Comparative analysis of power supplies of multi-electrode reactors of non-thermal plasma generated by sliding arc discharge

Abstract

So far, many different in terms of design and operating principles of arc plasma reactors and dedicated power supply systems have been developed. None of the power supply designs are universal enough to be used to power any type of plasma reactor used in any plasma process. Many of the power supplies used were developed using erroneous assumptions at the design stage. This is mainly related to the problems created by the power supply of a receiver which is difficult to describe and analyze, which is an electrical discharge. The dissertation concerns the conduct and analysis of four structurally different power supplies intended to power a three-electrode plasma reactor with sliding arc discharge. The topic was taken up due to the lack of publications presenting the issue of the impact of the power supply design on the efficiency of plasma generation. The conducted tests allowed to determine the impact of the power supply design on the plasma reactor operation. The plasma reactor with sliding arc discharge used for testing is a non-linear receiver, requiring high voltage for pre-ionization and ignition of the discharge and then effective limitation of the reactor current to maintain the low-temperature character of the discharge. The scope of the research included analysis of the static and dynamic characteristics of the reactor and analysis of the quantity and quality of energy consumption, assessment of the impact of the design of power supplies and their rated parameters on the ability to generate plasma with certain parameters, as well as on the efficiency of the plasma process, so that the cooperation of the power supply with the reactor was as beneficial as possible. Studies have shown that none of the power supply designs are universal enough to be used to power any type of plasma reactor used in any plasma process. When selecting the power supply system for the plasma reactor, it is necessary to pay attention to many parameters: power supply voltage, power supply, method of ignition realization, reactor power, current regulation capabilities, working capacity of the power supply system in the automatic regulation system, correct cooperation with the power supply network, high efficiency, simple operation, low construction costs. Analysis of the test results showed that it is possible to develop a power supply design that guarantees the correct cooperation with the plasma reactor while providing optimal conditions for plasma generation in a wide range of control characteristics. As a result, our own solution of the power supply system combining state-of-the-art converter technologies and the best properties of magnetic circuits, which are characterized by a three-phase five-column transformer in a special design. The obtained results proved the correctness of the conclusions drawn and the proposed power supply design solution has great application possibilities for powering arc plasma reactors.

Key words: high-voltage power supply, comparative analysis, arc discharge surges, non-thermal plasma, gliding arc reactor