Instructions for poster paper submission

Format-

- Please make your paper in **Microsoft Word**(paper_number.doc) only
- For details like margins, formats etc., please scroll down to view
- A sample paper is also provided in .doc format, please refer **Sample paper.doc**
- File memory size should not exceed 10 MB
- Text, figures and numbers should be in black & white only

Paper Length-

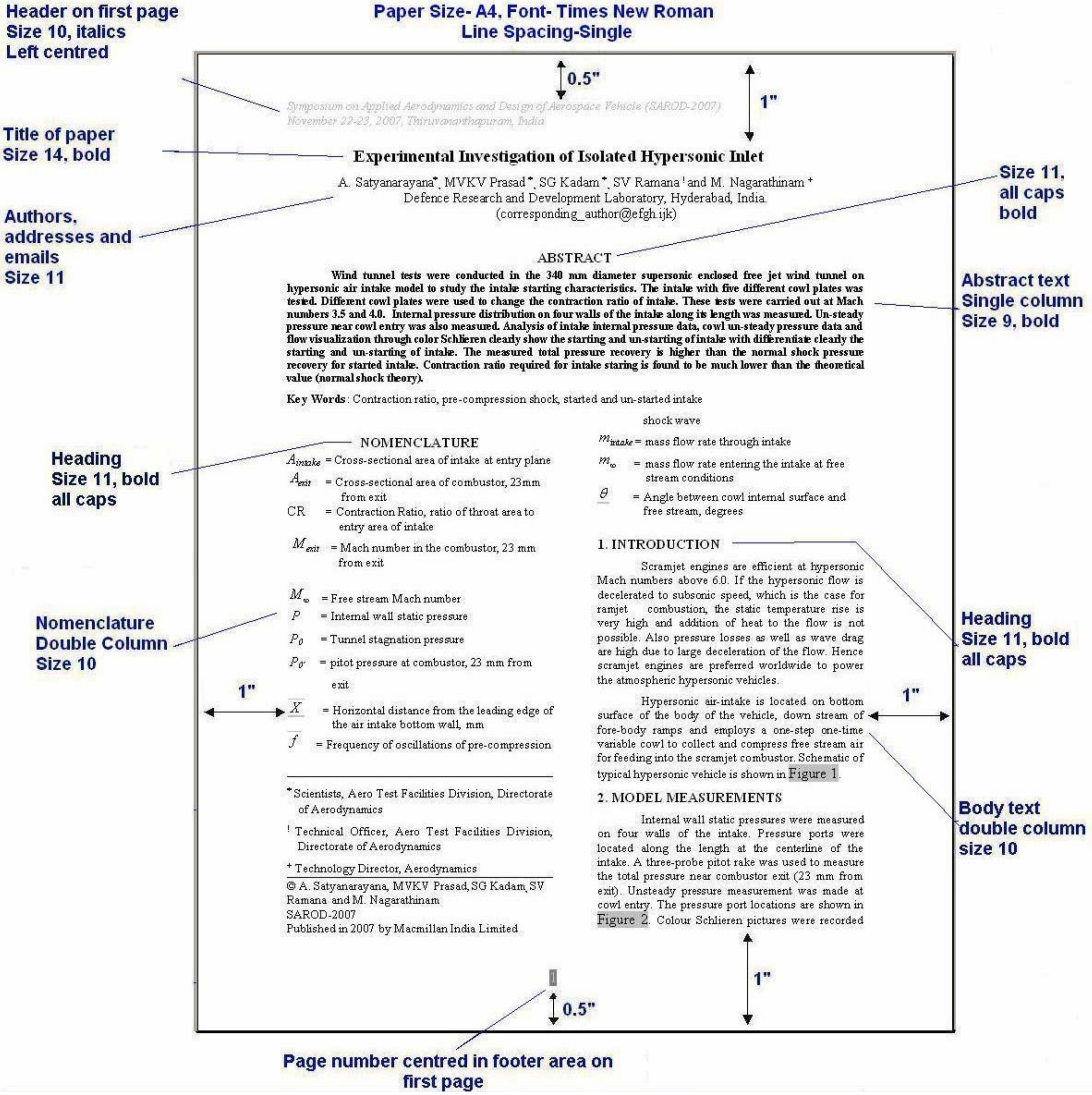
- Maximum – 6 pages

Paper submission-

- Paper should be sent by email only to **sarod07_review@yahoo.co.in,** latest by September 30, 2007.

In case of any difficulty please contact us

Pankaj Priyadarshi
Host Org. Secretary, SAROD-2007,
ADD / ADTG / AERO Entity, VSSC,
Trivandrum - 695 022 (India)
Ph. 91-471-256 4644 (O)
Ph. 91-471-270 4081 (R)
FAX 91-471-256 4097, 270 4134
e-mail: pankaj_priyadarshi@vssc.gov.in



Symposium on Applied Aerodynamics and Design of Aerospace Vehicle (SAROD-2007)
November 22-23, 2007, Thiruvananthapuram, India

Experimental Investigation of Isolated Hypersonic Inlet

A. Satyanarayana*, MVKV Prasad*, SG Kadam*, SV Ramana ! and M. Nagarathinam +
Defence Research and Development Laboratory, Hyderabad, India.
(corresponding_author@efgh.ijk)

ABSTRACT

Wind tunnel tests were conducted in the 340 mm diameter supersonic enclosed free jet wind tunnel on hypersonic air intake model to study the intake starting characteristics. The intake with five different cowl plates was tested. Different cowl plates were used to change the contraction ratio of intake. These tests were carried out at Mach numbers 3.5 and 4.0. Internal pressure distribution on four walls of the intake along its length was measured. Un-steady pressure near cowl entry was also measured. Analysis of intake internal pressure data, cowl un-steady pressure data and flow visualization through color Schlieren clearly show the starting and un-starting of intake with differentiate clearly the starting and un-starting of intake. The measured total pressure recovery is higher than the normal shock pressure recovery for started intake. Contraction ratio required for intake staring is found to be much lower than the theoretical value (normal shock theory).

Key Words: Contraction ratio, pre-compression shock, started and un-started intake

NOMENCLATURE

A_{intake} = Cross-sectional area of intake at entry plane
A_{exit} = Cross-sectional area of combustor, 23mm from exit
CR = Contraction Ratio, ratio of throat area to entry area of intake
M_{exit} = Mach number in the combustor, 23 mm from exit
M_∞ = Free stream Mach number
P = Internal wall static pressure
P_0 = Tunnel stagnation pressure
$P_{0'}$ = pitot pressure at combustor, 23 mm from exit
X = Horizontal distance from the leading edge of the air intake bottom wall, mm
f = Frequency of oscillations of pre-compression shock wave
m_{intake} = mass flow rate through intake
m_∞ = mass flow rate entering the intake at free stream conditions
θ = Angle between cowl internal surface and free stream, degrees

* Scientists, Aero Test Facilities Division, Directorate of Aerodynamics
! Technical Officer, Aero Test Facilities Division, Directorate of Aerodynamics
\+ Technology Director, Aerodynamics
© A. Satyanarayana, MVKV Prasad, SG Kadam, SV Ramana and M. Nagarathinam
SAROD-2007
Published in 2007 by Macmillan India Limited

1. INTRODUCTION

Scramjet engines are efficient at hypersonic Mach numbers above 6.0. If the hypersonic flow is decelerated to subsonic speed, which is the case for ramjet combustion, the static temperature rise is very high and addition of heat to the flow is not possible. Also pressure losses as well as wave drag are high due to large deceleration of the flow. Hence scramjet engines are preferred worldwide to power the atmospheric hypersonic vehicles.

Hypersonic air-intake is located on bottom surface of the body of the vehicle, down stream of fore-body ramps and employs a one-step one-time variable cowl to collect and compress free stream air for feeding into the scramjet combustor. Schematic of typical hypersonic vehicle is shown in Figure 1.

2. MODEL MEASUREMENTS

Internal wall static pressures were measured on four walls of the intake. Pressure ports were located along the length at the centerline of the intake. A three-probe pitot rake was used to measure the total pressure near combustor exit (23 mm from exit). Unsteady pressure measurement was made at cowl entry. The pressure port locations are shown in Figure 2. Colour Schlieren pictures were recorded

1

Page number in header area Left aligned for even pages

Header for even pages Authors names Size 10, italics Centre aligned

with video camera at shutter speed of 1/2000 second to capture the un-steady shock.

3. DISCUSSION OF TEST RESULTS

Internal wall static pressures were measured on four walls of the intake. Pressure ports were located along the length at the centerline of the intake. A three-probe pitot rake was used to measure the total pressure near combustor exit (23 mm from exit).

Sub-heading Size 11, bold

3.1 Effect of opening of air-intake

Internal wall static pressures were measured on four walls of the intake. Pressure ports were located along the length at the centerline of the intake. A three-probe pitot rake was used to measure the total pressure near combustor exit (23 mm from exit).

4. CONCLUSION

Sub-heading Size 11, bold

Acknowledgment

REFERENCES

1. Lawrence D. Huebner, Kenneth E. Rock, Edward G. Ruf, and David W. Witte, "Hyper – X Flight Engine Ground Testing for Flight Risk Reduction," Journal of Spacecraft and Rockets, vol.38, No.6, November – December 2001.

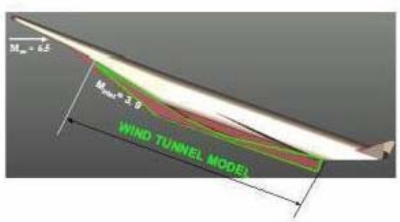


Figure 1 geometry of hypersonic vehicle

Figures and Tables Double Column

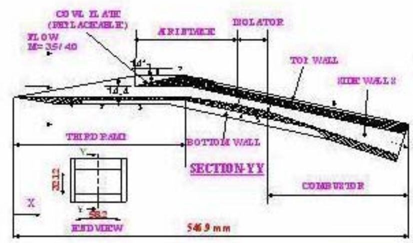


Figure 2 Pressure port locations

Caption Size 10, bold

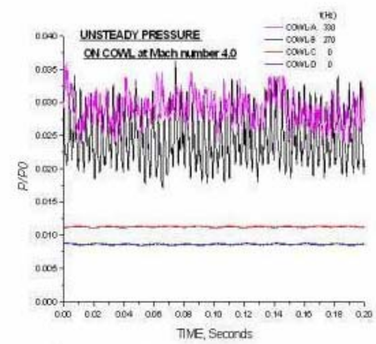


Figure 3 Unsteady Pressure Measurements

Header for odd pages
Paper title
Size 10, italics
Center aligned

Page number in header area
Right aligned for odd pages

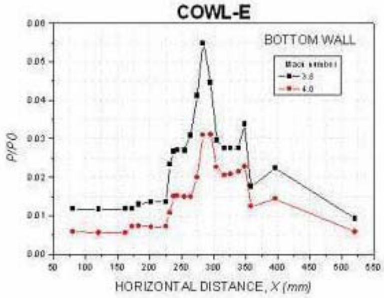


Figure 4 Comparison of bottom plate pressure at M=3.5 & 4