Energy Loss by Nonreturn Valve

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Nonreturn- valves (NRV) are used as an integral part of submersible pumps for their utility. In this paper energy loss in a conventional NRV- discharge outlet of different sizes used in both radial and mixed flow types of submersible pumps is described . The effects of valve weight on the loss coefficient are investigated and the need for optimum design of NRV- discharge outlet units to minimize energy loss stressed.

INTRODUCTION

Intrduction of water proof winding in electric motors has led to the application of submersible pumps in a wide range of job like water supply and irrigation from boreholes and rivers, mine de- watering, sewerage plants, sea- water services and fire- fighting on off- shore oil production platforms, oil well extraction, fluid storage caverns, etc.

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In submersible pumps nonreturn- valves are provided on the delivery pipe to avoid flow back when the pump is standing, which saves energy of the water pumped into the rising main, and to protect it from inertial forces that may arise in the pipeline. The nonreturn valves are attached to submersible pumps with discharge outlet pieces and forms an integral part of the pump. Each fitting in fluid flow passage causes some pressure loss and it is true for NRV- discharge outlet units also. As the mechanism of transfer of flow energy to turbulent energy and subsequent dissipation into heat is not sufficiently understood for adoption of an analytical procedure, it is necessary to depend upon experimental methods to determine the magnitude of these losses.

In this paper an attempt is made to find experimentally the loss of pressure head due to NRV- discharge outlet units for different delivery sizes commonly used with both radial and mixed flow types of submersible pumps. The effect of valve weight on the loss coefficient of the NRV- discharge outlet units have also been studied.

MATERIAL AND SET- UP

A study of several widely utilized designs of NRV- discharge outlet reveals that their inlet diameter is usually kept 65 mm for submersible pumps used in 150 mm bore size. It is also observed that while other design parameters and valve weight are kept the same, the size of delivery pipe of these units are varied from 50 mm to 80 mm diameter, for both radial flow and mixed types.

To ascertain the loss in NRV- discharge outlet units, a centrifugal coupled pump with 65 mm delivery size was taken. The units were fitted with the help of a designed adopter to the delivery pipe of the coupled pump. The coupled pump chosen for these experiments also facilitated inlet pressure tapping to the NRV- discharge outlet units, which would not have been possible with any submersible pump(Fig 1). However, the discharge range of the centrifugal pump chosen covered the discharge range of the submersible pump of which the NRV- discharge outlet units were taken for these experiments.

The pressure head loss across the NRV- discharge outlet units were measured with the help of a water- mercury differential U-tube manometer, while discharge rate were measure with a calibrated 90^{o} V-notch, available with the Bureau of Indian Standards (BIS) approved Fluid Mechanics Laboratory of the SGS Institute of Technology and Science, Indore.

EXPERIMENTS

In order to ascertain the variation of loss coefficient, K- experiments were performed in two stages (a) with three different delivery sizes of NRV- discharge outlet units, and (b) with different valve weights.

To find out loss coefficient in different sizes of the NRV- discharge outlet units, three samples were chosen from commonly used sunmersible pumps with 50 mm, 65 mm and 80 mm delivery pipes.

From the samples, it was found that the valve weight was 0.535 kg. To ascertain the effect of valve weight on the loss coefficient, K, three valves of same design which has been found in the nonreturn- valves, but different weight were made. The valves weights chosen were 0.250kg, 0.180kg and 0.065 kg. In addition to this, valve with full open position, right from minimum discharge, and without valve in the NRV-discharge, outlet units were also tested. These tests were carried out with delivery pipes of sizes 50 mm and 65 mm.

RESULTS AND DISCUSSION

Fig 2 shows the variation of loss coefficient with discharge rates for all the three sizes of NRV- discharge outlet units. In general, it can be seen that the loss coefficient is high in the whole range of the discharge rate. Specially, at low discharge rates the value of loss coefficient is very high for each case and becomes asymptotic to the y-axis for discharge rates tending towards zero in each case.

The loss coefficient decreases with the increase in discharge rate to a minimum value and then gradually increases by 5.8%, 22.0% and 13.6% of the minimum value, for the 50 mm, 65 mm and 80mm delivery pipe sizes respectively, at the maximum discharge rate. Throughout the discharge range, loss coefficients for 50 mm size were found to be lowest while for 80 mm size these were found to be highest, amongst the three sample chosen.

Fig 3 and Fig 4 show the variation of loss coefficient with discharge rates for the four valves of different weight chosen for experimentation with the 50 mm and 65 mm delivery sizes, respectively. These figures also show the coefficient variation with discharge rates for the full open valve at minimum discharge rates and for the case when the valves were absent. The loss coefficient in each case varies in the similar pattern as shown in Fig 2.

Fig 3 and Fig 4 also reveal that at lower discharge range the loss coefficient increase with increase in valve weights. This tendency of loss coefficients indicates that when the discharge valve is operated from full closure, with the increase in discharge rate, the nonreturn- valve lifts from the seat giving a gradual opening to the fluid mass, depending on the equilibrium condition of valve weight and buoyancy and drag due to the fluid flow. The lift of the nonreturn-valve continues with the increase in discharge rate till it reaches the top most position. In this discharge range the loss coefficient decreases steeply from a high value to the lowest possible value.

It is also clear from Fig 3 and Fig 4 that for lower discharge rates loss coefficients were minimum in cases where the valves were absent in the NRV- discharge outlet. As this does not serve the very purpose of the NRV-discharge outlet units, gives only a hypothetical limit of loss coefficients for these particular designs.

When the valve was kept open full even at minimum discharge rates, the values of loss coefficient were found to be less than the cases in which it was not fixed to full open position.

In all cases with the increase in discharge rates, the loss coefficient curves merge into a single curve and follow the same nature of gradual increase in loss coefficient values with increase in discharge rates. This small increase with increased discharge rates can be attributed to losses in the curved wall contraction passage formed when the valve is at the full open position. This can be understood from Fig5 in which sections A-A and B-B show the curved wall contraction passage formed.

CONCLUSIONS

Experiments carried out on 50 mm, 65mm and 80mm NRV-discharge outlet units of sizes with different valve weights and full open valve even at the lowest discharge rate reveal that:

1. The loss coefficient of the NRV-discharge outlet units used at present with submersible pumps are very high;
2. when the valve was kept open full, even at minimum discharge rate, loss coefficient were found to be minimum;
3. NRV-discharge outlet units loss coefficient increases with the increase in valve weight at lower discharge rates. This is only because the valve does not get fully open at lower discharge rates. This suggests that valve weight should be minimum possible so that it can lift to the full open position at lower discharge rates.
4. The intersection of full open valve position loss coefficient curve with other curves indicates the discharge rate at which corresponding valve will reach to the full open position;
5. To minimize energy loss with existing NRV-discharge outlet units, the submersible pump should be operated at a flow rate which would ensure full opening of the nonreturn-valves;
6. The weight of the valve does not affect the loss coefficient in higher discharge range;
7. Once the valve is full open, the loss coefficient further increases to a certain value. This is only due to the final flow passage formed inside the nonreturn-valves; and
8. It is clear from these experiments that NRV-discharge outlet units used at present with submersible pump sets have very high loss coefficients. An optimal value of valve weight and design of flow passage inside the nonreturn – valves can reduce energy loss to a tolerable limit.

REFERENCE

1. H.H Anderson. 'Submersible Pump.' The trade and Technical Press Ltd, England, 1st **edition, 1986.**
2. V P Vasandani. Theory of Hydraulic Machines.' Khanna publishers. Delhi, 7th edition, 1980.
3. J Lal. Hydraulic Machines.' Metropolitan Book Co-Ltd, New Delhi. 6th edition, 1975.
4. S Nagratnam. Fluid Machines.' Khanna publishers. Delhi, 5th edition, 1986.