Datasheet: PC-SF-Plasma Jets

Characteristics

- **First cannula jet with straight forward construction**
- **Well suited for direct processing of wires, fibers, yarn, powder, aerosols or thin rods**
- **Applicable in coating, cutting, cleaning, activation, melting, welding or rapid heating (different jet variants)**
- **Atmospheric plasma for high power levels up to 500 W**
- **Well suited for automated applications**
- **Very low energy consumption/ self heating**
- **Potential-free, maintenance-free and wear-free**

Overview

The patented PC-SF-Jet (**P**lasma**C**annula-**S**traight**F**orward-Jet) is the first plasma jet with a straight forward cannula construction. This enables an effective and easy transport of additives such as wires, fibers, yarn, powder or aerosol straight through the plasma!

The PC-SF-Jet is part of the microwave plasma jets available at Heuermann HF-Technik GmbH, which, in combination with our PlasMaster PCU generators, are the first commercially available 2.45 GHz atmospheric plasma sources in the power range between 20 W and 500 W. The physical advantages of the 2.45 GHz plasmas (microwave plasmas) have been verified in many scientific publications. These new jets now offer practical users and scientists these advantages for a variety of implementations.

This special SF Plasma Jet can principally be used for activating, cleaning and rapid heating of different materials. Furthermore, due to its unique construction, powder, aerosols, and thin rods can be transported via the inner electrode directly through the plasma for most effective welding, coating, melting, cutting, rapid heating or activation.

Fig. 1: The PC-SF3 jet at about 250 W with adaptor containing a stainless steel tube to separate gas 1 from eventual powder or aerosol to be treated.

Product Overview of the PC-SF-Jet

The plasma jet from HHF consists of an aluminum and stainless steel housing and uses Teflon and various temperature-resistant copper alloys as electrode feed, inner high-voltage transformer network, as well as electrodes. There is no tungsten implemented, so that oxygen and air can be used as process gas. The jet can principally cope with all non-aggressive gases as process gas. The electrodes are wear-free and maintenance-free. Spectroscopic measurements confirm that no electrode material is to be found in the plasma, guaranteeing a pure gas plasma.

The PC-SF-Jet requires argon as process gas, going through the inner electrode. Furthermore, oil free air is required for cooling. At the operation frequency in the ISM frequency band at 2.45 GHz, the jet can easily cope with power levels of up to 200 W delivered by the PlasMaster generators of Heuermann HF-Technik GmbH.

Specifications of the PC-SF-Jet

The general specifications of the jet are summarized in Tab. 1:

Parameters	Min	Typ.	Max	Unit	Comment
Frequencies of ignition and operation	2.4		2.5	GHz	In the ISM frequency band
Gas connection					
- Gas 1, process gas	0.2		2	sl / min	Argon or varigon
- Gas 2, cooling	1		5	sl / min	Air or nitrogen (oil-free)
Power required for ignition	130		350	W	Depending on gas flow and jet
Microwave power for operation	60		500	W	Can be regulated after ignition
Dimensions					
- width			35	mm	Diameter, without connection for gas
- length		150	210	mm	Length (standard configuration and with optional adaptor)
Weight		475		g	

Tab.1: Specifications of the SF plasma jet.

Technical Descriptions

One of the main features of this jet is the conductance of gas 1 (mainly argon) which runs straight through the plasma. Powder or aerosols can be mixed with the argon and thus highly effectively activated. Furthermore, thin rods (metallic and non-metallic) can be melted by the plasma at temperatures well above 3,000 °C and used for coating on surfaces, which are activated by the plasma.
The jet can also freely be used to activate, clean or rapidly heat surfaces.

Gas 2 (generally oil free air or nitrogen for an more inert environment) is conducted between the inner electrode and the outer conductor. The kind of gas implemented and the actual flow rate have a major influence on the process characteristics and determine the resulting temperature of the plasma, which is directly proportional to the microwave input power and inversely proportional to the gas flow rate.

Although the plasma temperature can be well above 3,000 °C, even temperature sensitive sheets can be successfully treated by optimizing the process parameter:

- Process velocity,
- Distance between jet and object,
- Microwave power,
- As well as the gas flow.

Using varigon instead of argon as process gas results in a higher plasma temperature (around 10 to 15 %).
Replacing air through nitrogen normally leads to a higher level of activation and reduces the burnt effect (darkening) caused by oxidation.
By optimizing the process parameters, the plasma temperature can be varied from below 100 °C to a few thousand degrees.

In the standard configuration, the process gas is fed to the plasma through the inner electrode (such as in PC-SF3 and PC-SF5, cross section in Fig. 2).
For special applications where an additive (such as powder or aerosols) is to be treated, an adaptor is available. In this configuration (PC-SF2, PC-SF4 and PC-SF6), the adaptor presents separate connections for the additives and the process gas (cross section in Fig. 3). An exchangeable stainless steel tube (O-tube) with an outer diameter of 1.5 mm and an inner diameter of 1.3 mm is inserted in the adaptor. O-tubes with smaller inner diameters going down to 0.2 mm are available on demand. Alternatively, a ceramic o-tube is also available.
The position of the corresponding tube within the inner electrode can effect the ignition and should not be observed (please see Remarks to Assembly of the Adaptor).

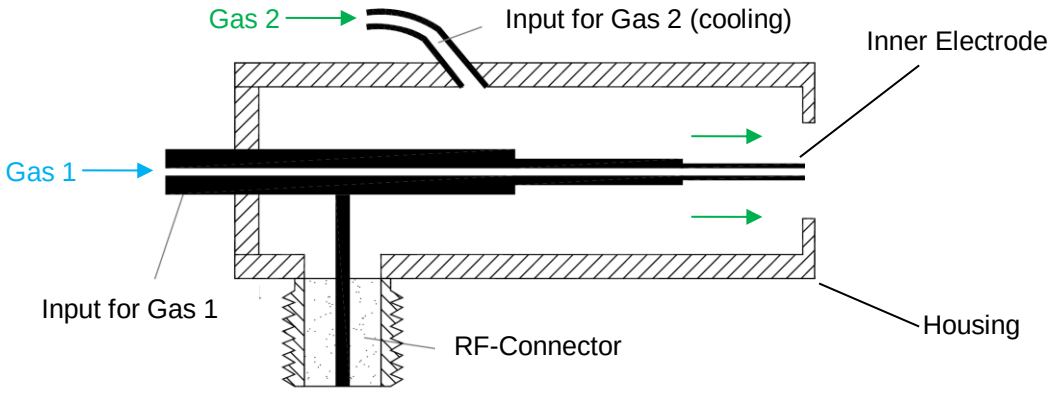


Fig. 2: Simplified sectional view of the PC-SF plasma jet to illustrate the construction and the two gas connections (here without adaptor = standard configuration).

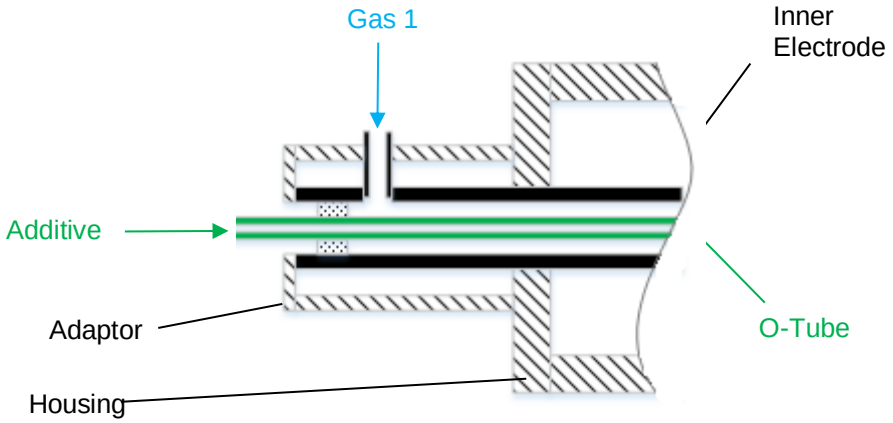


Fig. 3: Simplified cross section of the PC-SF2-Jet (also SF4, SF6) demonstrating the gas flow in combination with the exchangeable O-tube.

Overview of the variants:

Jet	Power level	Process gas (1)	Generator	Comment	Application
PC-SF2	60 - 250 W	argon	PCU-L250	with adaptor (Fig. 3), N connector	Also applicable for powder and aerosols
PC-SF3	80 - 500 W	air / nitrogen	PCU-L500	no adaptor (Fig. 2), 4.3/10 connector	Activation, cleaning, heating
PC-SF4	80 - 500 W	air / nitrogen	PCU-L500	with adaptor (Fig. 3), 4.3/10 connector	Also applicable for powder and aerosols
PC-SF5	80 - 500 W	argon	PCU-L500	no adaptor (Fig. 2), 4.3/10 connector	Activation, cleaning, heating
PC-SF6	80 - 500 W	argon	PCU-L500	with adaptor Fig. 3), 4.3/10 connector	Also applicable for powder and aerosols

Tab. 2: Overview of the different PC-SF-Jets.

Overview of the Characteristics of the PC-SF-Jet

- High-purity atmospheric 2.45 GHz plasma with power ratings up to 200 W (CW operation).
- Activation / cleaning / rapid heating of diverse materials and shapes including plastics and thin foils.
- Can be used for a variety of gases (two classes of jets: inert gases (argon) and the rest).
- Line and broad beams for hot and colder applications.
- Well suited for hand and robot applications (100% potential-free).
- Extremely low energy requirements.
- Extremely handy (even shorter models available upon request).
- Robust jets in stainless steel housing.
- Maintenance-free and wear-free.

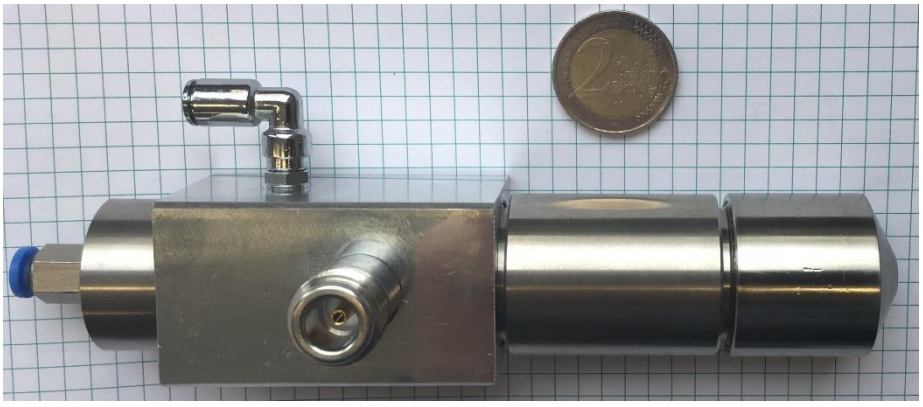


Fig. 4: The PC-SF3-Jet in standard configuration without adaptor.

Remarks to Assembly of the Adaptor and Gas Flow

As seen in Fig. 3, using the adaptor, different materials such as powders, aerosols or wires can be passed through a stainless steel o-tube that merges in the plasma and be directly treated. The o-tube is passed through a PTFE cylinder and clamped in place within the adaptor with a special hollow screw. Fig. 5 (left) shows the o-tube in the PTFE cylinder. When clamping the o-tube, make sure that **the o-tube is set a little (around half a millimeter) behind the inner**

electrode (Fig. 5, right), so that the o-tube is not directly exposed to the plasma. This will cause the o-tube to be thermally damaged, up to being melted.

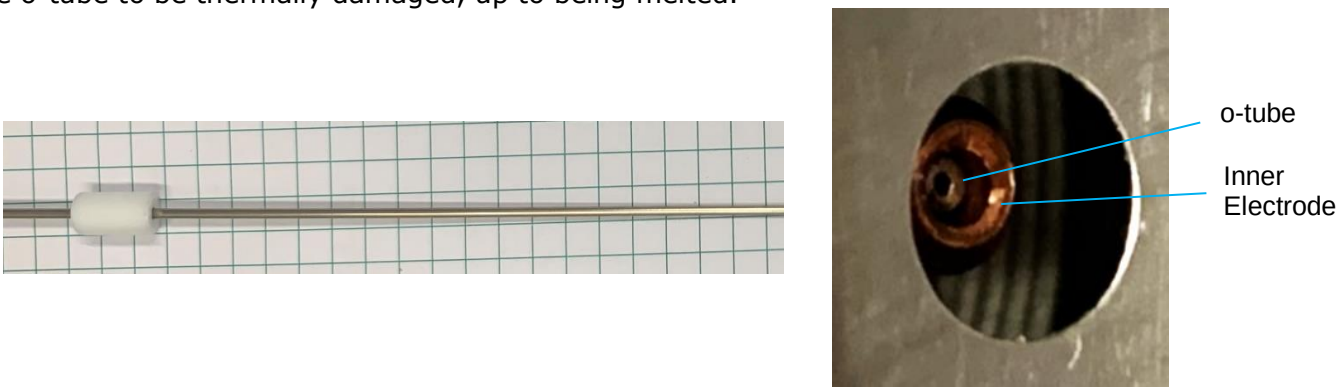


Fig. 5: The o-tube in the PTFE cylinder, which is set in the adaptor (left) and the position of the o-tube in the inner electrode (right).

The gas flow has a direct effect on the plasma form, intensity and temperature, especially the process gas in combination with the adaptor. Lower flow rates lead to a broader plasma with a higher temperature, which is more suitable for a homogeneous treatment through the o-tube. Fig. 6 shows the plasma in combination with a few different flow rates for the process gas at different power level.

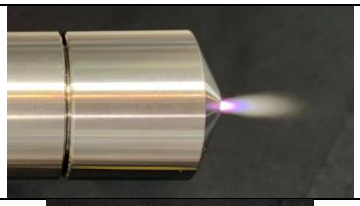
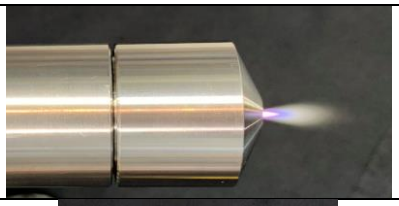
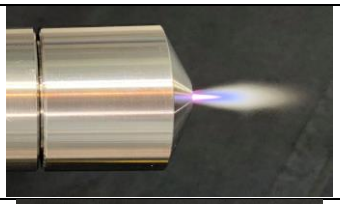
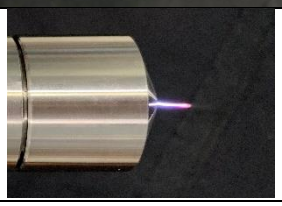
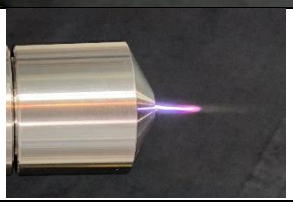
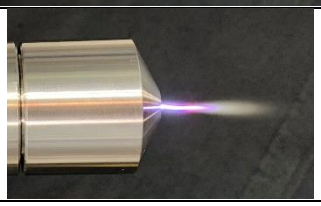
	50 W	100 W	200 W
0,5 sl/min			
2 sl/min			

Fig. 6: Typical plasma as result of variations in flow rate (process gas) and at different power levels.

Mounting recommendations

The operating frequency of the jets can be detuned if residues from the treatment process gather on the inner conductor, leading to a degraded performance. For this reason, we recommend installing the jets in a downward position as shown in Fig. 7.
To stably assembly the jet, four screw threads (M4) have been implemented on the side of the casing opposite to the rf connector.

Downwards	Lateral	Upwards
		
Recommended		Inadvisable

Fig. 7: Recommended assembly of a typical jets for optimal performance.

Comments and Safety Issues

1- The plasma jets are hand-tuned.
Do not disassemble! Assembling is only possible using hot S-parameter measurements.
2- **At higher power levels**, the housing of the jet may turn very hot. Do not hold the jets in your bare hands.
Since the radiated microwave power also increases, automated operation is recommended. Keep a 50 cm distance from the jets. To monitor the radiated power, a simple hand held device (e.g. EME Guard 3140 from ANTENESSA) can be used.
3- For longer usage, a good ventilation is essential.
4- The plasma is very bright. Refrain from looking at it directly.
5- Please ensure that the air flow is sufficiently high. At too low flow levels, the plasma may turn yellowish or red, carrying with it traces of the inner electrode.

Ordering information

Please contact us for price information for the corresponding PC-SF-Jet (Tab. 2).
We can also customize jets for special applications, such as higher power density. Please feel free to contact for further information.

Guaranty

The guaranty period is 1 years after delivery.
The guaranty does not cover defects based on wrong operation or improper usage, such as connectors not being properly attached or insufficient gas flow.

Contact

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