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Experimental analysis of the influence of contact conduction on the effective thermal conductivity of steel bar bundles

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Steel bars are the primary group of metallurgical fabrications. Just like the vast majority of steel products, bars are produced using the rolling process. In many cases, such metalworking in itself does not provide the required mechanical and technological properties. This means that bars require additional heat treatment. The bars to be treated are usually heated in the form of bundles. Steel manufacturers are always anxious to optimize heat treatment processes. This is done mostly by numerical models. One of the conditions for such models is the thermal conductivity of the heated element. Bar bundle should be treated as porous medium with a discrete solid phase. Thus its primary thermal property is effective thermal conductivity k_{ef}.

The article presents an analysis of the effect of contact conduction that occurs at the interface between adjacent bars on the effective thermal conductivity of the bar bundle. For this purpose a special mathematical model of heat transfer phenomena is used. This model depends on an analysis of the thermal resistance for the various mechanisms of heat transfer which occur in the bundle. The basis of the considerations was the results of experimental measurements of the effective thermal conductivity of the samples having the form of flat packed beds of steel round bars. The measurements were performed for three types of beds, characterized by a different manner of packing of the bars in successive layers. These beds were arranged in crossed, covered and partitioned manner. For each type of beds were investigated four samples made from bars having a diameter of 10, 20, 30 and 40 mm. The studies were performed on a laboratory stand which operates on the principle of the guarded hot plate apparatus. Measurements were made for the temperature range from 50 to 650°C. Each type of a bed has different geometrical conditions for contact conduction heat transfer. Thus, these results indicate the influence of contact conduction on the effective thermal conductivity of the bar bundle.

Keywords: steel porous charge, contact conduction, thermal properties, effective thermal conductivity.