Vibration	Vibration of Downstream Piping of High Pressurized Pump	Plant
Self-Excitation Forced Vibration		

Object Machine

Downstream piping of high pressure centrifugal pump (total head 1,000m)

Observed Phenomena

During commissioning, vibrations occurred on the discharge side piping of a high pressure pump. Also, after injecting gas in the piping downstream, piping vibrations were observed further downward.

Cause Estimation

(1) The first vibrations were self-excited vibrations associated with mini-flowrate operation region of the pump.
(2) The second vibrations were forced vibrations due to a gas-liquid two-phase flow.

Analysis and Data Processing

(1) The relationship between the pump flowrate and vibrations on the discharge side piping is shown in Fig.1. It is observed that decreasing the pump flowrate causes the amplitude to start increasing at a rate of 11m^3/h or less, and vibrations reached the maximum amplitude of 1,016μm$_{p\text{-}p}$.
(2) Frequencies for vibrations to start were constant at about 14Hz, irrespective of the pump flowrate.
(3) After injecting gas in the piping downstream of the pump, large piping vibrations in the vicinity of the heating furnace located on the pump downstream were observed. Fig.2 shows the relationship between the gas flowrate and piping vibrations, which confirmed that increasing the gas flowrate causes the piping vibrations to increase. On the other hand, no clear correlation was identified between the liquid flowrate and the vibration value.
(4) Frequency of the piping vibrations that appeared at the inlet of the heating furnace was about 4Hz, whose amplitude varied irregularly at an interval of several seconds.

Countermeasures and Results

(1) Judging from the pump performance curve and the occurrence condition of vibrations, it was found that vibrations of the discharge piping occurred in the region where the pump performance curve has a positive slope. Thus, in consideration of self-excited vibrations due to surging and the like, the minimum service flowrate was changed from 9 m^3/h to 12 m^3/h.
(2) As for vibrations of the piping due to gas inflow, the flow pattern was of an intermittent flow, thus, it was understood that an excitation force was applied to the piping when the liquid phase collided with the piping bend. The calculated excitation force applied to the piping by the gas-liquid two-phase flow was relatively small (100kgf or less), thus it was judged to be able to adequately reduce the vibrations by the piping support. As an emergency countermeasure, the piping was fixed by a chain block, resulting in the decrease of vibration values to 1/3 to 1/4 of original value.
(3) As a permanent measure, the piping will be fixed by a strong support.

Lesson

Surging will not necessarily occur in the positive slope area of a pump performance curve. However, as the operating point is not stable, it is advisable to avoid as much as possible such a region for operation. In case of piping for gas-liquid two-phase flow, it is better to firmly support the piping system in consideration of the impact of thermal expansion.

References

Nothing in particular

Keywords

Surging, gas-liquid two-phase flow

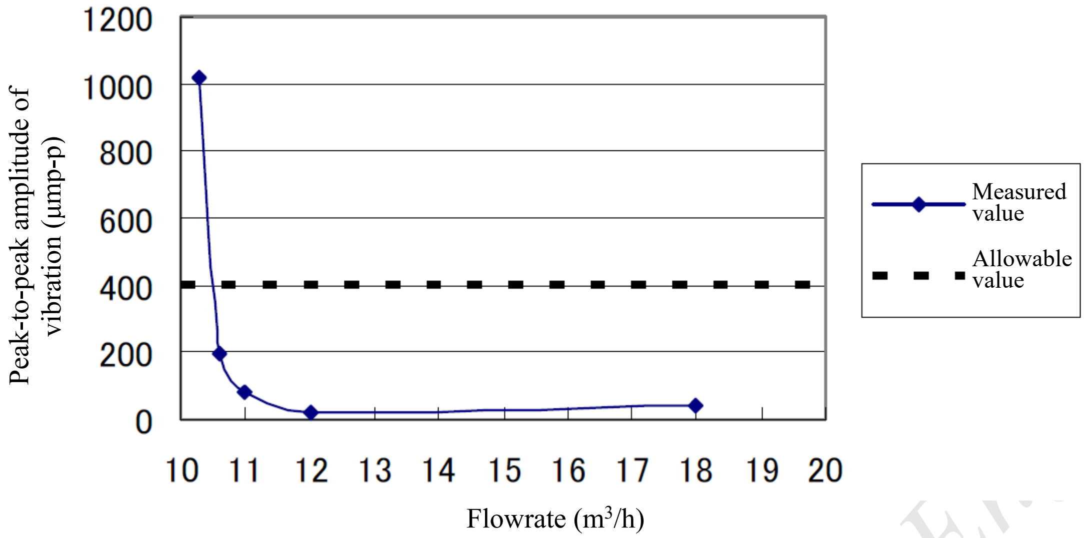

Fig.1 Relationship between pump flowrate and piping vibration

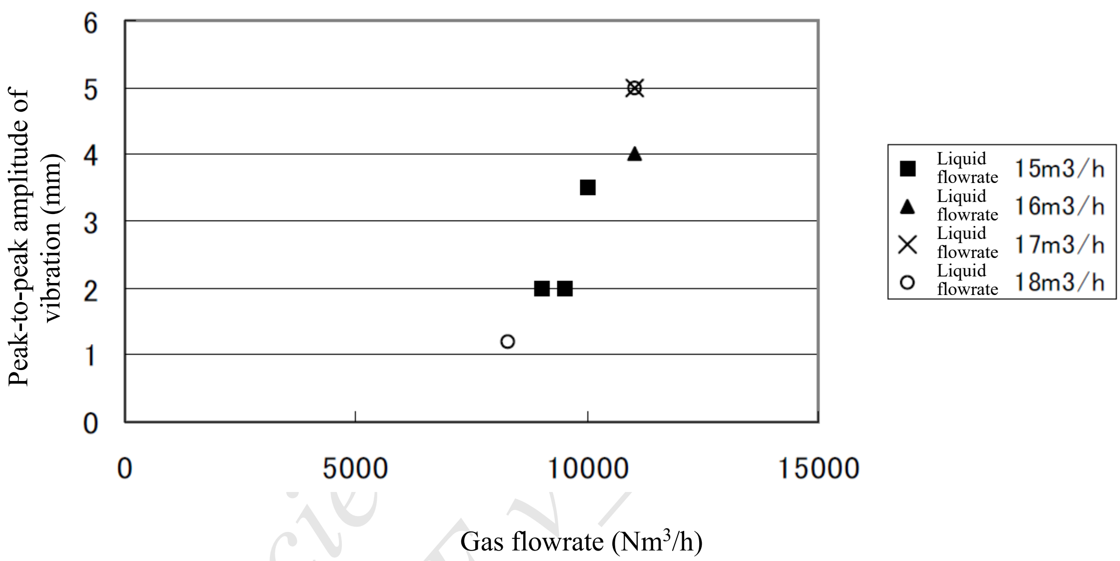

Fig.2 Relationship between gas flowrate and piping vibration