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Experimental parametric equation for the prediction of valve coefficient (C_v) for choke valve trims

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ABSTRACT

The calculation of nominal choke valve size determines the effective capacity for an oil and gas production system. The degree of restriction for the controlling area in the valve is a function of the surrounding geometry. In an orifice plate this is known as the "velocity of approach" and can be used to determine the meter coefficient (C_m). This paper presents a technique for choke valves, based on the meter velocity of approach parameter, which can be used to predict the Valve Coefficient (C_v) for new trim designs. The prediction method uses a data trend based on a number of flow tests conducted on various trim characteristics. The resultant parametric equation is used to predict the C_v of a new trim geometry. The method relies on experimental data determined per IEC 60534-2-3, with calculations per IEC 60534-2-1. This paper further investigates the effect of varying upstream geometry on C_v for a 4″ nominal valve.

1. Introduction

Control valves are used primarily to control operating conditions such as flow, pressure and temperature in fluid systems. A choke valve is a special type of control valve typically used in heavy industries like oil and gas production. The term choke valve is derived from the choked flow operating condition, wherein the limiting flow condition has been reached. Choke valves are generally located at the production block (known as the Christmas Tree or XT). It is the first control valve seen by the production fluid and as the primary restriction governs the operating capacity of the well.

A choke valve is sized based on the natural parameters of the reservoir including; pressure, temperature and fluid properties, but also the design of downstream systems including; pressure rating and production capacity. An undersized control choke can ultimately reduce the operating capacity of the production system leading to commercial losses. An oversized choke valve has a reduced controlling range which inhibits adjustment and can also lead to increased erosion due to high velocity, Hutchinson [1].

A choke valve consists of an inlet and outlet bore, typically an annulus, a trim and an actuation system (manual or automated), as detailed in Fig. 1. The choke valve is used to take the majority of the pressure drop in a system and as such the valve may be a number of nominal sizes less than connecting pipe-work. In this case the inlet and outlet connections may include line reducers. The trim consists of a cylindrical cage with ports for flow and an internal plug which is linearly actuated to open flow area.

The calculation of the valve size required to control a reservoir condition is a function of the valve's internal geometry. The current industrial standard IEC 60534-2-1 [2] for sizing valves requires a series of flow tests to be completed which define three parameters of internal geometry. For any valve designed to have a unique control characteristic [2] would require a manufacturer to first produce the valve, then flow test it, before confirming that the design meets the required controllability. Without a design rationale this would lead to a costly iterative process. This paper will describe a design technique wherein the valve internal geometry parameters are interpolated from experimental data, based on a new non-dimensional geometry ratio. This non-dimensional ratio is derived from the restrictive geometry of an orifice plate and the non-dimensional geometry ratio used therein. This technique will then be applied to a sample case to demonstrate its use.

2. Valve sizing and the meter coefficient

Sizing is the term given to the calculation of the restrictive area in a valve required to control a specific operating condition.

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