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Effects of bleed hole size on supersonic boundary layer bleed mass flow rate

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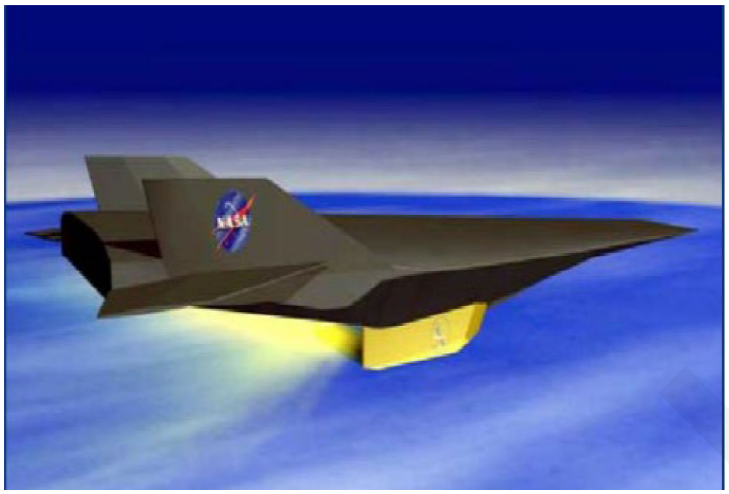
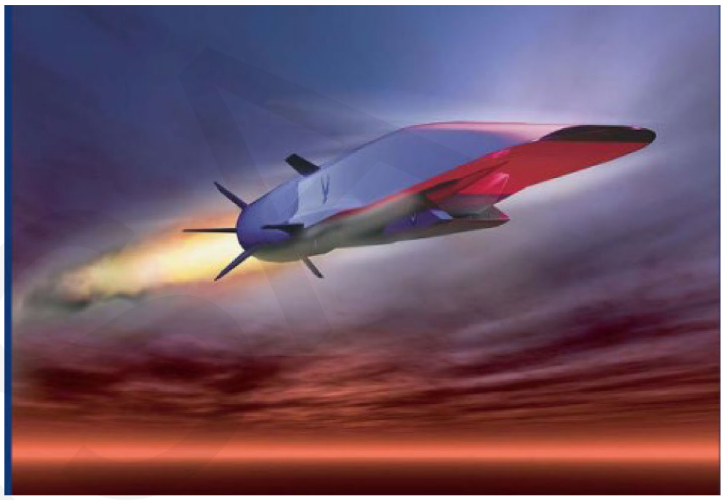
Hypersonic inlet





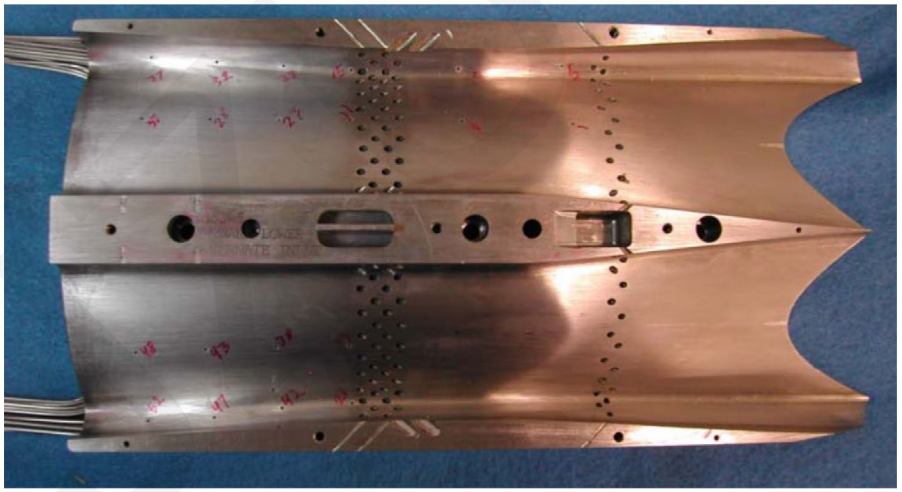


Fig. 1. Hypersonic inlet is a key component of hypersonic vehicle, and bleed is an effective control method of its efficiency .

The parameters of supersonic bleed

Boundary layer thickness δ
Bleed hole diameter D
Bleed hole thickness L

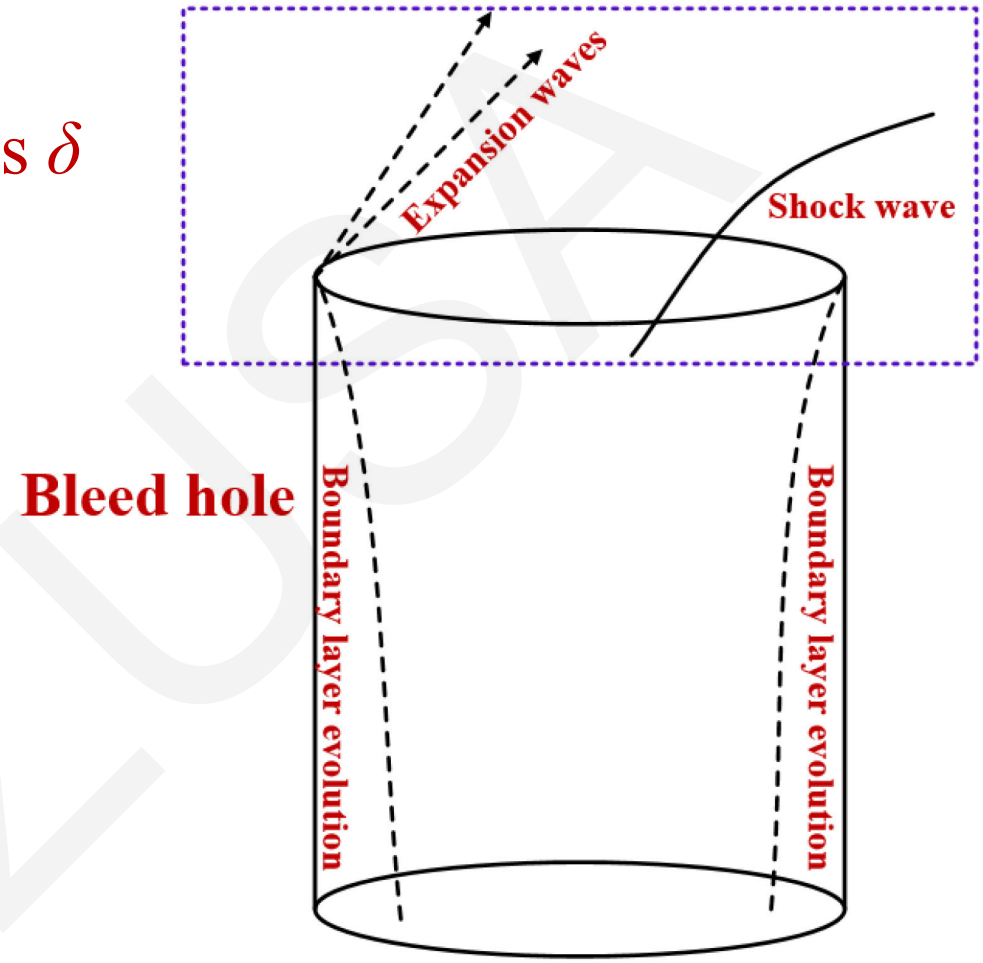
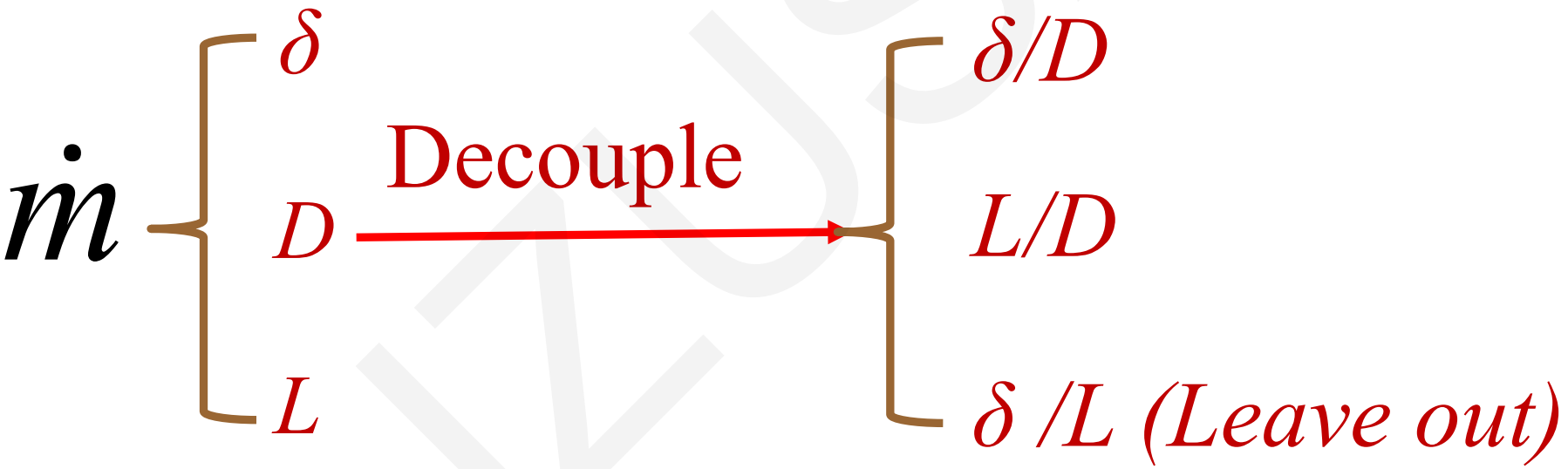


Fig. 2. The parameters of the thickness of boundary layer, diameter and depth of bleed hole are key parameters affecting bleed mass flow rate.

The parameters were decoupled

The parameters affecting bleed mass flow rate are decoupled



These first two combinations were studied respectively to obtain the main parameters that determine the bleed mass flow rate.

Bleed lateral interactions

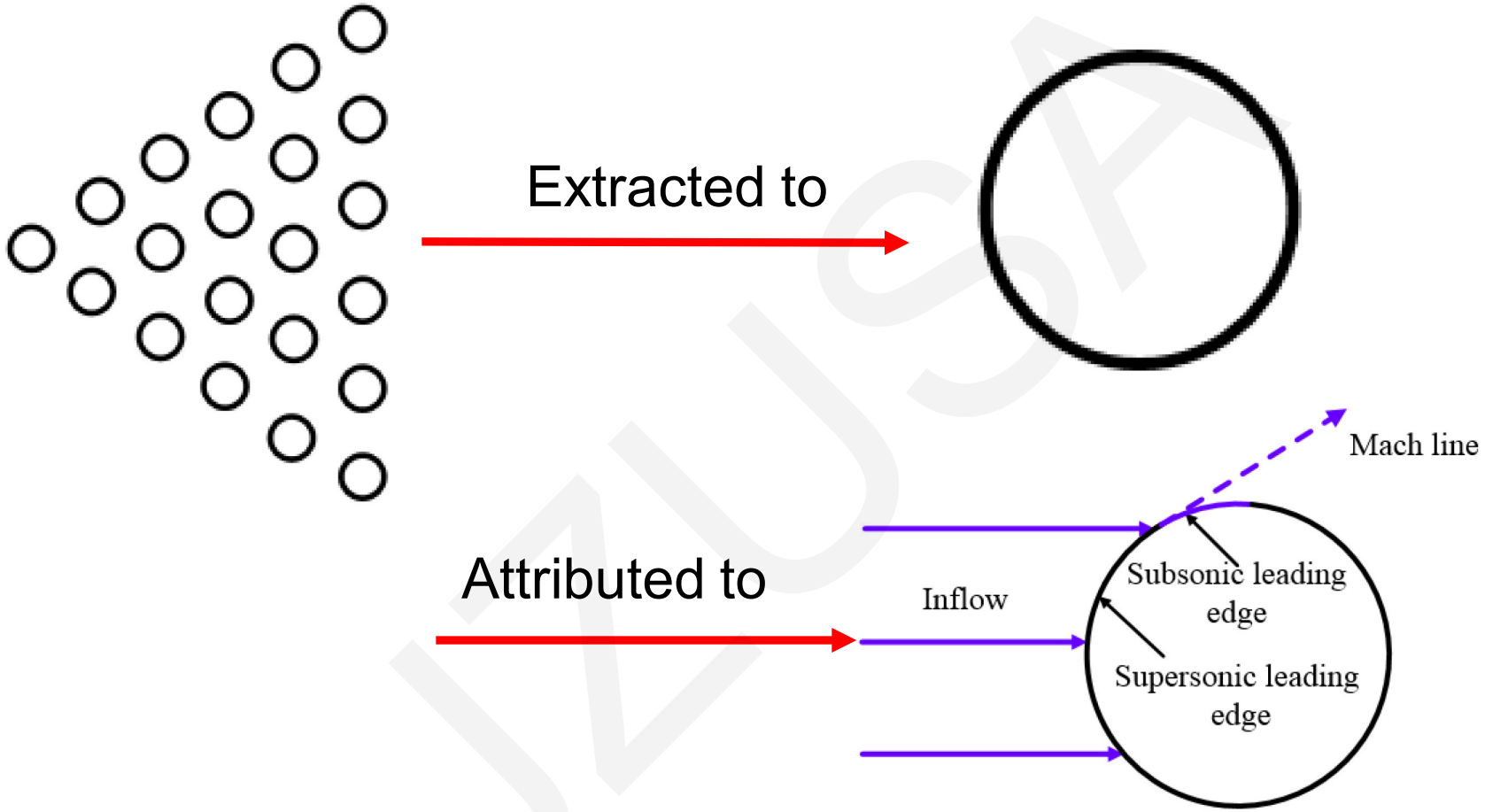
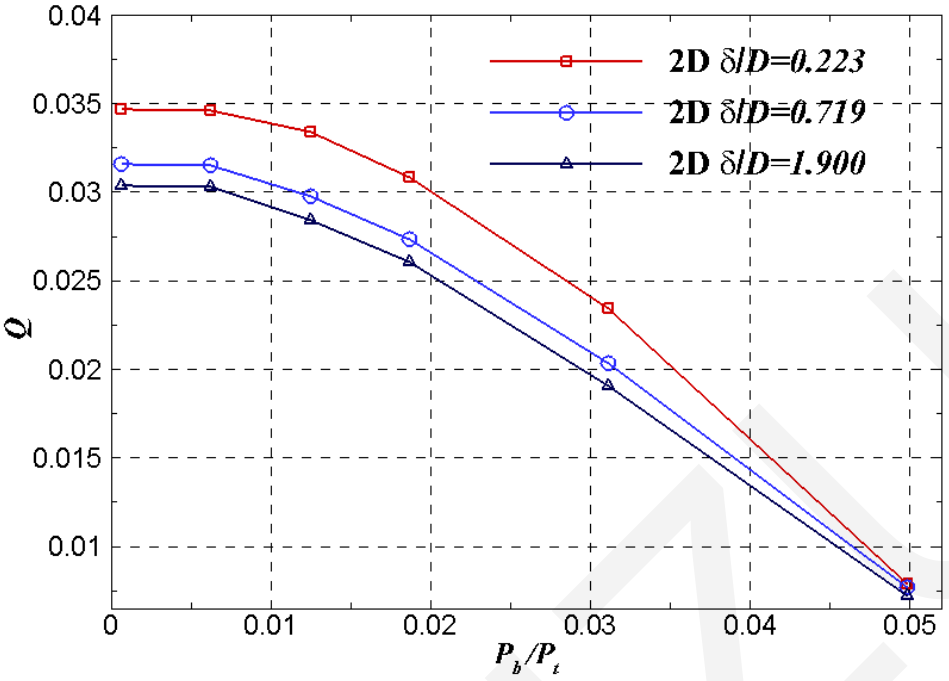


Fig. 3. The interaction of multi-bleed hole was attributed to lateral flow, which is further determined by the boundary layer, subsonic and supersonic leading edge.

Bleed lateral interactions



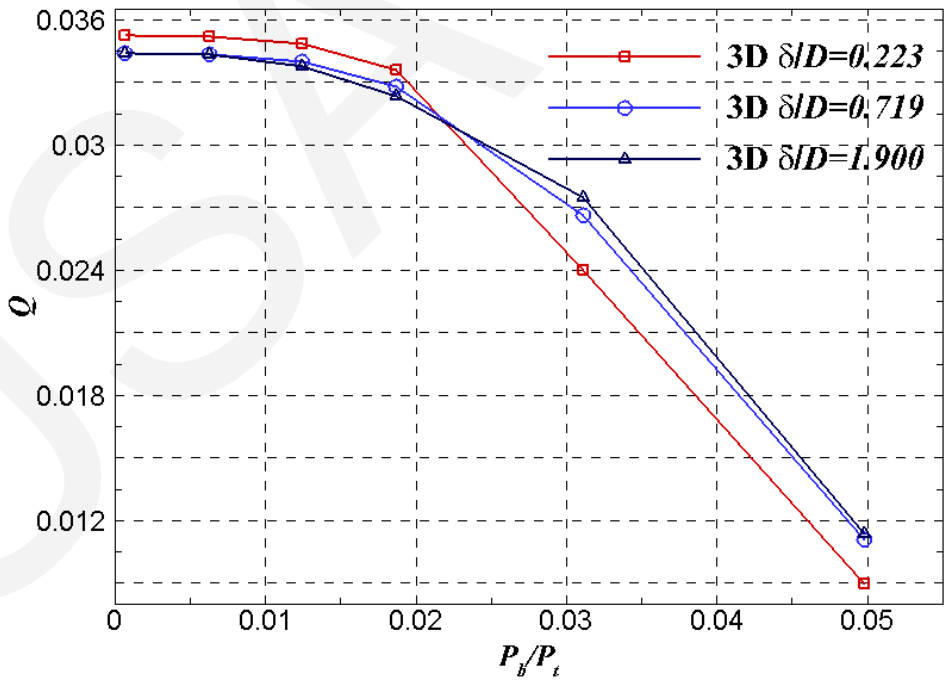
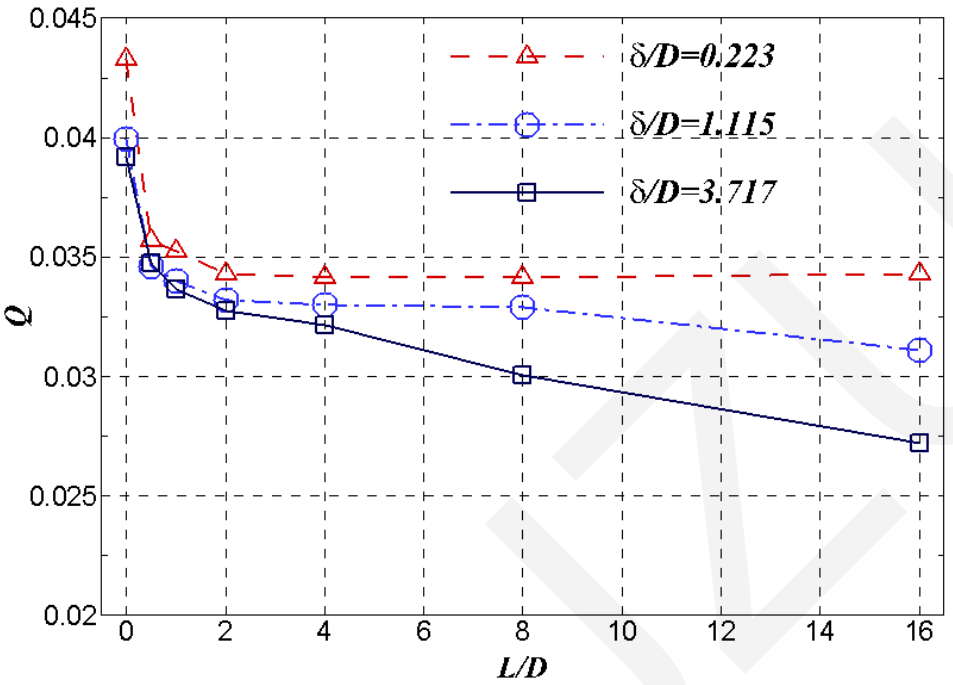


Fig. 4. The effects of 2D and 3D only appears when the pressure ratio exceeds a certain value, and the smaller of the thickness of boundary layer, the more obvious this effects.

The results of the scale *L/D*

The effects of scale *L/D* is studied by simulation with different *L/D* bleed hole.



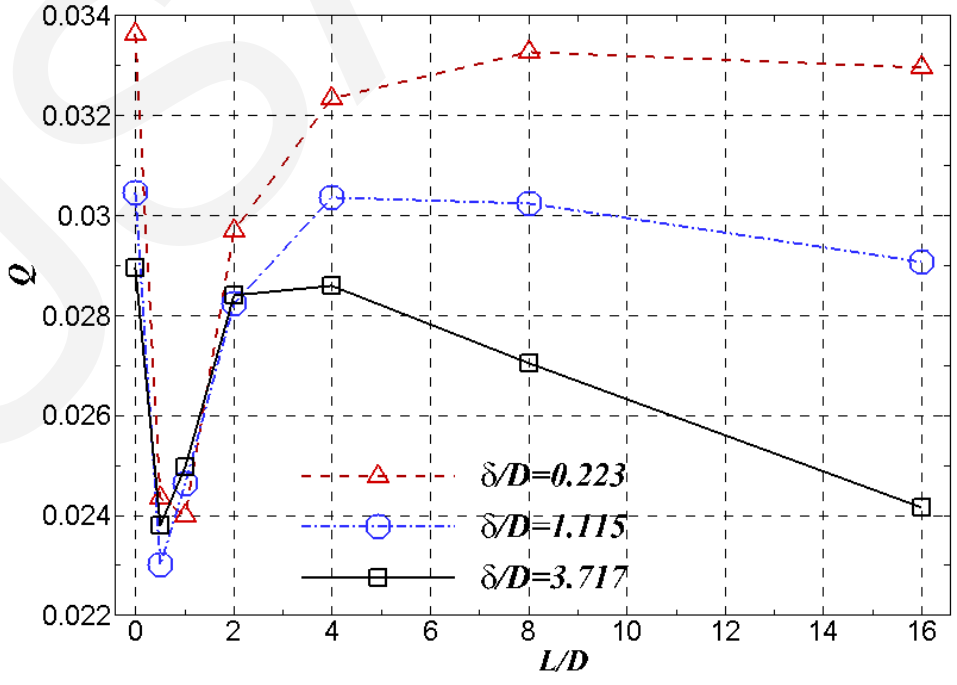


Fig. 5. The bleed mass flow rate has different evolution under chocking and non-chocking conditions with different *L/D*.

Conclusions

- δ determining the location
- D determining the single hole mass flow rate
- L determining the structure of bleed system

When the total bleed mass flow rate is determined, the optimal effect be achieved by reasonably arranging the bleed multi-holes.

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Conclusions

For more information about supersonic bleed, please to refer to the papers below:

[1] Baohu Zhang, Yuxin Zhao,Jun Liu, and Qiancheng Wang. Supersonic Bleed Rate Model for a Circular Orifice Based on Geometric Similarity. AIAA JOURNAL,58(6), 2020.

[2] Baohu Zhang, Yuxin Zhao,Jun Liu. Model and validation of two dimensional compressible bleed flow. Journal of national university of defense technology. 42(2), 2020.

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