NON-ISOTHERMIC PLASMA ON ELECTRODES OF SOME DISCHARGE IN PLASMACHEMISTRY[1])

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Processes due to which the electrons in non-isothermic plasma of some high frequency discharges produce atomization of molecular gases and hence some effective plasmachemical reactions are discussed. Laboratory testing of the clinkers originating in non-isothermic plasma of some discharges has been carried out. Regarding the fact that the activation energy available for these reactions can be supplied by electrons a more economical use of thermal power can be suggested.

НЕИЗОТЕРМИЧЕСКАЯ ПЛАЗМА НА ЭЛЕКТРОДАХ ПРИ НЕКОТОРЫХ РАЗРЯДАХ В ПЛАЗМОХИМИИ

В работе обсуждаются процессы, вследствие которых электроны в неизотермической плазме в случае некоторых высокочастотных разрядов вызывают расщепление молекулярных газов на атомы, т.е. вызывают некоторые плазмохимические реакции. Выполнены лабораторные испытания образцов, полученных в неизотермической плазме. На основе факта, что энергия активации для этих реакций может быть достигнута при помощи электронов, может быть предложено более рациональное использование тепловой энергии.

1. INTRODUCTION

Positive ions in high frequency discharges with respect to their reduced mobility do not take part in the charge transport and produce a strong electric field by their space charge on the discharge electrodes. The field accelerated electrons in inelastic collisions do excite neutral particles up to relatively high energy levels. For example, molecular ions of nitrogen having an excitation energy of 18 eV are present in the electrode layer of the torch discharge burning in air at atmospheric pressure. However, in the channel of the discharge where plasma approximates the local thermodynamic equilibrium and obtains the highest temperature of about 6000 K such ions do not exist [1].

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The molecular ions of this high excitation energy are leaving the electrode layer by diffusion motion to decay by dissociative recombination. The molecular ions decay into atoms, and this atomization is relevant for plasmachemical reactions [2].

In the torch discharge unusual high yields were obtained by some plasmachemical reactions.

The thermodynamically equilibrated concentration of NO in a stoichiometric admixture of N_2 and O_2 obtains the maximum value at a temperature of 3500 K, i.e. 5 % of NO [3]. The value 15 % of NO was determined in the torch discharge. The maximum concentration of ozone has been found in oxygen at thermodynamic equilibrium and a temperature of 3500 K, it means 10^{-4} % of O_3. In the torch discharge the concentration of ozone was 1.8 % [4].

Similar yields were obtained in the torch discharge during the formation of C_2H_2 from CH_4 and at the conversion of $SiCl_4$ into $SiHCl_3$ [5].

The atomization of molecular gases by dissociative recombination is responsible for such great yields of the above reactions. The non-isothermic plasma on electrodes of high frequency discharges has also been applied to the identivication of the ordinary clinker.

II. EXPERIMENTAL ARRANGEMENT

In the present study the experiments have been carried out using the ordinary available cement mixture poured through the torch discharge flame, burning in air at atmospheric pressure and a frequency of 24 MHz. The power liberated in the discharge flame was about 600 W.

The heterogeneous quality of the ordinary powdered cement mixture does not allow the fairly great volume of individually reacting components to create the cement clinker.

In the next treatment the cement mixture was compressed into tables of about 60 mg of weight. These tables were placed on the electrodes, which upon the torch discharge were ignited. After heating the tablet the electrode layer moved from the discharge electrode towards the tablet and, here begins the intensive heating of the individual components of the cement mixture and hence the formation of cement clinker. The whole tablet firing took 15 seconds.

III. RESULTS

The microphotographic analysis of the fired tablets shows a considerable firing inequality. In the tablet surface layer situated closely below the electrode layer we observe the formation of long crystals of alite due to the crystallization from the melt. In the lower part of this layer these crystals disappear and we obtain the normally melted clinker. In the still lower layer towardd the discharge electrode

a higher content of belite and lime is found. The cement mixture of the layer closest to the electrode remains nearly unfired. To avoid the cooling of the lowest part of the tablet situated on the metal electrode we used the capacitively coupled electrodeless high frequency discharge burning in air at atmospheric pressure [6].

The tablets made from the ordinary cement mixture were placed on a quartz plate on which the above discharge was ignited. Previous results of these treatments have shown that with the help of the capacitively coupled high frequency discharge the above tablets are much more unifromly fired than those treated by the torch discharge.

IV. DISCUSSION

To reduce the power consumption new methods are searched for firing the cement clinker by means of the electric power [7] of high frequency heating [8] of plasma burners [9]. Some of these methods according to their laboratory testing can complete with each other regarding the efficiency and methods of firing. However, all of them suppose the change of the electric power into the thermal one making the production of the clinker possible. In this respect, the reduction of thermal losses in the thermal supply into the reactive mixture can be one result of economical power saving.

A relatively high efficiency is obtained on using the method of bombarding the cement mixture with accelerated electron beams [10]. In this case it can be supposed that the activation energy is transported directly by electrons from the electron beam into the reaction, which can save thermal power.

A similar method of activation energy transfer by means of electrons can be realized in non-isothermic plasma as it has already been discussed with experiments carried out using the torch discharge and the capacitively coupled high frequency discharge. Equipments utilizing these discharges are fairly realizable and may be provided at very small costs if compared to those with electron guns.

The non-isothermic plasma can be, by means of electrons, an effective supply of activation energy for numerous plasma-chemical reactions under available conditions. The temperature of the reacting components can therefore be lower than that of reactions in the thermodynamic equilibrium state, which appears to save power, too.

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