Emittance Changes of Metals During Heat Treatment Processes

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Heat treatment is state of the art for many manufacturing processes to improve the quality of the products. Heat treatment means, that the very different metallic products - after their manufacturing - still will get a further reheating by a material-specific temperature-time schedule in high-temperature furnaces, which are working with different furnace atmospheres. These processes are designed and controlled by process models which are based on heat-transfer calculations. The calculations will be done for many different process steps (or points) of the temperature-time schedule. The furnaces with all their different working zones and temperatures will be regulated on basis of those calculations, e. g. their fuel consumption and temperature fields. It can be considered that presently all these models are calculating with only one value of total emittance for the entire set of process steps of every metal. The furnaces can work with reducing atmospheres of protective gases, e. g. containing H_2 and CO, which lead to a reduction of oxide layers on the surface of the metallic products during the heat-treatment processes. Otherwise, the furnaces can also work with oxidizing atmospheres, e.g. containing O_2 (air) or H_2O and CO_2 (of combustion products), which lead to an oxidation of bright surfaces of the metallic products during reheating. It is well known that in both cases the different atmospheres must lead to strong changes of the values of emittance of the metallic products, especially of their surfaces. But until now, in the industrial process models these emissivity changes are not taken into consideration, because there is normally only one constant value of the emittance of the metals in use. The goal of this paper is to present measured temperature- and atmosphere-dependent spectral emissivities, and calculated total emissivities of metals with their dependence on different process steps and conditions. To this end, in our measurement device at the University Duisburg-Essen, metallic samples were reheated with temperature-time schedules and within different atmospheres (reducing or oxidizing), similar to industrial heat-treatment processes. As a result we generated so-called "process-dependent emissivities" of metals, which show strong changes of emittance during the different processes in dependence on the temperature and atmosphere. The results will be presented for oxidized steel, heated in a reducing atmosphere, and for a bright copper sample, oxidized by heating in air. The measured process-dependent emissivities led to changes in the database of the furnace models, and to new calculations using the real process-dependent emissivities with all their variability.