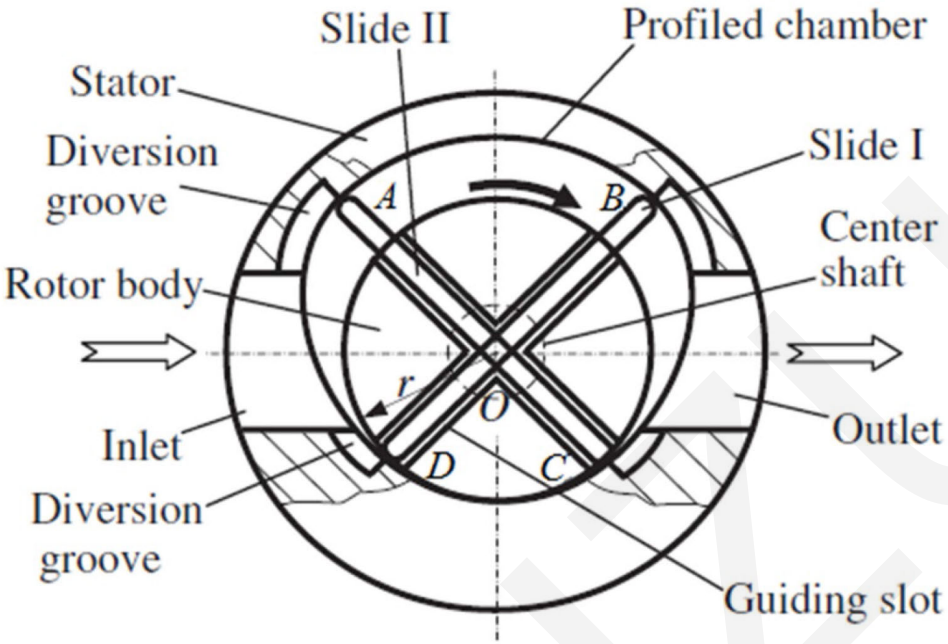
Design of transition curve of profiled chamber flow sensor considering slides with arc ends



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Key words:

Profiled chamber flow sensor;

Transition curve;

Optimal design;

Curve curvature

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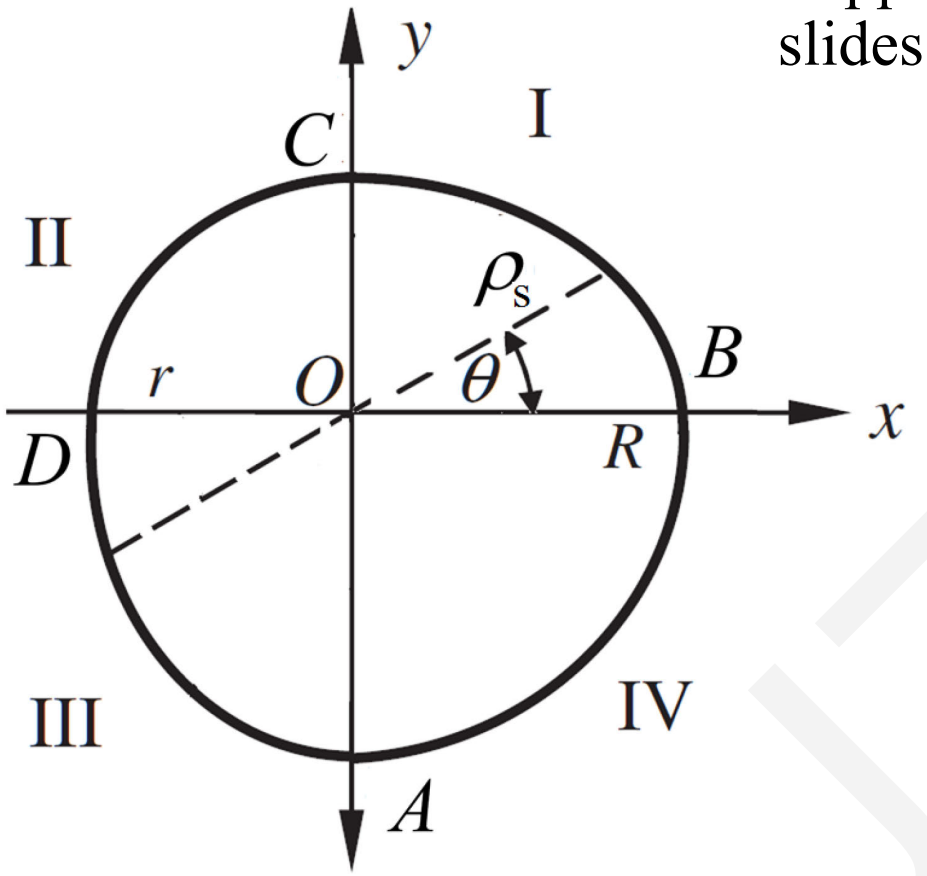
The design of basic transition curve



Supposing the slide ends are sharp and the contact between the slides and the chamber is point-contact

$$\rho_S(\theta) = r_1 + (r_1 - r_2)\left[k_{(n+1)/2}\bar{\theta}^{(n+1)/2} + k_{(n+1)/2+1}\bar{\theta}^{(n+1)/2+1} + \cdots + k_n\bar{\theta}^n\right],$$

$$\bar{\theta} = \theta/(\pi/2)\,.$$

The coefficients of the polynomial function above can be determined by boundary conditions to obtain optimized dynamic conditions of the slides

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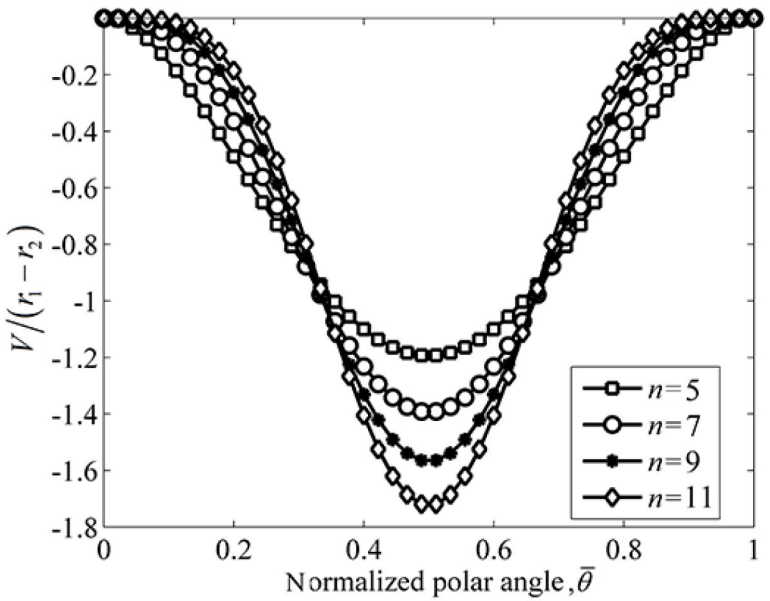
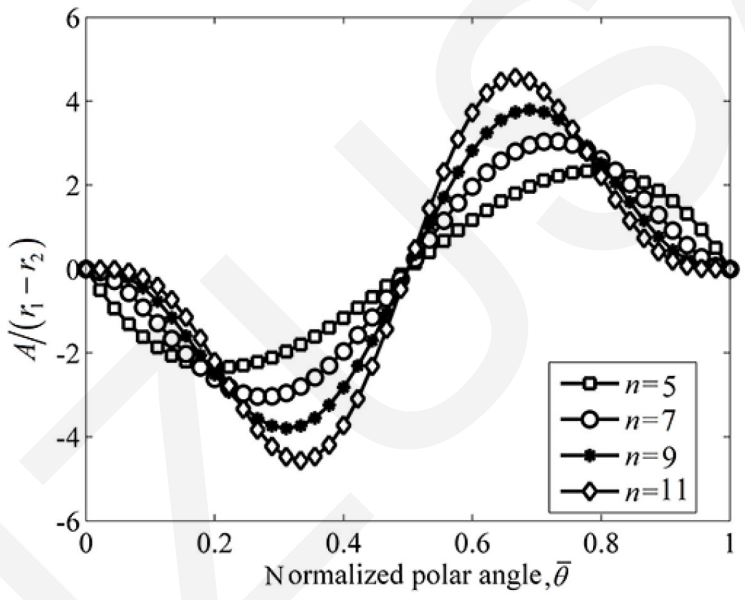
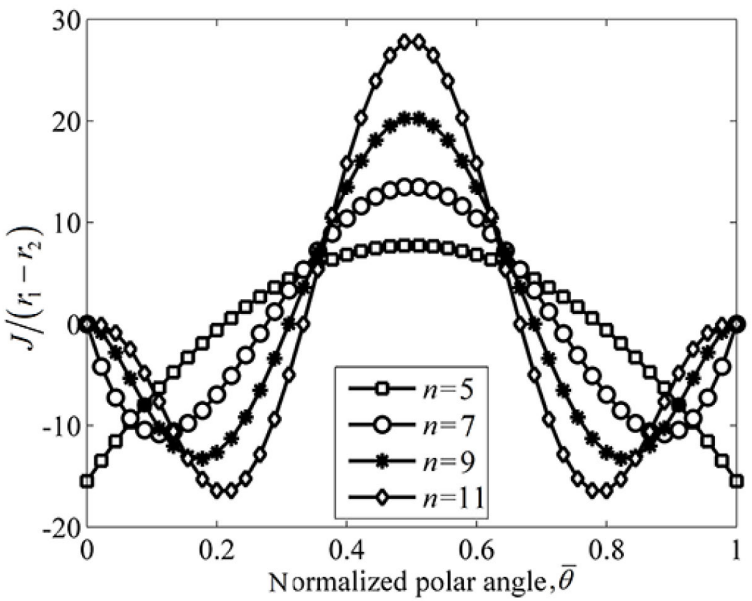
Optimization of basic transition curve

Point 1:

the V-A-J curves of the polynomial-function transition curves with 5th, 7th, 9th, and n=11th orders







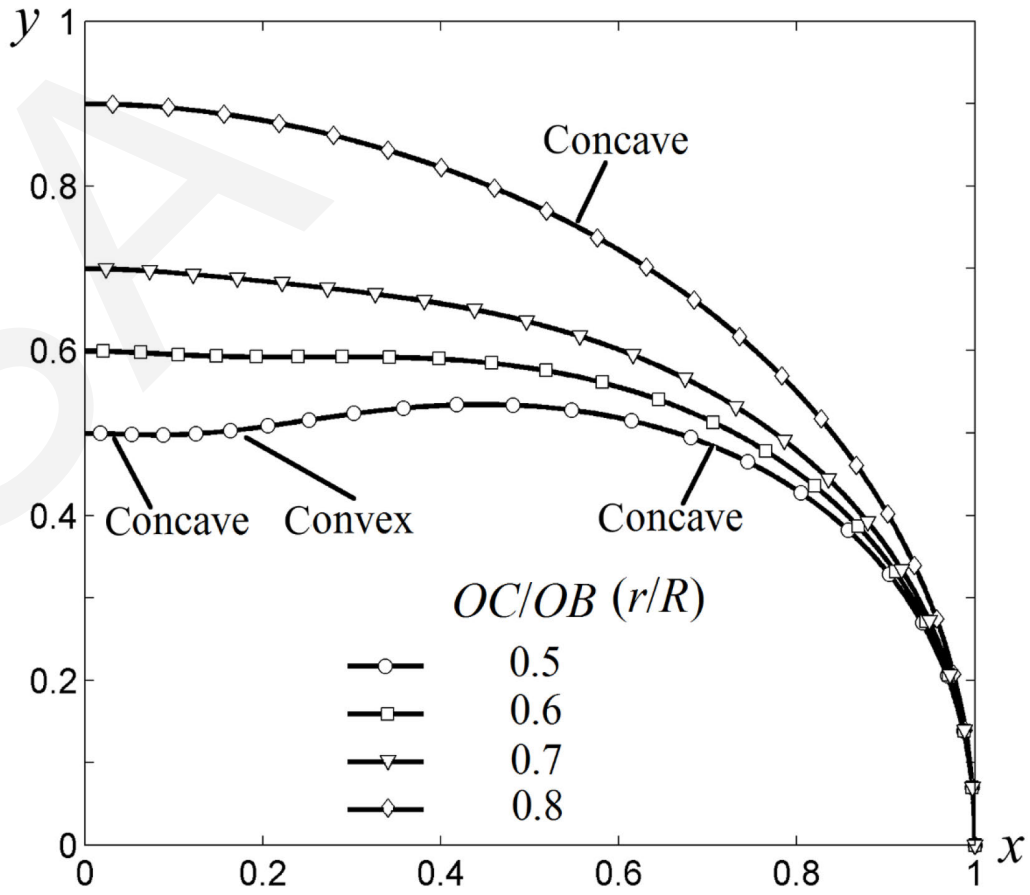
For “A-criteria”, the 5th order polynomial function is the best for the design of the basic transition curve, with for “J-criteria”, the 7th order polynomial function is the best.

Optimization of basic transition curve

Point 2:
the curvature of the designed curves

For a 5th order basic transition curve, the curve is entirely concave and suitable for manufacturability when $0.677 \leq r/R \leq 1$;
For a 7th order curve, the range is $0.728 \leq r/R \leq 1$;
For a 9th order curve, the range is $0.771 \leq r/R \leq 1$;
For a 11th order curve, the range is $0.804 \leq r/R \leq 1$;

The 5th order basic transition curve is the best with a largest designing range for *r*/*R*, followed by 7th order, and 9th order, and 11th order.



Shapes of the transition curves of 5th order polynomial function with different values of *OC*/*OB*

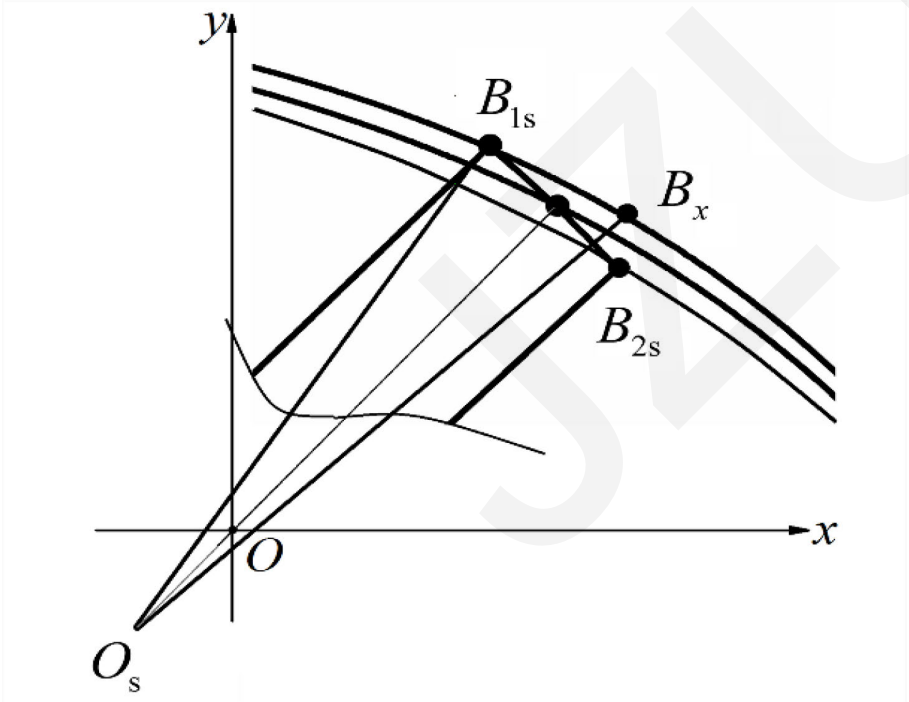
Design of the transition curve considering the slides with arc ends

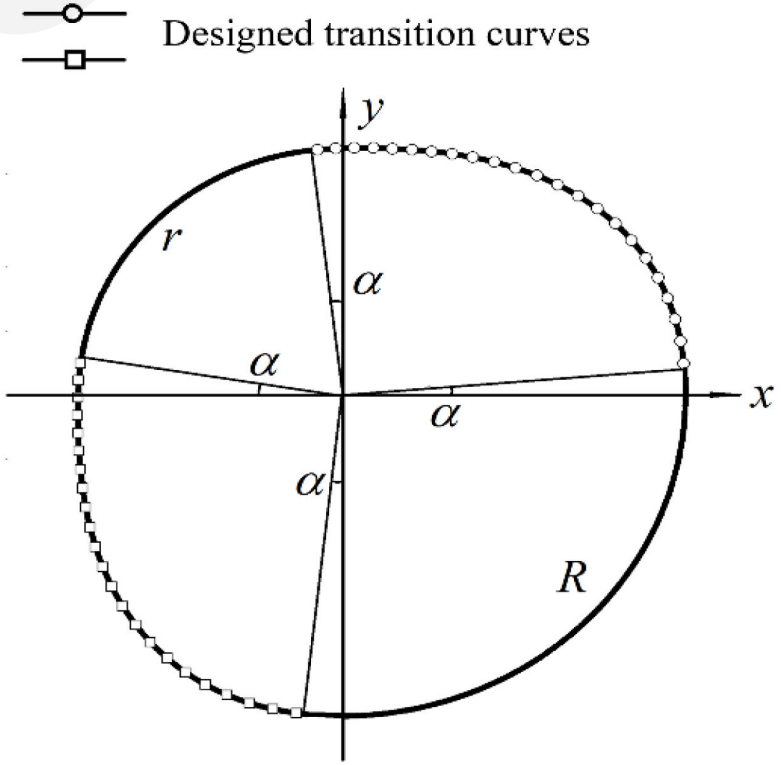
Point 1:

The V-A-J dynamic properties of the transition curves should be the same with the basic transition curves.

Point 2:

The transition curve should be designed to make sure on interaction exists between the slides and the chamber.





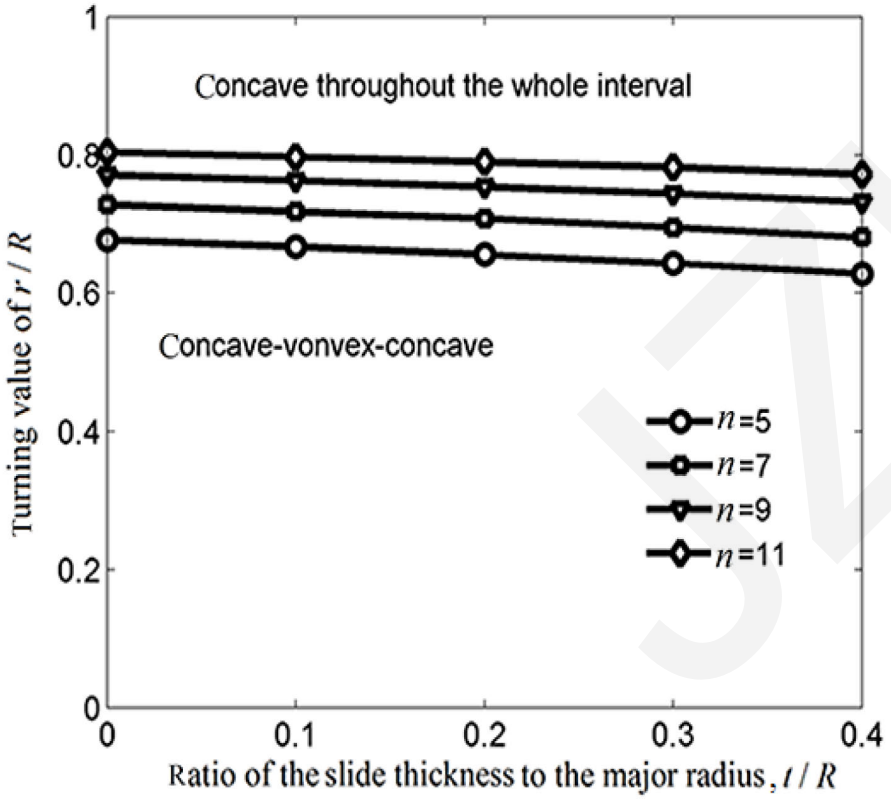
Optimization of the transition curve considering the slides with arc ends

Point 1:

the V-A-J dynamic properties, which are the same with that of the basic transition curve

Point 2:

the curvature of the transition curve, which should be re-analyzed



The 5th order basic transition curve is the best with a largest designing range for *r*/*R*, followed by 7th order, and 9th order, and 11th order.

The ratio of the slide thickness to the major radius affects the curvature of the transition curve slightly; with larger *t*/*R*, slightly larger designing range for *r*/*R* is obtained.

Summary

The transition curves of a profiled chamber flow sensor considering the slides with arc ends are designed and optimized.

- The concept of “basic transition curve” is proposed and the design and optimization are given in a more general and systematical way compared with that our former work.
- The curvature of the transition curve is analyzed for the first time.
- The design and optimization of the transition curves considering the slides with arc ends are proposed and the curvature is analyzed.

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Some relevant works of the research group

1 Lei H, Lu Y. Optimization of transition curve of casing cavity of profiled chamber flow sensor[J]. Mechanism and Machine Theory, 2011, 46(11): 1773-1783.

2 Lei H, Hu H, Lu Y. A Dynamic Analysis on the Transition Curve of Profiled Chamber Metering Pump[J]. Journal of Dynamic Systems, Measurement, and Control, 2016, 138(7): 071003.

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