SIMULATION OF DEPOSIT GROWTH ONTO RECUPERATOR TUBES IN PIT FURNACES

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Nowadays, operation of pit furnaces without air preheating is not acceptable. However, deposit growing onto tubes of air preheaters significantly decreases their efficiency. This paper presents a two-dimensional simulation of the phenomenon of deposition onto tubes of air preheaters with staggered tube layout. It has been shown that it is possible to predict deposit shape and its effect on heat transfer from combustion gas to combustion air with dynamic meshing of CFD software. Such approach can also be used when a mechanical structure is exposed to variable loadings from for instance snow, ice, mud helping in material failure calculations.

U tube recuperators are set up in 2 layouts: in line or staggered (see Figure 1). During long time of operation of pit furnaces, even over 20 years, the surface of the tube is covered with deposit. Such deposition affects operation of furnaces increasing heat transfer resistance, resulting in lower temperature of air and higher of combustion gas; increasing pressure drop along the combustion duct, resulting in increase of energy demand for induced-draft fans; possible acceleration of corrosion of the tube material. Current computational fluid dynamics software CFD, like Ansys (Fluent), can be used to simulate flow and heat transfer in many practical applications. One of the interests is prediction of deposit growth onto tubes of air preheaters and its influence on heat transfer from combustion gas to combustion air

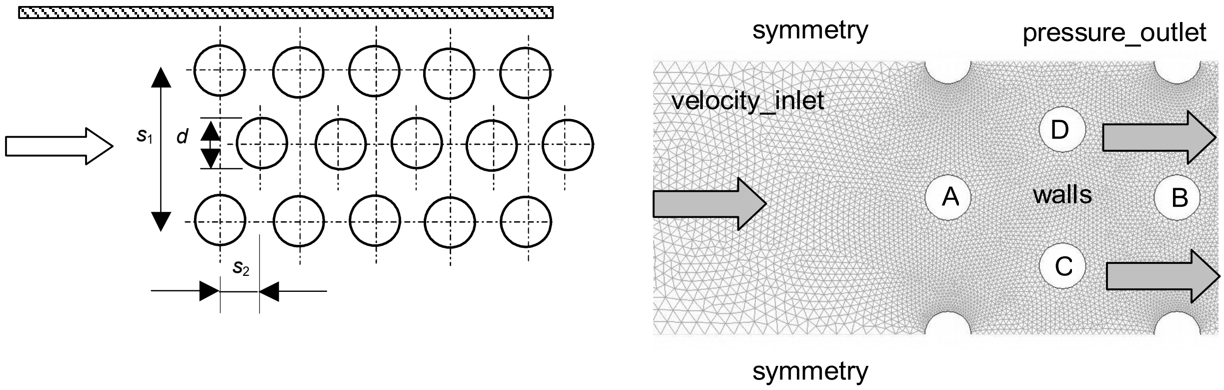

Figure 1. Staggered arrangement of U-tube recuperators and boundary conditions with mesh used in numerical simulations

The publication of 2006 [1] presents a summary of deposits found in Polish pit furnaces in relation to the recuperator zone. Deposit height ranged from 4 to 6 mm after 3-4 years of operation. However, it is possible to find regions where deposits are 20 mm high. In gas-fired pit furnaces, there is no mineral matter originating from fuel and what is found on the tube surface must come from insulation, wall materials and from steel stock. Thus, the content of mineral, solid matter in the combustion gas is minimal and extremely difficult to assess or measure on-line. This paper pointes out the lack of the mechanism of deposition. The observed deposits had porous or rarely grainy structure. To make matters worse, the deposits found on the recuperators are exposed to erosion from the same mineral matter hitting their surface. Prediction of deposit shape and features during operation of coal-fired boilers in case of superheater and heater tubes was shown in the publication of 2009 [2]. The said paper described bonded deposits formation and was the first ever two-dimensional modeling of deposit growth onto heat exchanger tubes in commercial boilers. The most important tool for such a prediction was dynamic meshing, an option of Fluent code where a single node can be moved independently during calculations. A similar approach was employed in this paper.

The goal of this numerical simulation is to predict shape of deposits on the tubes in a staggered arrangement. This tube spacing significantly influences gas flow and, eventually, tracks of the solid particles. An example of such tracks for uniform and size distribution is shown in Figure 2. The second row of tubes (tubes C and D) is hit with more particles than the first one, because the flow path-lines are "squeezed" there by front tubes. Thus, it is likely there should be higher and faster growing deposits. In order to simulate the deposition phenomena when no real, dependable datum is available, a set of velocities was tested. It is interesting to compare deposit growth on the first, front tube A (Figure 1) and "shaded" by it, tube B. It is obvious that less particles hit its surface (Figure 2), leading to slower deposit growth – see Figure 3.

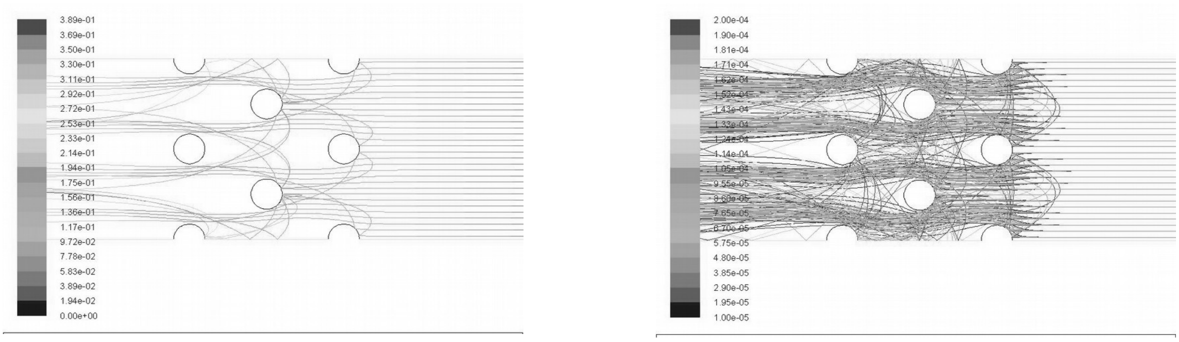

Figure 2. Solid particles' tracks in case of their velocity of 3 m/s and uniform (100 μm-upper) or size distribution (down)

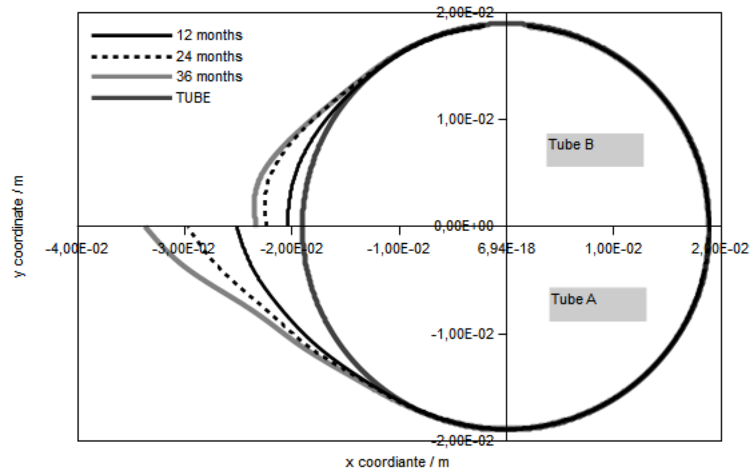

Figure 3. Shape of deposits on tubes A and B (velocity is 5 m/s, solid particles mass flow is 0,17 mg/s)

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