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Research on MHD-Steam Combined Cycle System

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Abstract: Magnetohydrodynamic(MHD) power generation utilizes the high-temperature (around 2400k) plasma incising magnetic force line to induce electromotive force. The temperature of tail gas from the magnetic hydro-electricity generator unit is fairly high, around 2200K. Combined with steam turbine generating equipment, the combined cycle system of MHD power generation can produce relatively higher efficiency. This paper proposes two combined cycle systems of MHD power generation: MHD-steam combined cycle system with tail gasification and direct coal-fired MHD-steam combined cycle system. In the system with tail gasification, clear conductive gas enters the MHD generation channel to avoid a series of problems for the existence of cinder. In contrast, the cinder in the direct coal-fired system will inevitably affect the performance of MHD generation channel. Based on building mathematic models, the new computing program has been developed. This paper is contributed to the systematic analysis and performance calculation of the two combined cycle systems. MHD-steam combined cycle system with tail gasification results higher electric power as the gasified mixed gas pass through the MHD generation channel with mass flow rate greater than that through the system of the direct coal-fired. With the same thermal input, MHD-steam combined cycle system with tail gasification has higher efficiency and will have good prospect.

I. Introduction

MHD power generation is a new technique with directly converting the thermal energy into electric power. The high temperature plasma with certain electric conductivity rate passes through the mutually perpendicular magnetic field to incise the magnetic curve to produce the electric power. The most simple MHD generator includes parts of combustor、 MHD generation channel and superconducting magnet system. Combustor is to produce high temperature plasma and the temperature must be above 2800 K to attain the certain electric conductivity rate[1].

The energy conversion takes place in MHD generation channel. The conversion will stop till the temperature declines to the certain value. The tail gas getting out from the generation channel still have higher temperature of 2200K～2500K. The electricity efficiency of single MHD generator is only 20～30％[2]. The electricity the efficiency combined cycle system must be higher if put the MHD generator forward and then combine the steam turbine to generate the electric power using remaining heat of the tail gas[3-5].

II. Characteristics of MHD-steam Combined Cycle System

The direct coal-fire MHD-steam combined cycle system utilizes thermal energy of tail gas getting out of MHD generator to push the steam-turbine to generate electric power. But the system still has a part of energies do not make good use of. The efficiency of combined cycle can be described with the simple diagram of temperature-entropy, see the fig. 1.

The fuel burns to generate the heat Q_{ABCE} and makes the temperature of work material up to 3200K, W_1 and W_2 stand for the dissipative heat of MHD generator and steam turbine. η_1 and η_2 stand for their electricity efficiency.

So the efficiency of the whole cycle is: $\eta = \dfrac{W_1\eta_1 + W_2\eta_2}{Q_{ABCD}}$.

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