Smart Shell Co,Ltd

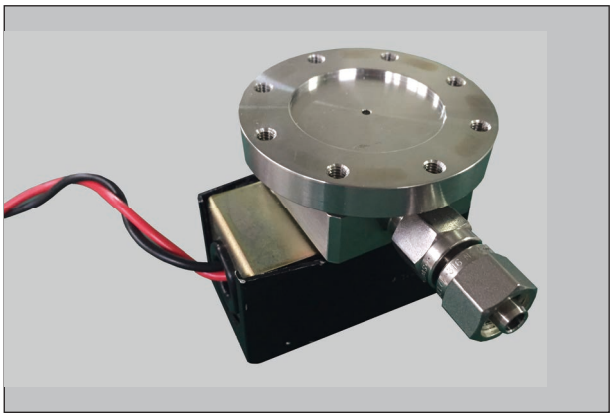
SMART SHOT

Wave-free supersonic pulsed gas jet system

The wave-free supersonic pulsed gas jet system SMARTSHOT™ is developed as a gas target for laser-plasma interaction studies such as laser-plasma acceleration, X-ray lasers, laser-plasma X-ray sources, etc. It can be used for the experimental studies which require the production of very localized high-density gas target with high repetition rate in vacuum.

Density distribution of the gas jet

1. Wave-free supersonic slit nozzle (MS series)
2. High-speed solenoid valve (A2-6 series)
3. Fast pulsed valve driver (LX-03R)



(A2-6275-FL + MS05-10-120-1405)

(LX-02-Prototype)

Characteristics of the system

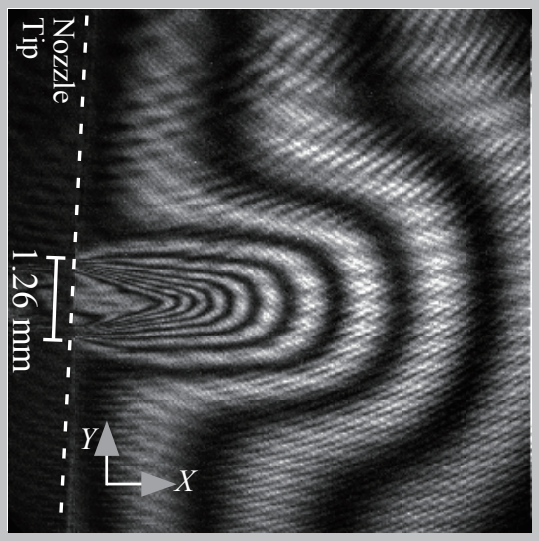
1. The system uses a special slit nozzle to produce localized uniform gas jet in tiny region. It is designed by aerodynamic method and manufactured by micro-machining *.
2. The system uses a valve which can eject high-pressure gas (up to 7(10) MPa) through an orifice with large diameter. Accordingly, this can allow to use the slit nozzle with larger throat size and higher Mach number.
3. The valve can be operated with high-speed opening and closing (100-200μs) by proper driving pulse control. The valve can open fully and provide a stable ejection pressure even under the condition of regulation pressure of 10MPa **.
4. By the current output monitor signal from the LX-03R the gas jet operation can be precisely synchronized with laser pulses or signals from another devices. (In this case trigger pulse into LX-03R is required.)

* It has been applied for a patent in JAPAN (No.2004-100878)

** The ejection gas pressure reduction due to stroke shortening of an armature inside the solenoid valve can not occur even in high-pressure range at 10MPa. (we recommend up to 7MPa for normal use.)

High speed valve A2-6 series

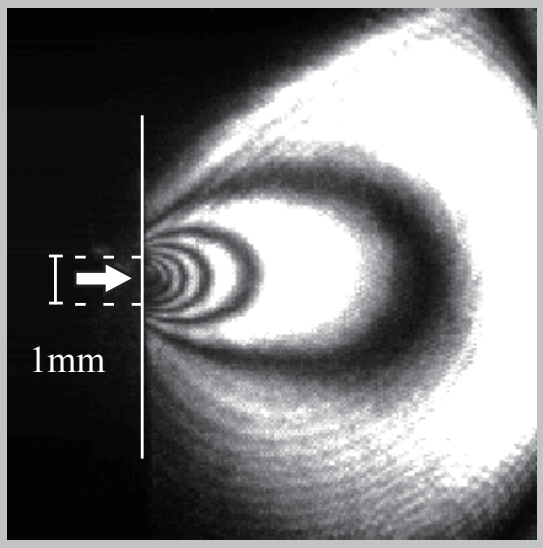
The interferogram image of the gas jet by the wave-free supersonic slit jet shows a contour density map.



Example of supersonic gas jet injection into vacuum by the Wave-free slit nozzle.

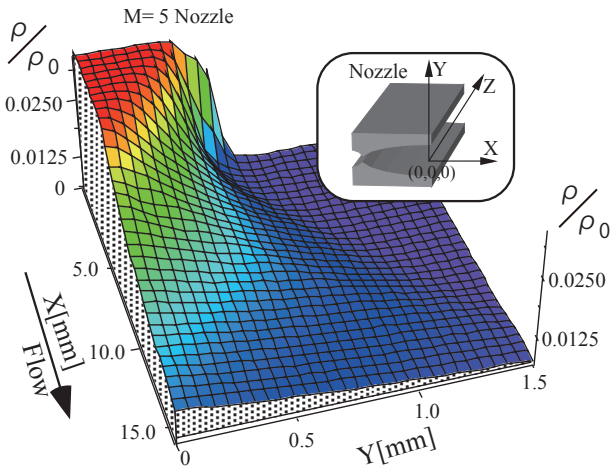
(Ar-gas, Stagnation pressure:6MPa
Wave-free slit nozzle, MS05-10-166
(Mach no.5, 1.2x10.0 mm for g=1.66))

Cf.



Example of sonic gas jet injection into vacuum by a conical nozzle.

(Ar-gas, Stagnation pressure:2MPa)



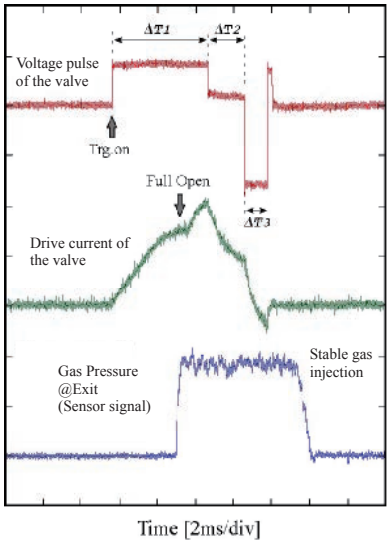
Density distribution of the gas jet (3D-plot)

As shown in the interferogram image, the wave free nozzle can produce a supersonic laminar flow with sharp boundary between gas jet and Vacuum.
In contrast to sonic injection, an uniform density distribution is formed inside triangular area at the exit of the nozzle*. (See red region in 3D-plot.)

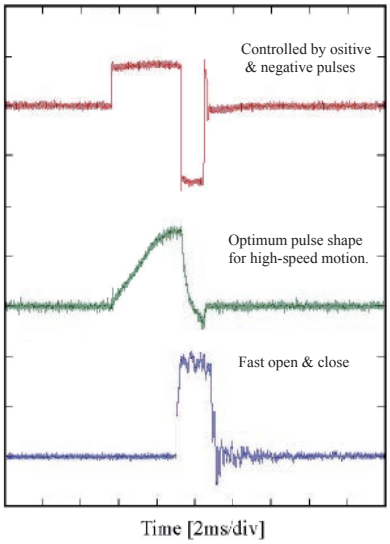
** Reference J. D. Anderson, Jr, Modern Compressible Flow with Historical Perspective 2nd Edition, (Mc Graw Hill,1989)*

Time response of the gas jet

Normal operation

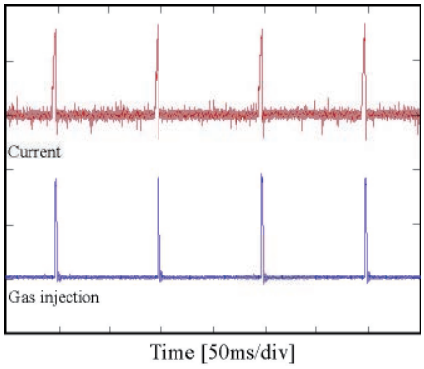


Fast mode operation



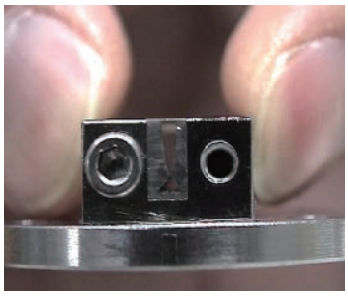
Typical time response of the solenoid valve. (He 10MPa, A2-6304)

10 Hz operation

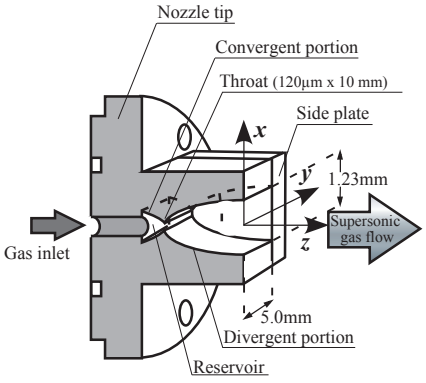


Maximum pressure 10MPa
High-speed open&Close ~200μs
Flat top ~1.8ms (for Helium)
Rep. rate maximum 10Hz

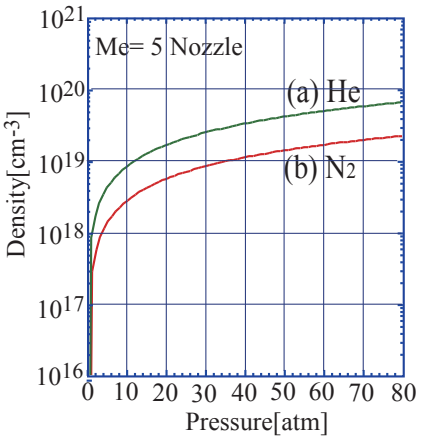
Wave- free supersonic nozzle MS series



We can design the nozzle based on your requirements, such as density and species of gas, target size (L x W), Mach number of the flow, available gas pressure etc.



Sample Pictures (MS05-10-166)



Sample;

Stagnant pressure vs. Density @ exit of the nozzle

Mach number = 5
(a) for helium gas
(b) for N2 gas

High speed valve A2-6 series

> Valve Type A2-6443
> Orifice (D) [mm] φ1.5
> Operation Range [MPa] 0.01 - 7(10)
> Remarks low leakage (Soft poppet)
> Gas temperature -10 - 40℃ (No freeze)

Specification

1) LX-03R Fast Solenoid Valve Driver

Input Voltage ..... 85 - 264V (AC)
Drive voltage ..... 40 - 180V (Pulse)
Pulse duration for excitation 0.1-99ms
Pulse duration for negative voltage 0.1-10.1ms
Maximum Drive current 35A

2) A2-6443 Fast Solenoid Valve

Out-let Aperture size ..... D=1.5 mm
Maximum working pressure 7MPa
Internal leakage ..... Less than 10 cm^3/min
External leakage ..... Less than 1.33*10-6Pa*m^3/s He
Voltage ..... DC48V for driving armature (7~10 ms),
DC12V for keeping armature position (0~10 ms)
Gas Connection ..... 1/4 inch Swagelok
Repetition ..... 10Hz (Max)

3) MS05-XX-166 Wave-free slit nozzles

Nozzle Wall ..... designed by the Method of Characteristics
Exit slit size ..... (1.2x XXmm)
Throat width ..... 120 micron with slit shape
Pulse duration for negative voltage 0.1-10.1ms
Mach Number at Exit of nozzle ..... ~5 (for Helium, Argon)

Smart Shell Co.,Ltd

Selling agency

JLC
JAPAN LASER

3-1-30, Nishiki, Naka-ku, Nagoya

TEL 052-205-9711
FAX 052-205-9713

URL: www.japanlaser.co.jp
E-Mail: sasaki@japanlaser.jp