of flexible tube before and after taking countermeasures