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A Calculation Method of Required Stem Loads for Globe Valve

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1. Introduction

Air operated valves are used extensively in the power generation industry for process control and isolation. Air operated valve consists of valve and actuator. Valve includes valve body, bonnet, stem, disc and actuator includes positioner, air regulator, spring and actuator body. A globe valve uses a cylindrical or spherical shaped, tapered disc or plug. There are various valve designs and specific details of a particular valve may have a large impact on the validity of the performance evaluation methods. This study presents prediction method used to establish the required stem load for a globe valve. The stem load depends on the fluid flow and differential pressure at the time the valve is operated. The “required stem load” refers to the largest value of stem thrust necessary for the valve to complete its operating function.

2. The Stem Thrust of Globe Valve

The required stem thrust is the axial force applied to the valve stem to cause the valve to perform an operating function. This force is either a pushing or a pulling force, depending on whether the valve is being colsed or opened. The globe valve is to consider several contribution terms to valve stem thrust and then to calculate the total required stem thrust by adding the terms. The major term of valve stem thrust is differential pressure load. Globe valve requried thrusts are generally proportional to the differential pressure across the valve. And valve stem thrust is included the additional force, example for packing friction thrust, piston effect thrust, disc-to-body friction thrust and sealing force. Figure 1. shows required stem thrusts during the valve operation. And figure 2. shows measured signal for stem thrust.

2.1 Packing Friction Load(F_{pack})

When the valve operation, friction is occured between the packing and valve stem. Packing friction always opposes disc motion. It is difficult to predict the packing friction load exactly. So packing friction load is determined from valve test data. However, if the packing is correctly maintained, it should be possible to estimate this load analytically. Equation (1) ~ (2) are generally used to calculated packing friction load.

$$F_{pack} = \pi \times S \times D_s \times L_{pack} \times fY \quad (1)$$
$$F_{pack} = 1000 \times D_s \quad (2)$$

S : radial stress L_{pack} : packing length
fY : packing friction factor D_s : stem diameter

2.2 Piston Effect Load(F_P)

The piston effect load is the load caused by the internal line pressure acting on the stem area. In case of underflow type globe valve, the piston effect load is positive in the closing direction and is negative in the opening direction. The piston effect load is given by equation (3).

$$F_P = P_{bonnet} \times A_{stem} \quad (3)$$

2.3 Disc-to-Body/Cage Friction Load(F_{DF})

The Disc-to-body/cage friction covers friction loads between the disc and the body guides, stem bearing or cage, as applicable. This load is always positive since it always opposes disc motion. For balanced disc globe valves, the stem thrust due to disc-to-body/cage friction load is essentially zero at the fully open position since It

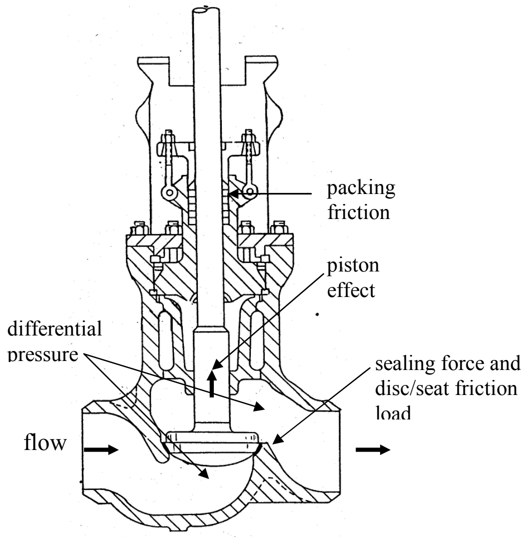

Figure 1. Required stem loads

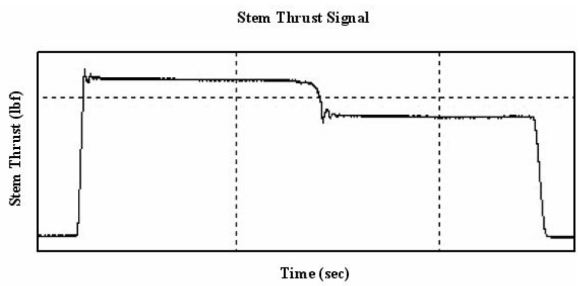

Figure 2. Measured signal for stem thrust

is neligible differential pressure across the valve disc.

$$F_{DF} = C_1 \times \triangle P \times A\% \times L \times OD_{seat} \quad (4)$$
$$F_{DF} = C_2 \times (H_L / D_G) \times \triangle P \times (\pi/4) \times (D_G)^2 \quad (5)$$

C1, C2 : Constant A : Cage Hole Area
L : Valve Stroke Length HL : guide ring height
DG : guide ring diameter ODseat : outside dia. of seat

2.4 Differential Pressure Load(F_{DP})

Differential pressure(DP) load is the vertical component of the load that reacts the differential pressure. It depends on the fluid pressure around the valve disc. The DP load is positive regardless of valve travel direction. DP load is zero at the fully open position since there is negligible DP across the valve disc. DP load at the fully closed position is calculated by equation (6).

$$F_{DP} = VF \times \triangle P \times A_{orifice} \, (1/\cos \upsilon - \mu \sin \upsilon) \quad (6)$$

VF : valve factor
$A_{orifice}$: area of disc on which pressure acts
υ : seat angle

Appropriate values for valve factor are dependent on the materials of the contacting surface (disc & seat), the contact stress between the material, the surface finishes of these surfaces, the fluid in the line, and the temperature. Figure 3. shows valve factors of globe valve from field test results.

2.5 Sealing Load(F_{SL})

The valve disc must contact the seat with some force to establish an initial seal, consistent with the leak class used. Sealing load is only applicable for closing strokes, and the stem thrust due to sealing load is zero at the fully open position. Table 1. shows calculation equation for sealing load. In this equation, constant value is determined by ANSI B16.104 seat leakage classifications.

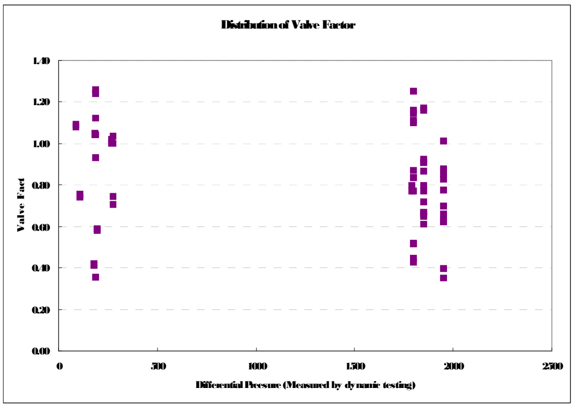

Figure 3. Distribution of valve factor from field test

Table 1. Equation for sealing load

ANSI B16.104 seat leakage classification	Seat load using metal seat
Ⅱ(C=20)	Force = C Dp π
Ⅲ(C=40)	Force = C Dp π
Ⅳ(C=60)	Force = C Dp π
Ⅴ(C=100~300)	Force = C Dp π

3. Conclusion

The basic approach used here is to consider several contribution terms to valve required stem thrust and then to calculate the total required stem thrust by adding the terms. In applying this calculational method to determine required stem thrust, it is critical that the user evaluate the specific valve conditions and construction with regard to the assumptions used in developing these equations. Valve specific details and field variables will affect the ruquired stem thrust calculations. The recommended empirical coefficients will provide bounding estimates of the required stem thrust.

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