EXPERIMENTAL INVESTIGATIONS OF SUPERSONIC TURBULENT FLOW OVER A COMPRESSION RAMP

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Abstract Experimental investigations of a 28 deg compression ramp which based on NPLS (Nano-tracer Planar Laser Scattering) and PIV technique are carried out in a Mach 3.0 low-noise wind tunnel, the incoming flow is supersonic turbulent flow (STF). Wave system can be observed by schlieren method, fine flow field structures is visualized via NPLS technique, density distribution is got by measurement based on image gray level analysis, velocity distribution is obtained using PIV technique which showed the separation region of flow field and revealed phenomenons of separation as well as reattachment.

EXPERIMENTAL DEVICE AND NPLS TECHNIQUE

Experimental investigations in this paper are carried out in a Mach 3.0 low-noise wind tunnel, the incoming flow is dried and dust free, the total pressure and stagnation temperature are P_0 = 0.1MPa and T_0 = 300K. The cross section of test chamber is a 100 mm × 120 mm rectangle, the dimensions of its two sides which are installed with high quality optical glass for imaging and testing are 250 mm × 120 mm.

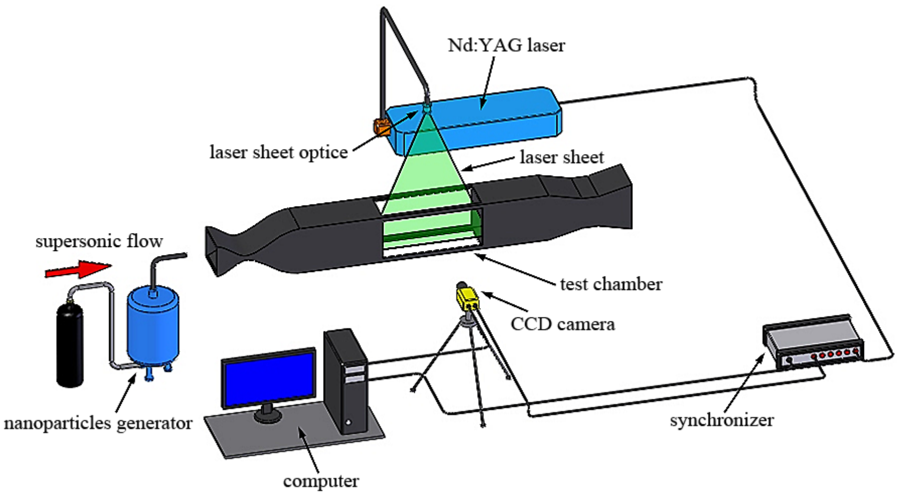

Figure 1. NPLS testing system.

NPLS, is a visualization technique for measuring fine flow structures using nanoparticles for tracing, which based on traditional planar laser scattering, for excellent following ability of the particles which ensures that the distribution of the scattering light can reveal flow structures exactly, NPLS is appropriate for measuring in high speed and complicated flow field, it has been used widely in accurate measurements for supersonic/hypersonic complicated flow[5]. As shown in Figure 1, the NPLS system used in this paper is composed of light source, synchronous controlling, imaging, data acquisition and processing systems as well as nanoparticles generator.
The compression ramp model is shown in Figure 2.

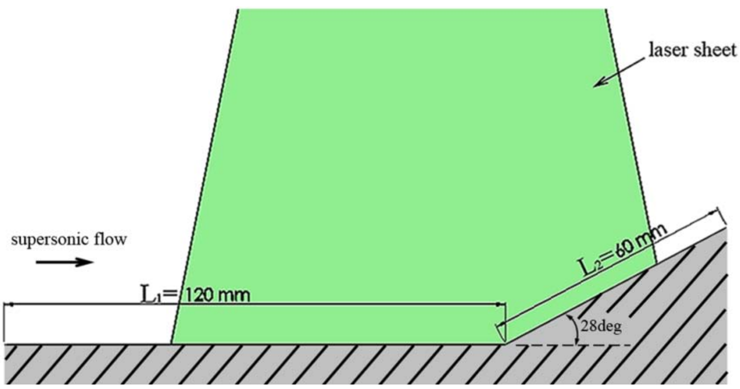

Figure 2. Sketch of compression ramp model.

The length of forepart flat L_1 is 120 mm, the compression ramp length L_2 is 60 mm, the spanwise width d is 100 mm, the ramp angle is 28 deg, the distance between the ceiling of the test chamber and the upper surface of the forepart flat H is 120 mm. The spanwise width of the model is consistent with the spanwise size of the test chamber, which enable the flow to be considered as two-dimensional. These parameters and incoming flow conditions are shown in Table 1.

Table 1. Parameters of compression ramp model.

L_1	L_2	d	H	Ma_∞	$P_{0\infty}$	$T_{0\infty}$	Re_h
120 mm	60 mm	100 mm	120 mm	3.0	0.1 MPa	300 K	7.496×10^6

PRELIMINARY EXPERIMENTAL RESULTS

The transient structure of STF-compression ramp flow field is shown in Figure 3, which distinctly reveals the structures of whole flow field and its evolution, the origin of X is located at the point of inflection. The Mach waves are caused by step between the nozzle, test chamber and experimental model, the supersonic flow forms turbulent boundary layer which develops adequately on the wall of wind tunnel upstream from test chamber, flow separation occurs at somewhere before the ramp as a result of adverse pressure gradient caused by compression effect, at the same time, separation shock wave is formed. A free shear layer is formed between the separated flow and the recirculation region nearby the point of inflection, reattachment occurs at somewhere on the ramp, and a recirculation region forms between the separated point and the reattachment point.

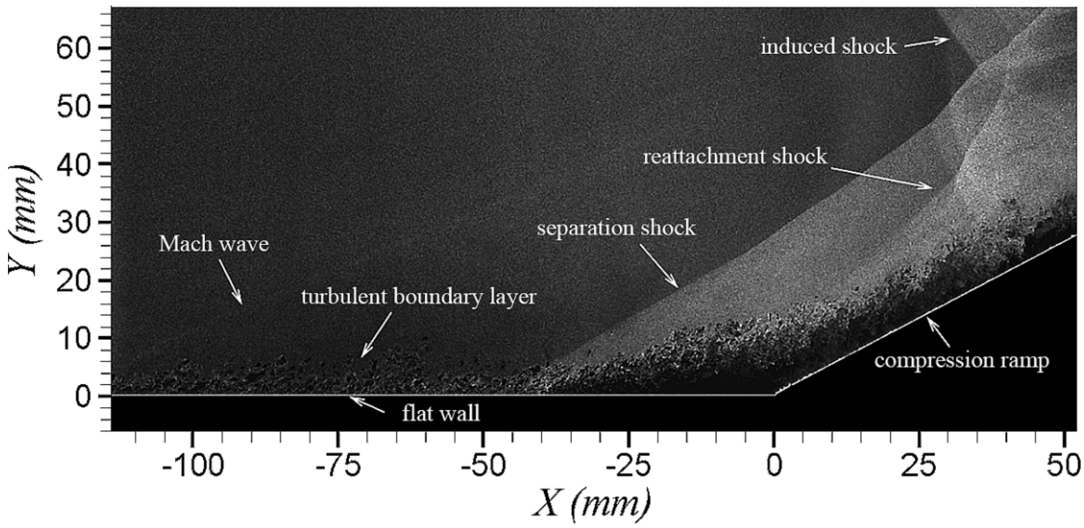

Figure 3. NPLS image of the STF-compression ramp transient flow field.

In further investigations, the schlieren, the fine structures of, the density field and the velocity field distributions of the STF-compression ramp flow field will be obtained and analysed detailedly in the final paper.

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