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Methodology for expressing the flow coefficients of coupled throttling grooves in a proportional–directional valve

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Basic Principle

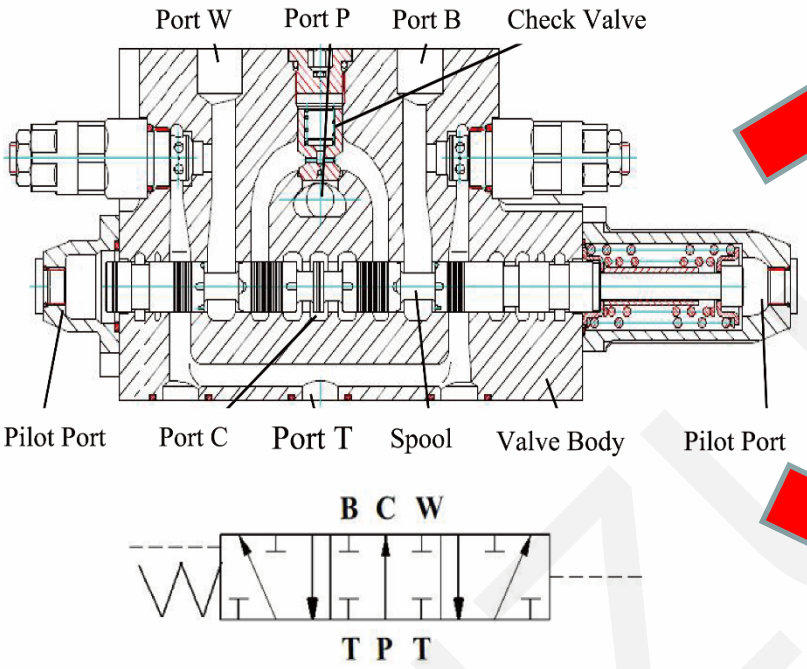


Fig. 1 Sketch of the typical geometric architecture of the valve

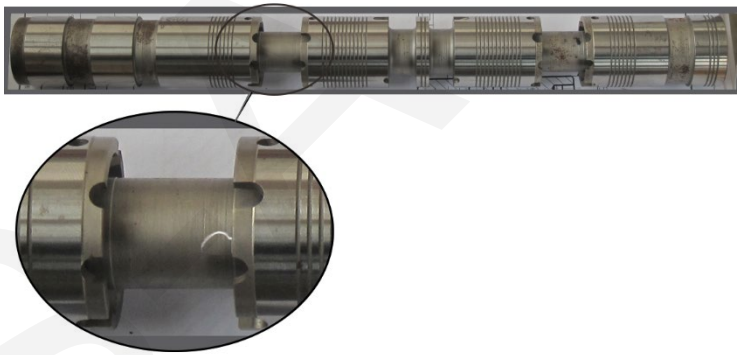
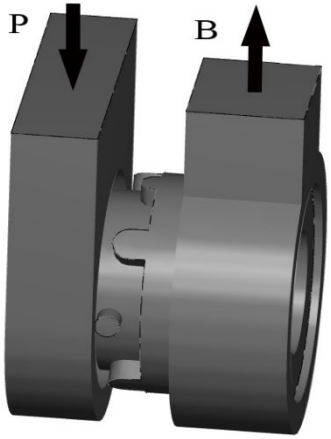


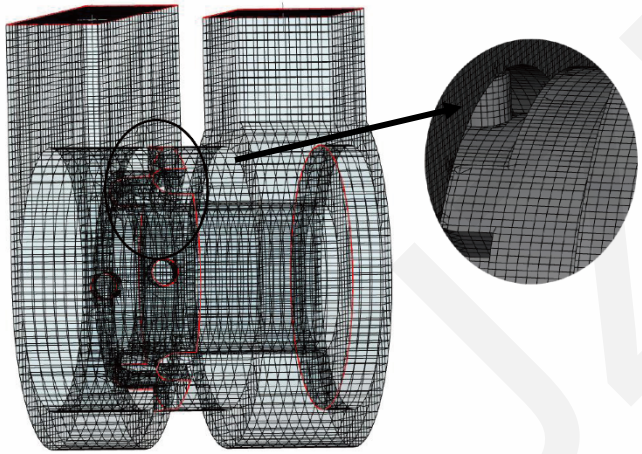
Fig.2 Valve Spool and throttling grooves

Fig.3 Valve Body

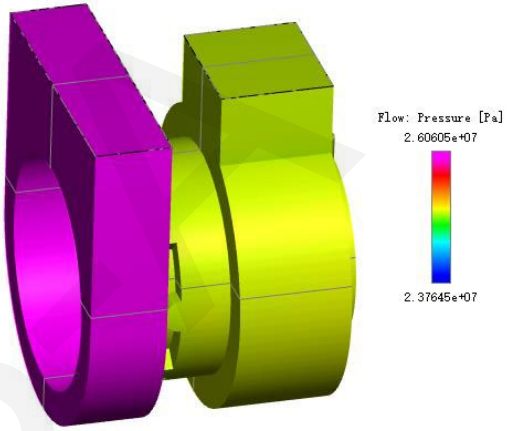
CFD and Test



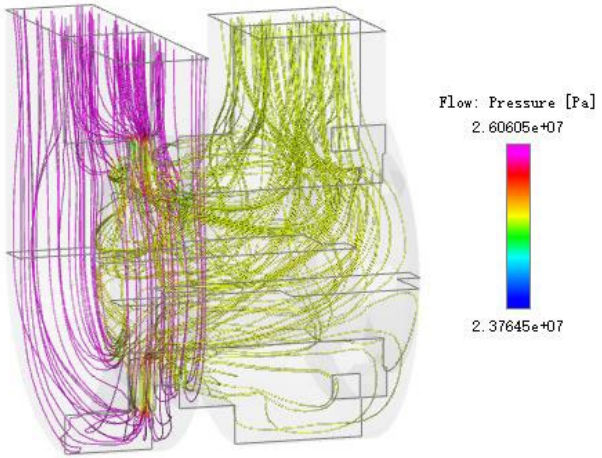
(a) Year 1994-2013



(b) Year 1994-2013



(c) Year 1994-2013



(d) Year 1994-2013

Fig. 4 CFD model and pressure results of contours

CFD and Test

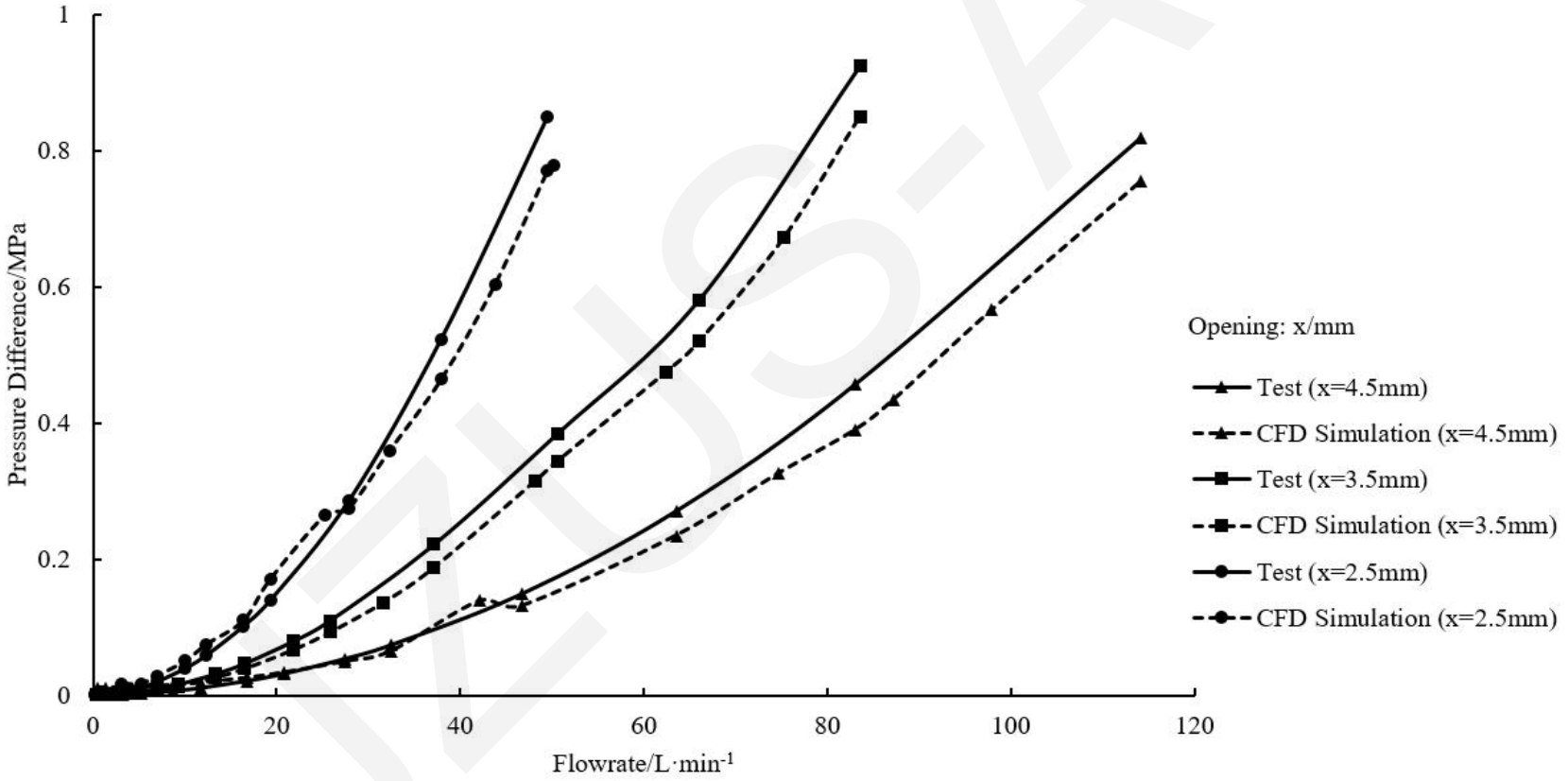


Fig. 5 Results of the CFD simulation and test

Mathematic Model

Structural variable space

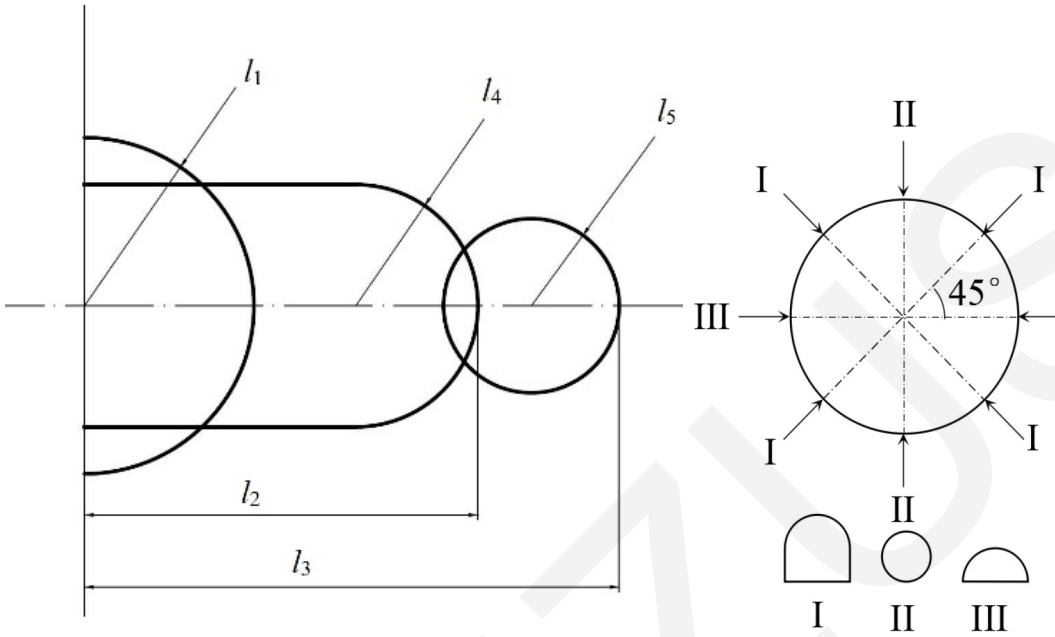


Fig. 6 Design variables and circumferential distribution of the grooves

Table.1 Orthogonal test samples

Samples	l_1/mm	l_2/mm	l_3/mm	l_4/mm	l_5/mm
1	1.6	3.2	4.6	1.2	0.9
2	1.6	3.6	4.9	1.6	1.2
3	1.6	4	5.2	2	1.5
4	1.6	4.4	5.5	2.4	1.8
5	2	3.2	4.9	2	1.8
6	2	3.6	4.6	2.4	1.5
7	2	4	5.5	1.2	1.2
8	2	4.4	5.2	1.6	0.9
9	2.4	3.2	5.2	2.4	1.2
10	2.4	3.6	5.5	2	0.9
11	2.4	4	4.6	1.6	1.8
12	2.4	4.4	4.9	1.2	1.5
13	2.8	3.2	5.5	1.6	1.5
14	2.8	3.6	5.2	1.2	1.8
15	2.8	4	4.9	2.4	0.9
16	2.8	4.4	4.6	2	1.2
Prototype	2.1	3.8	5.0	1.8	1.4

Mathematic Model

Approximate model for flow coefficient

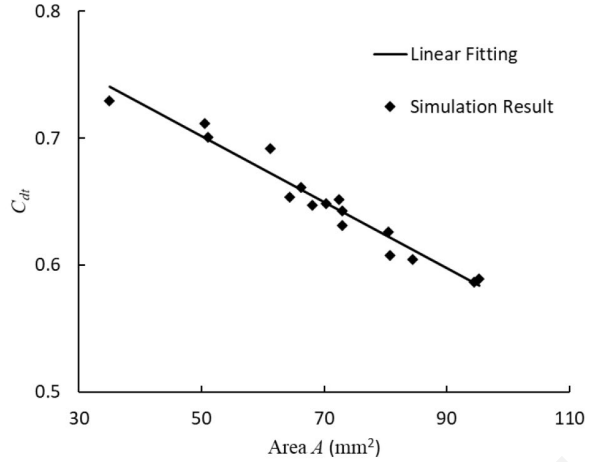


Fig.7 Fitting curve of C_{dt}

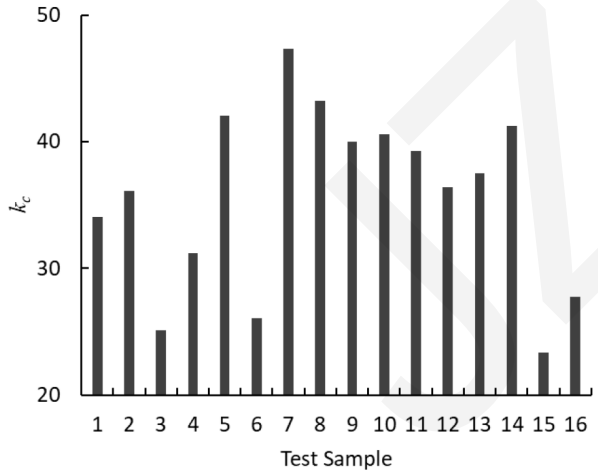
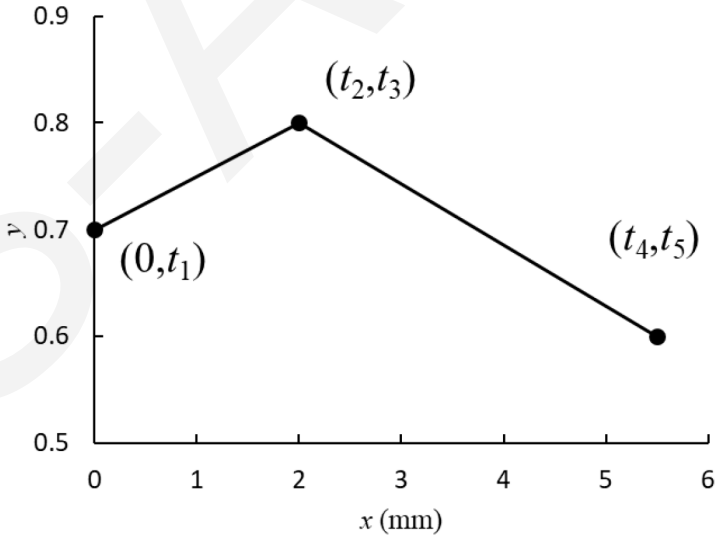


Fig.8 Fitting curve of k_c



$$y=\begin{cases}\dfrac{x-t_2}{-t_2}\cdot t_1+\dfrac{x}{t_2}\cdot t_3, 0<x<t_2,\\ \dfrac{x-t_4}{t_2-t_4}\cdot t_3+\dfrac{x-t_2}{t_4-t_2}\cdot t_5, t_2\le x\le t_4,\end{cases}$$

Fig.9 Fundamental forms of the expression model

Mathematic Model

Results

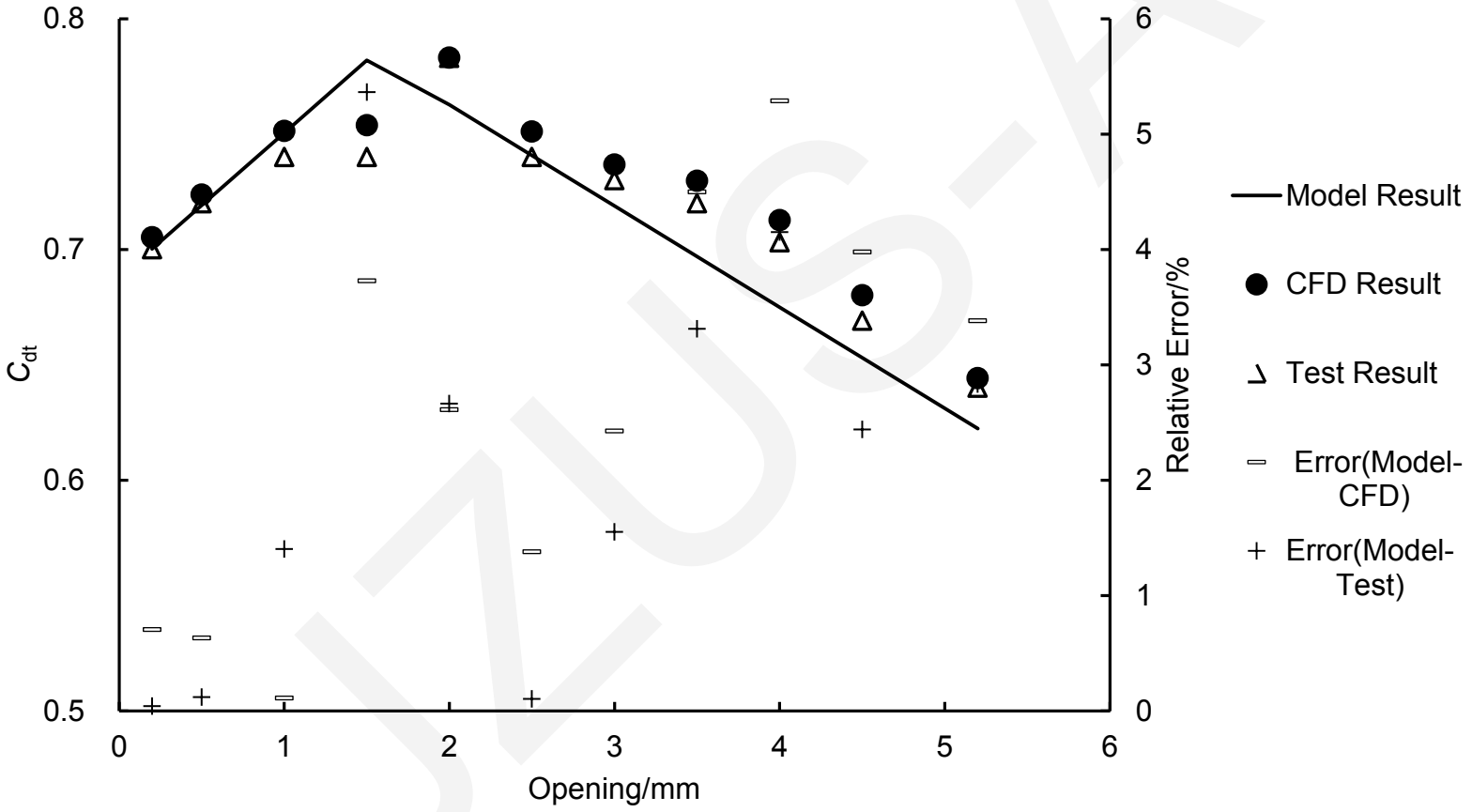


Fig. 10 Verification of model with the real structure dimension

Conclusions

This paper primarily presents a new method-ology for accurately approximating the flow coefficient of spool valves with respect to coupled throttling grooves, based on a prototype of a typical commercial proportional–directional valve.

I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me.