Study on Sonic/Supersonic Impinging Jets on a Flat Pate
평판에 충돌하는 음속/초음속 제트유동에 관한 연구

김희동, 이호준, 서태원, 금기헌
(안동대학교)

The problem of the impingement of a sonic or a supersonic jet on a flat surface has not only wide applications but has also interesting and very complex flow phenomena. The main applications of this impinging jet include prediction of solid surface erosion, design of launcher systems, stage separation of multi-stage rocket system, V/STOL operations, thermal spray system, and manufacturing technologies of materials.

Much have been learned about the supersonic impinging jet flow field but many fundamental questions have not been answered satisfactorily. The problem encompasses many facets of fluid dynamics which, in combination, present the compressibility effect and the viscous-inviscid interaction, coupled with flow separation and reattachment. What is more, there are many flow parameters that have on the impinging jet flow field, for example, Mach number, Reynolds number, pressure ratio, distance between the nozzle exit and flat plate, jet shock structure, nozzle diameter and etc. Thus the existing data on the supersonic impinging jet flow present considerable disagreement in which quantitative comparison between one result and another is often impossible.

The current work depicts an experimental results about the sonic and supersonic impinging jets at moderate pressure ratios. Five different nozzles having the design Mach numbers of 1.0 to 2.0 were employed. Nozzle wall boundary layer was changed by using a connecting pipe upstream of the nozzle. The distance between the nozzle exit and flat plate, and pressure ratio were changed to investigate their effects on the impinging flow field. Static pressures along the jet centerline and on the flat plate were measured by a pressure transducer(Kulite XCQ-062) and a Scani-valve system, as seen in Figure, and the jet flow field was optically observed by both conventional Schlieren photograph and Schlieren Interferometry.

Numerical computation using mass-averaged explicit Navier-Stokes equations was applied to axisymmetric compressible flow field. A mesh generation code was employed to produce unstructured and structured meshes. The governing equations were discretized in space using a finite volume difference formulation. Adiabatic no-slip conditions were assumed at solid wall boundaries, while the non-reflecting gar-field boundary was constructed using the Riesman invariants. The standard k-e turbulence model was employed to close the governing equations. The obtained data was used to show the effects of Mach number, pressure ratio, boundary layer thickness, and the distance between the nozzle exit and flat plate on the pressure distribution over the flat plate surface.