Comparative Outline of PJ-100, Sulzer-METCO and TAFA Plasma Guns

Plasma spraying is the most flexible material deposition process, which is used today for coating of different substrate material, usually metals, with the same or any other materials: metals, alloys, composite materials (metal-ceramic) or ceramic material, depending on the engineering functions that such a deposited coat should perform in service. Most commonly requirements are: necessitate for a higher hardness, the higher required abrasion resistance, the improved wear and cavitations resistance, better corrosion protection, and increased resistance to higher thermal load.

A spraying material is generally in powder form and requires a carrier gas to feed the powder into the plasma jet formed by passing the plasma forming gas mixture, either nitrogen or argon based, between the hot cathode and the cylindrical nozzle-shaped anode. The main characteristic of this system is to generate high temperature plasma, up to 12,000^{o}C (four times higher than the melting point of materials with the highest melting temperatures) and high velocity of droplets hitting the surface of a substrate material. Because of the high thrust of the individual droplets, high bond strength of the coat is achieved. And yet the temperature of the substrate material on which the coat is depositing remains below 100^{o}C. The coat may be, in some cases, as thick as 5 mm but they are usually 0.3 – 1.0mm thick.

Two best known producers of the spraying plasma jet installation are Sulzer-METCO and Praxair's TAFA.

Sulzer-METCO

Established in nineties by fusion of the USA METCO and Swiss's Plasmatechnik, Sulzer-METCO became the world largest company in plasma spraying technology. The Sulzer-METCO plasma gun can work with any mixture of gasses such as Argon, Nitrogen, Hydrogen and Helium. The power of plasma generation is up to 80 kW.

An example of the Sulzer-METCO's gun working parameters is:

Argon flow rate:	54 l/min
Hydrogen flow rate	7.5 l/min
Voltage	60-70 V
Amperage	500 A

The restriction inherent to the Sulzer-METCO gun design is low voltage, which dictates high amperage required for production of plasma with the higher power. Hence, the constraints seem to be equally limiting for more advanced usages of DC-arc plasma, because of:

1. A short length of the arc path, which commence at 1mm and ends to at approximately 8mm.

2. The current oscillation alongside the plasma path.
3. **At** the time only a volume part of the gas is passing through the arc and heats up, while the rest of the passing gas is cold. The arc rotates all the time and the impression of a homogeneous plum heating up creates. Thus, temperature non-homogeneous plasma generates.

TAFA

Within giant Praxair – the world's largest producer of liquid Oxygen – TAFA is now second USA Co, which produce the DC-arc plasma jet installation. TAFA increased the working voltage in order to remain amperage within the 500A range. The company engineered it by a specific approach. The gas flow rate was increased considerably what causes the arc is blowing off, so that maintenance of a longer plasma plum requires a higher voltage. And, Nitrogen + Hydrogen were chosen as the working gas because these gases have higher enthalpies, and because for such high gas flow rate only those two gases are commercially affordable. An example of the TAFA's gun working parameters is:

Nitrogen flow rate	236-330 l/min
Hydrogen flow rate	94-151 l/min
Voltage	330-440V
Amperage	450-500A
Power	165-220kW

TAFA's design solution didn't solve entirely the problem of the arc length oscillation. The arc is drifting alongside the anode opening but far less than in the case of Sulzer-METCO gun. The limitations of the TAFA's gun technology arise from the opted working conditions for plasma generation that are essentially fixed. The temperature of this plasma is considerably lower (approx 6,000^{o}C), what can be a disadvantage for the ceramic materials depositions being they lower the influx of depositing material.

Plasma Jet–100

In contrast to the Sulzer_METCO and TAFA guns, the arc length is physically totally defined in the case of PJ-100 gun, and cannot be shorter than once chosen one, which is defined by the very design of the anodic nozzle. The applied solution of PJ-100 gun provides a co-linear gas flow with the arc path. On this way a well heated up plasma generates, with the homogeneous temperature cross section. Such plasma is the "fully" developed compared with Sulzer-METCO. The end result of the originally designed of PJ-100 gun is that the much longer plasma plume exits the anode opening, twice longer than in conventional Sulzer -METCO design, mainly as a result of the higher exiting plasma speed. Higher plasma speed and a longer plasma plume both are conducive to a higher heat and momentum transfer from plasma to particles of spraying material. They are the most valuable characteristics of the plasma spraying process. It was proven with the testing results achieved for different deposited materials with PJ-100 gun compared with the results Sulzer-METCO provides as the coating characteristics for the same materials*. The quality of coatings made by PJ-100 gun is considerably better than coatings made with Sulzer-METCO gun. An extra bonus in case of the PJ-100 gun is much higher mass rate of sprayed material what makes the coating process faster and consequently less expensive, when compared with the Sulzer-METCO technology.

The PJ-100 technical and technological invent does not impose any limitation in terms of gasses used and the flow rates required for those gasses. As the matter of fact, the gas flow rates are far moderate than TAFA's, while in terms of temperature achievable, the PJ-100 attains the same temperatures that Sulzer-METCO does.

The design principle applied in PJ-100 allows the plasma power increase up to 300kW, without any serious technical and engineering problems. Namely, the employed input voltage/amperage feature inherent to the original constructive characteristics of the PJ-100 gun allows self-maintenance of the amperage, corresponding to the voltage used. It is not the case with either of the two other DC-arc plasma gun designs; the PJ-100 gun is compared with. They have hyperbolic Voltage/Amperage working regime (electronically managed), while PJ-100 has simple Ohmic working regime.

Two examples of working parameters for the PJ-100 gun are as follows:

Argon flow rate	80 l/min
Hydrogen flow rate	30-40 l/min
Voltage	180-185 V
Amperage	460-500 A
Power	85-100 kW

Nitrogen flow rate	55-65 l/min
Hydrogen flow rate	0 - 5 l/min
Voltage	190-210 V
Amperage	450-600 A
Power	85-120 kW

* Testing the Performances of PJ-100 Plasma Spraying Installation, Report, Vinca 2002