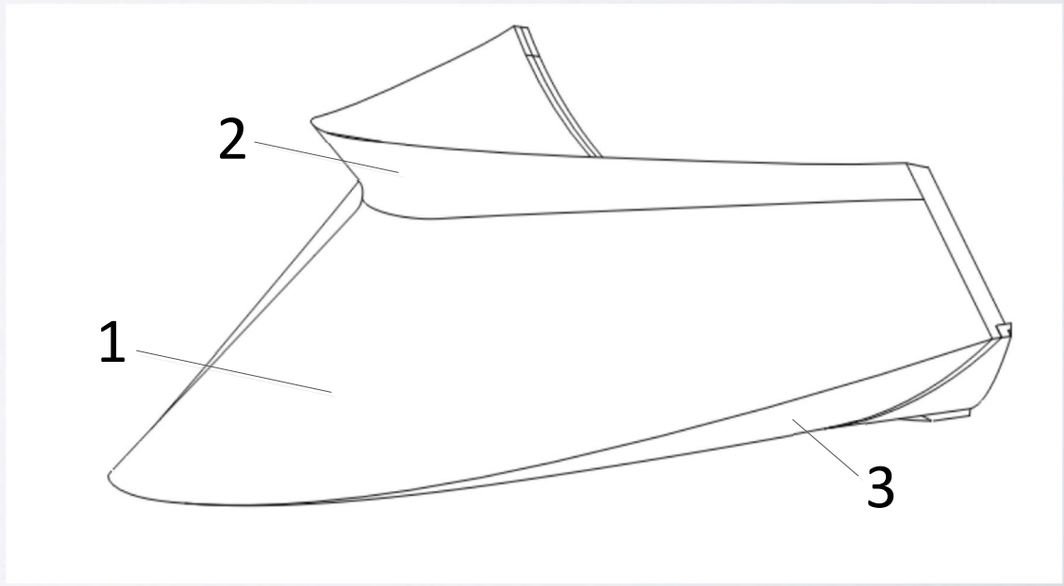
Journal of Zhejiang University-SCIENCE A

Cite this as: Xun Wen, Jun Liu, Jie Li, Feng Ding, Zhi-xun Xia, 2019. Design and numerical simulation of a clamshell-shaped inlet cover for air-breathing hypersonic vehicles. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 20(5):347-357. https://doi.org/10.1631/jzus.A1800620

Design and numerical simulation of a clamshell-shaped inlet cover for air-breathing hypersonic vehicles

Key words:

Aerodynamic configuration design; Novel inlet cover; Aerodynamic force; Heat evaluation



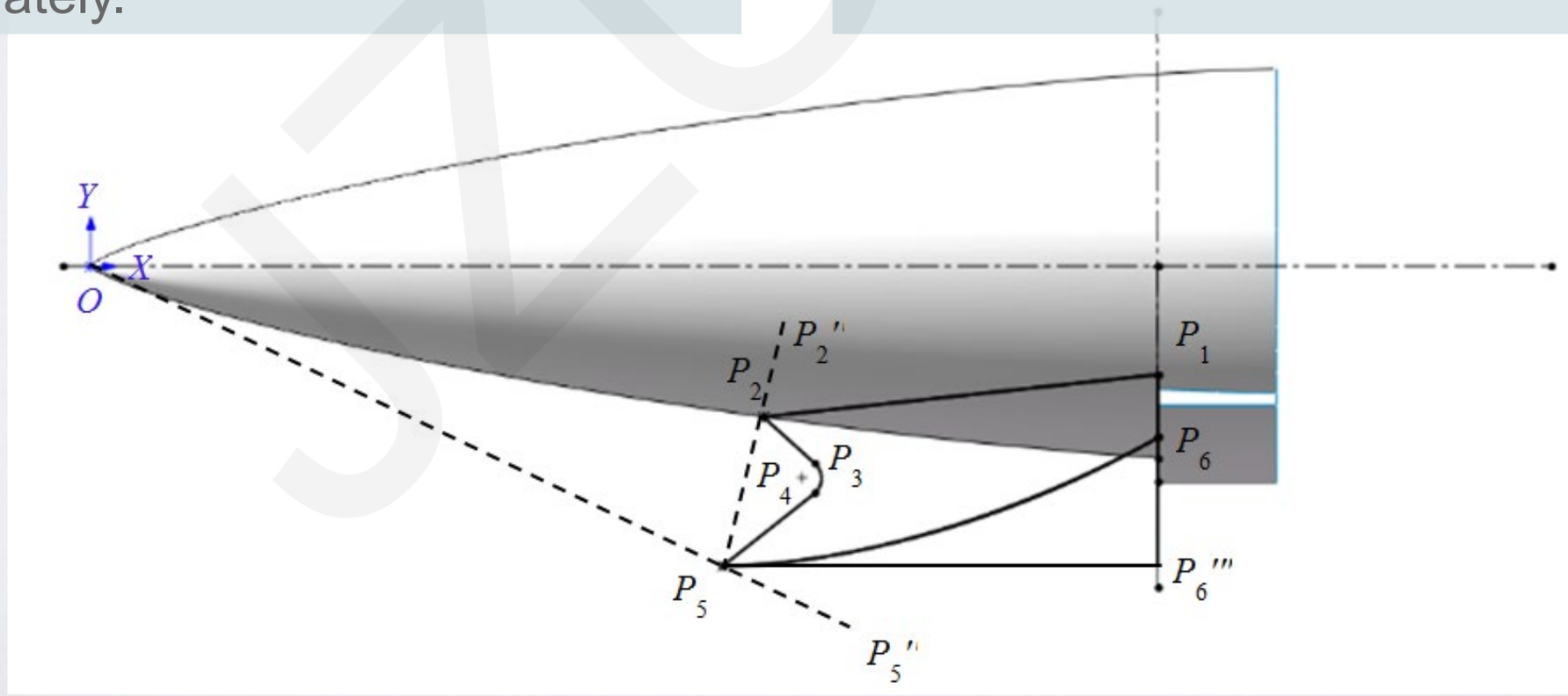
Method

Intentional Application

- In hypersonic vehicles, the precursor shockwave may interact with the bow shockwave at the leading edge of the wings, lips, or inlets.
- To avoid strong reflections of the shockwaves onto the fragile cone, it is necessary to design the shape of the front edge of the inlet cover appropriately.

Accidental Release

- The inlet cover consists of a front separation surface, a transition surface, and a lower surface, in addition to the rear surface consisting of a baffle in the tail.
- Each of these surfaces serves an aerodynamic purpose.



Design parameters

Details in uptake and translocation are discussed under following sections:

- The main part of the cover has a normal vector that points upward and mainly provides the separation force at the stage transition.
- The other part of the front surface has a downward-pointing normal vector, and transitions between and connects the head and inlet cover.
- Without the rear or lower surface, there will inevitably be a cavity at the end of the configuration, and the air inlet of the vehicle will not be shielded or closed over.

$$x_I = \begin{cases} A_{11}y + B_{11}, y \in (Y_{P3}, Y_{P2}) \\ A_{12}y + B_{12}, y \in (Y_{P5}, Y_{P4}) \end{cases}, \quad (4)$$

$$x_{II} = \begin{cases} A_{21}y + B_{21}, y \in (Y_{P3}, Y_{P2}) \\ A_{22}y + B_{22}, y \in (Y_{P5}, Y_{P4}) \end{cases}, \quad (5)$$

$$A = \begin{bmatrix} -1.026 & 348 \\ 1.500 & 920 \end{bmatrix}, B = \begin{bmatrix} -1.083 & 644 \\ 1.278 & 1286 \end{bmatrix}. \quad (6)$$

Table 1 Design parameters of the inlet cover

Design parameter	Value
Ma	6.5
α (°)	0
L (mm)	1,500
R (mm)	250
C (mm)	0
H (mm)	140
x_1	1,350
φ	55

Physical models

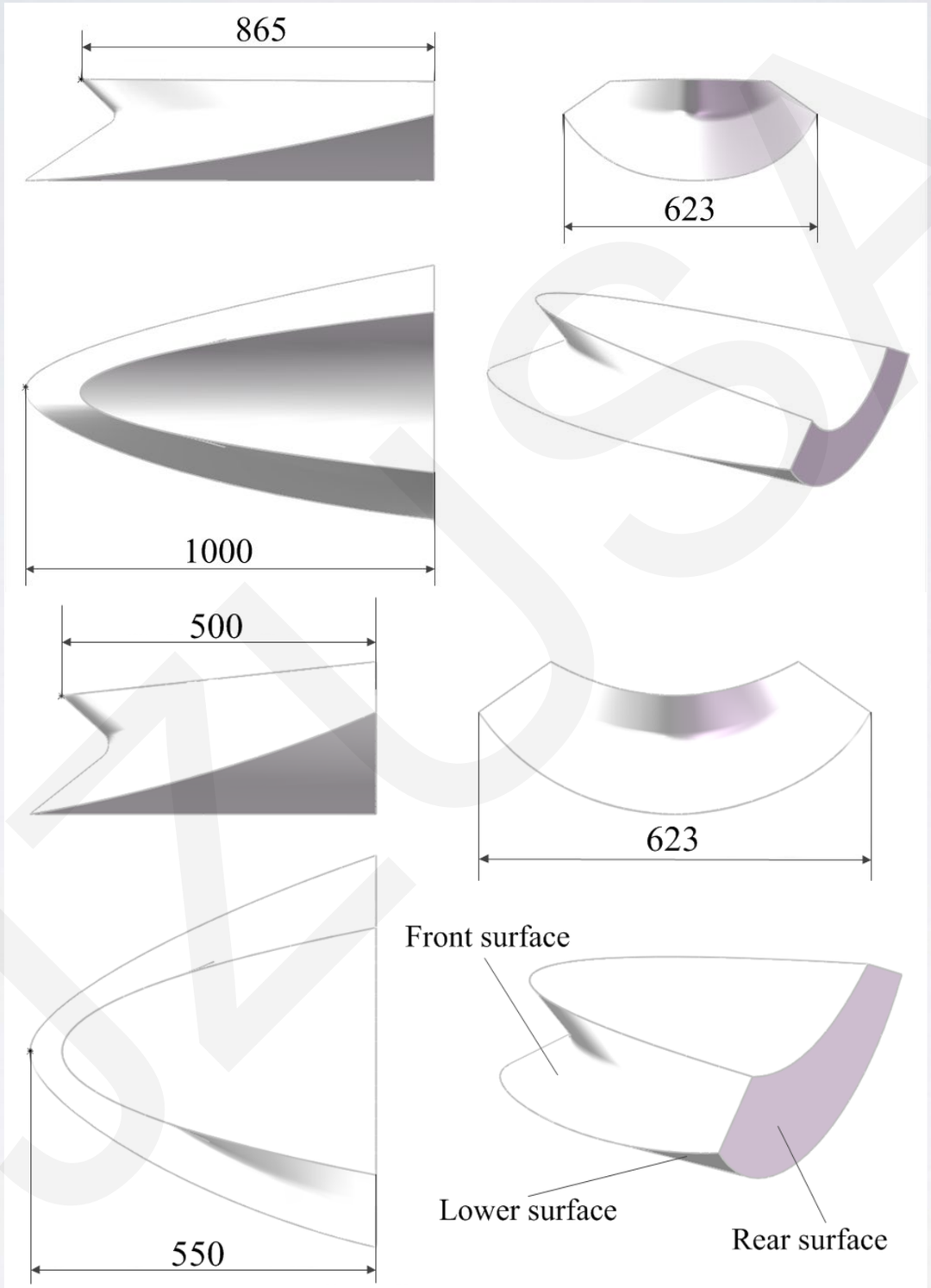


Figure 1. Three views of each inlet covers, a) Profile I, b) Profile II.

Schematic diagram in principle

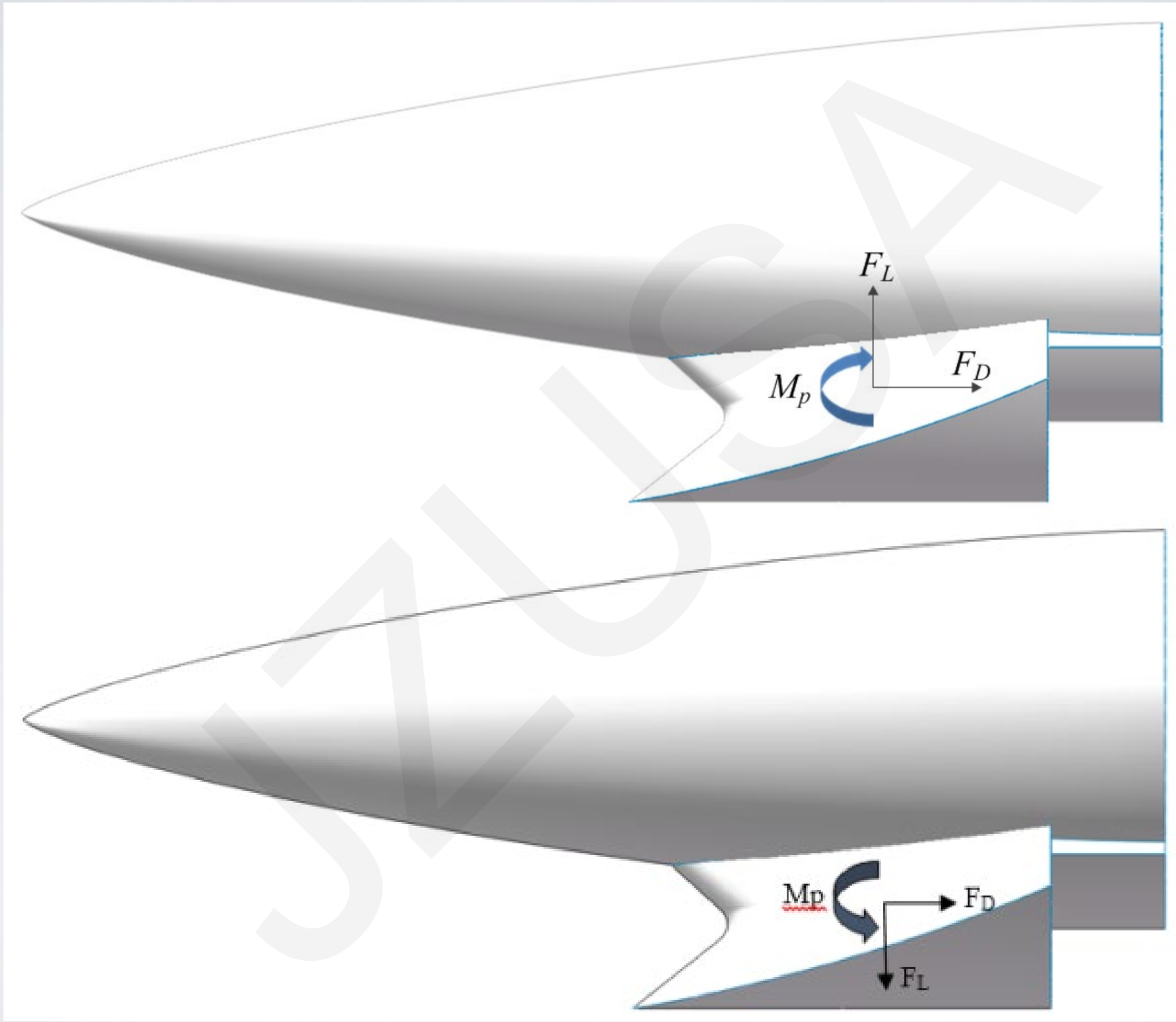


Figure 2. **Schematic diagram of the inlet cover, a) illustration of positive lift and closing tendency, b) illustration of negative lift and opening tendency.**

Results and conclusions

Research Priorities:

- The fairing can generate negative lift force in the separation state and has the tendency of opening automatically.

- Reducing the design length of the fairing is beneficial to reducing the aerodynamic force and reducing the peak heat flux.

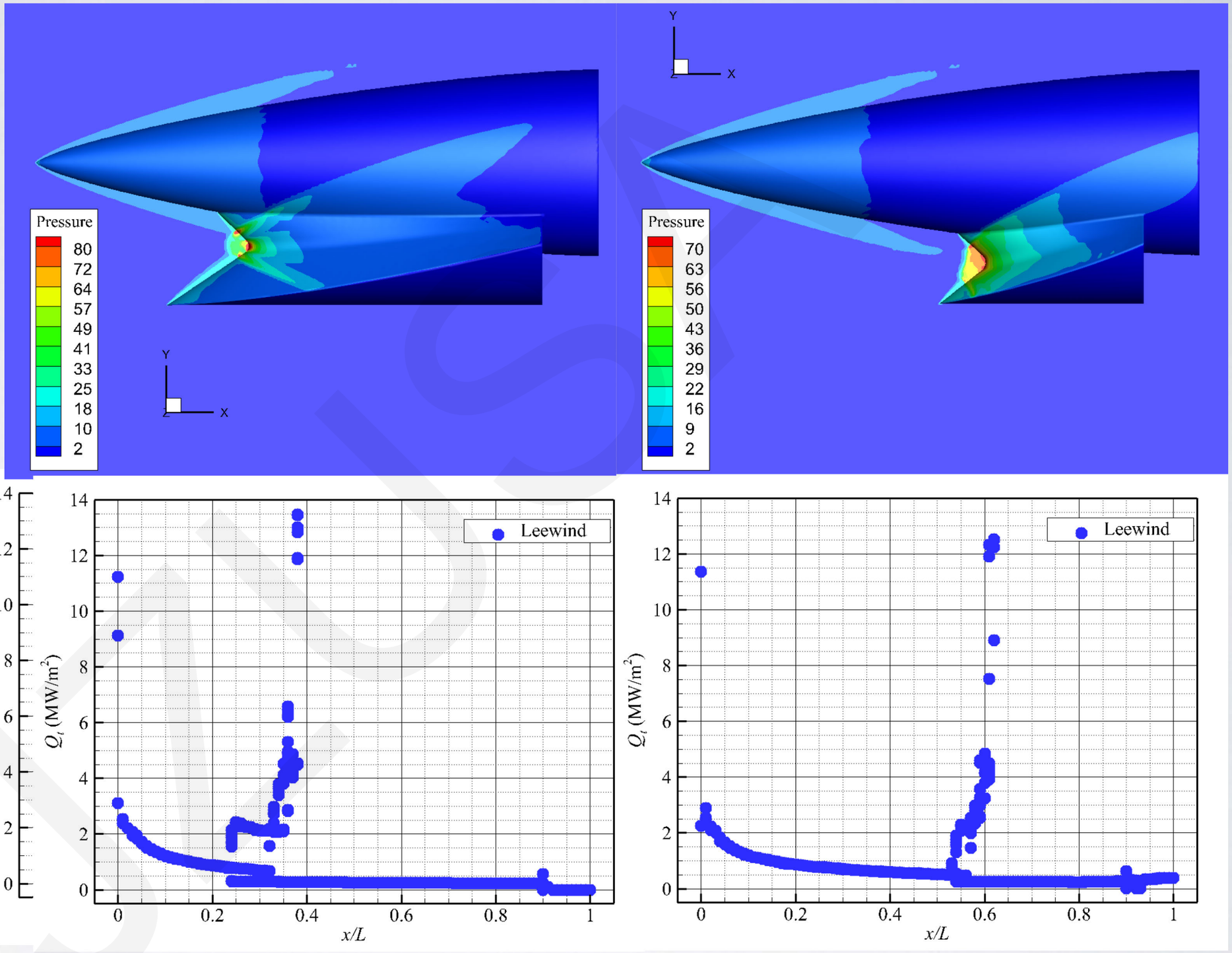


Figure 3. Some of the results, a) pressure contours on the longitudinal symmetric plane of profile I, b) pressure contours on the longitudinal symmetric plane of profile II, c) heat flux in lower meridian for profile I, d) heat flux in lower meridian for profile II.