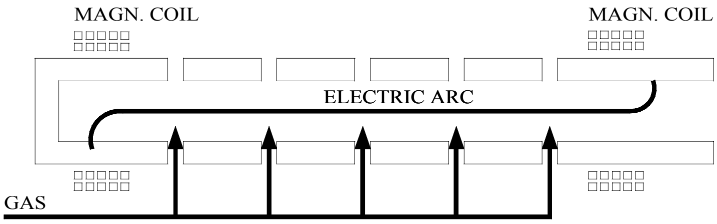
The Non-Transferred Plasma Generator

Scanarc PlasmaTechnologies AB develops plasma processes for metallurgical and environmental applications.

Processes developed by ScanArc use non-transferred, segmented type plasma generators. In such a plasma generator an electric arc heats a gas to high temperature. The gas is introduced into a process vessel where the heat content of the gas is utilised and where the gas may take part in chemical reactions.

Segmented Plasma Generator



The electric arc is established between tubular electrodes made of micro alloyed copper. Tubular spacers are used to obtain a suitable distance between the electrodes. The spacers are electrically insulated from each other and from the electrodes.
Magnetic coils are usually used to induce a force to rotate the arc attachment points inside the electrodes. This will spread and reduce the electrode wear.
The gas is introduced tangentially between the segments at a high velocity to produce a swirl that stabilises the arc.

Geometrical dimensions and the composition of the plasma gas are the most important factors governing the performance of a plasma generator. The strength and shape of the magnetic fields together with the swirl velocity are also important.

Plasma Generator Characteristics

Two variables are available for manipulation when operating a plasma generator - arc current and gas flow rate. Directly available measured values are arc voltage and temperature increase of the cooling water. For most applications the input power and the temperature (or rather the enthalpy) of the heated gas are the most important parameters from process control point of view. The data for a plasma generator is therefore normally presented as power and thermal efficiency on enthalpy. The enthalpy is calculated as input power divided by gas flow rate.

Diagram 1 shows how arc current and gas flow rate should be chosen to obtain desired power and enthalpy. From diagram 2 it can be concluded that the thermal efficiency of the plasma generator is almost entirely determined by the enthalpy, e.g. the arc current has very little influence.
Diagram 1 is typical for the segmented type plasma generator.

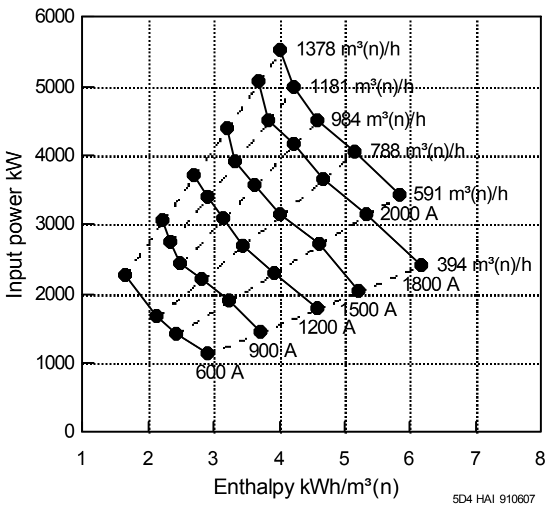


Diagram 1. Input power as a function of gross enthalpy (input power/gas flow rate)

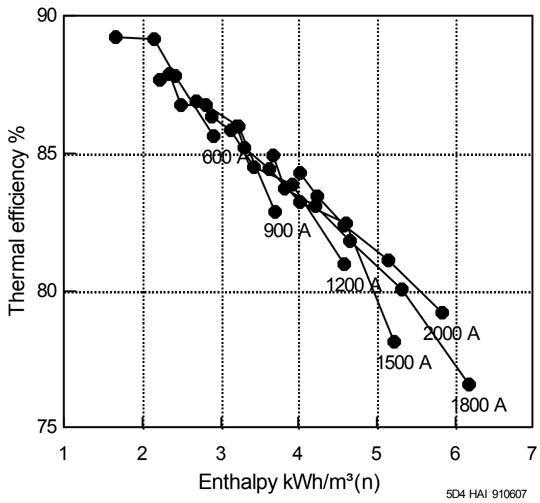


Diagram 2. Thermal efficiency as a function of gross enthalpy.

One important variable that is not directly available is the electrode erosion rate and wear pattern. It is important to stress that electrode service life is not directly dependant on the erosion rate. Even more important is the wear pattern. A wear that is well spread along the electrode surface will enable a much longer electrode service life than a lower erosion rate with a concentrated wear pattern. The erosion is measured by weighing and inspection of the electrodes before and after use.

Plasma Gas Composition

Changes in the composition of the plasma gas will influence the voltage and the cooling losses substantially. In diagram 3 tests with mixtures of nitrogen and air is presented.

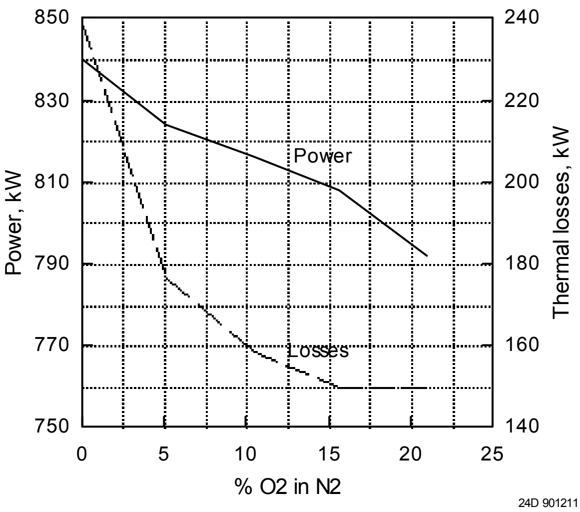


Diagram 3. Input power and thermal losses as a function of oxygen content at constant gas flow rate, 200 m^3 (n)/h, and arc current, 800 A.

As oxygen is added to the nitrogen the voltage will drop slightly, while the losses are reduced considerably. The result is that the power at constant enthalpy will be lower when oxygen is added to the nitrogen.

Gas composition has great influence on electrode erosion. For example, no anode erosion can be measured for nitrogen with added hydrogen but when oxygen is added to the nitrogen, the erosion increases. By adjustment of the magnetic field and the swirl velocity the anode erosion with oxygen in the gas can be reduced considerably at the expense of somewhat lower power and efficiency.

Plasma Generator Geometry

The length of a plasma generator can be changed by varying the number of inter electrode spacers. At constant gas flow rate and arc current, power will increase when the distance between the electrodes is increased. But since the water losses will increase even more the thermal efficiency will be reduced when the length of the arc channel is increased. The presented relation between arc channel length and plasma generator performance is taken from tests using air but is quite general regardless of arc channel diameter and gas composition.

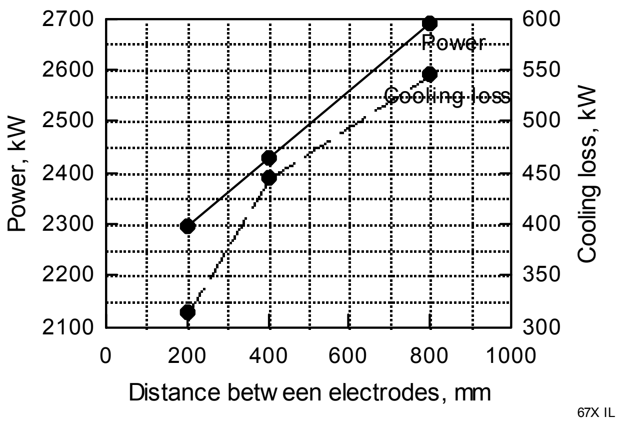


Diagram 4. Power and efficiency as a function of electrode separation (1800 A, 500 m^3(n)/h)

The area of the arc channel can also be varied. A generator with larger diameter has to be operated on a somewhat higher current to reach the same power as a generator with smaller diameter. On the other hand is the erosion rate (μg/C) usually lower for a larger diameter. This is probably because the arc attachment is spread over a larger area. Even at constant erosion rate, the service life of the electrodes will be longer simply since more material can be eroded before electrode failure.

Gas Swirl

The swirl velocity of the gas has a substantial influence on plasma generator data. A compromise has usually to be made between power, efficiency data and electrode erosion. The best swirl rate has to be found for each combination of gas composition and plasma generator geometry.

Magnetic Field

The magnetic fields at the electrodes rotate the arc attachment inside the electrodes. The magnetic field must be carefully adjusted since a strong field can concentrate the wear leading to shorter service life for the electrodes. If the magnetic field strength is to weak, the rotation will cease and result in excessive wear. To a certain extent the magnetic field also influences the power and the efficiency. The stronger the magnetic field the higher the power and also the efficiency. Also for the swirl rate the optimum configuration has to be found for each combination of gas composition and plasma generator geometry.

ScanArc Plasma Technologies AB
Box 41
813 21 HOFORS
SWEDEN

Tel: +46 (0)290 767800
Fax: +46 (0)290 20075
Email: mail@scanarc.se
Web: www.scanarc.se