Study of Hydraulic Shock at a Low-Pressure Pump Station

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Abstract: *The paper presents a study of hydraulic shock at a low-pressure pumping station. If, at the moment of the greatest decrease in pressure, water is supplied to the source of hydraulic shock and the cavitation cavity is filled, the impact pressure will decrease to the value of the previous reduced pressure. This circumstance can be used as a means of protecting pipelines from high shock pressures of hydraulic shock.*

Keywords: *pumping station, hydraulic shock, vacuum, pressure pipe, check valve, break the continuity of the flow.*

1. Introduction

An unplanned emergency cutoff of the electric current powering the motors is the principal source of hydraulic shocks in the pressure pipes of pumping stations. When the motor is cut off in long pipes, the pump interrupts the flow of water so quickly compared to how long the impact phase lasts that the pumping unit's inertia may be disregarded. Although this presumption makes the computation of hydraulic shock considerably easier, it does not always reduce it to a straightforward application of the N.E. Zhukovsky formula [1].

$$\Delta h = \frac{a\vartheta_0}{g},$$

here Δh - shock pressure over static; a - impact propagation speed; ϑ_0 - initial water velocity; g - acceleration of gravity.

The fact is that many pumping stations and units used for irrigation and water supply operate at pressures lower than the shock's magnitude, as calculated by N.E. Zhukovsky's formula. At low operating pressures, the hydraulic shock brought on by the pump stopping is accompanied by a break in the flow, either along the length of the liquid column or separation of the entire liquid column from the pump [2,3,4,5].

The hydraulic shock process and the maximum pressure rise, which is the calculated value in actuality, are both significantly impacted by the gap.

Consider the most common design, which consists of a pumping unit connected to a pressure pipeline that rises to a pressure basin. Working pressure h_p must be met throughout the pipeline.

$$\left(h_p + h_B\right) < \frac{a\vartheta_0}{g},$$

here h_p - operating pressure; h_B – the magnitude of the vacuum at the impact site.

In order to rule out the effect of the spinning masses of the pumping unit's rotating masses on the phenomena of water hammer, we first assume that the pump is swiftly shut off by shutting the check valve.

In accordance with N.E. Zhukovsky's theory of impact, [1] when water flow in a pipe abruptly ceases, its living force is expended on the elastic work that pressure causes as it changes. The first change in pressure under the circumstances is restricted by h_p+h_B. As a result, just a portion of water's life force will be used for elastic work. As a result, when the first wave of reduced pressure has passed, the flow of water in the pipeline will continue at a specific residual speed, which may be described as follows [1,4]:

$$\vartheta_1 = \vartheta_0 - \frac{g}{a}\left(h_p + h_B\right).$$

The velocity value ϑ_1 with a pipeline profile rises with increasing distance from the pump. As a result, conditions are set up for the liquid column after the check valve to burst.

N.E. Zhukovsky was the first to postulate that a liquid column would break under a hydraulic shock at low pressures. Direct observation of the fluid movement in a glass tube and video served as complete confirmation. After the check valve at the start of the pressure pipeline, the glass pipe was fitted.

2. Methodology

According to the protocol, experimental trials were conducted [2,4,5]. According to the results of the trials [4, 5], the shock pressure may be easily brought down to static pressure by introducing liquids into the hydraulic shock source just as a deep vacuum is being created.

It is simple to add water to the pipeline by utilizing a tiny reservoir that is connected to the pipeline by a short line and a check valve that only enables water to flow in one direction, from the reservoir to the source of hydraulic shock when a deep vacuum forms.

The estimated formula can be used to determine the necessary tank volume [4,5]

$$W = \frac{L\omega\vartheta_0^2}{2g\left(h_0 + h_B\right)},$$

here ω - pipe cross-sectional area; h_0 - working pressure; $h_в$ – vacuum value.

3. Conclusion

1. A interruption in the continuity of the water flow with the creation of voids may accompany water hammer at pumping stations and stations with lengthy pressure pipelines (caverns).
2. The N.E. Zhukovsky formula states that a rise in pressure over static pressure can approach the maximum impact value at fractures.
3. The impact pressure will drop to the prior lowered pressure at the point of the greatest pressure drop, in one manner or another, to ensure the flow of water into the impact site and so fill the produced voids. Additionally, this situation may be employed to safeguard pipes against excessive water hammer pressures.

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