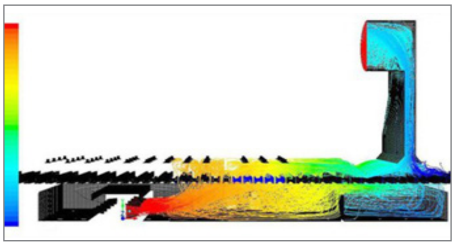
RENUDA
FLUID SOLUTIONS

Modelling heat transfer processes: ArcelorMittal

The Background



ArcelorMittal is the world's leading steel and mining company. Guided by a philosophy to produce safe, sustainable steel, it is the leading supplier of quality steel products in all major markets including automotive, construction, household appliances and packaging. ArcelorMittal operates in 60 countries and employs about 260,000 people worldwide.

At its Differdange site in Luxembourg, ArcelorMittal manufactures beams for the construction industry. Various beams of different length, breadth, height and thickness are produced there.

The beam production process involves numerous stages starting from melting a combination of materials in an electric arc furnace, casting the generic beam blank using a continuous casting process, reheating the beam in a reheating furnace to the desired temperature and various stages of rolling to produce the final product.

"Renuda's results have shown that numerical simulations are capable of predicting the flow field with a good degree of confidence"

Pierre Hubsch

Process Department, ArcelorMittal Esch

For a given beam blank type, various lengths can be produced for optimization purposes. For example, Beam Blank 1 is commonly produced in three lengths that pass through the Differdange furnace in three configurations. ArcelorMittal wanted to know if the reheating process could be achieved with less energy; to identify which alternative configurations would save energy; and to investigate the reasons for non-homogeneous temperature distributions in the beam blanks exiting the furnace.

The Challenge

As part of their goal to optimise the use of energy and understand how the beam blank temperature non-uniformities occur, ArcelorMittal needed to simulate the flow and heat transfer processes in their Differdange furnace using Computational Fluid Dynamics. This analysis would be used to determine the extent of the non-uniformity in beam blank temperature and to analyse the numerical results in order to understand why such non-uniformity occurs. Following this analysis, the furnace geometry could be modified in order to try to improve the homogeneity of the beam blank temperature.

CAD data for the Differdange furnace was not available and the Renuda engineers first had to build the CAD geometry of the entire furnace using technical plans and documents supplied by ArcelorMittal.

For one of the furnace configurations studied in the project, the model geometry also had to be modified to account for, and model the effect of, the internal deflector that ArcelorMittal had been investigating in an attempt to homogenise the beam blank temperature distributions by separating the gas jets emanating from two burner zones.

Physical phenomena:

- Time varying flow.
- Gaseous mixing.
- Multi species flow (combustion products).
- Turbulence.
- Combustion.
- Radiation.

Accurately simulating the heat distribution on such a large scale whilst taking into account beams and doors motion, and physical phenomena such as combustion, turbulence, multi-species, radiation and other variables presented a significant modelling and computational challenge.

A combination of complex physical phenomena and processes are present in the furnace. The physical flow domain consists of two zones: static and mobile. The static zone contains the interior of the furnace itself, the chimney zone and the ducting downstream of it which contains a heat exchanger to preheat the combustion air used by the burners.

The mobile zone contains the beam blanks which move through the furnace

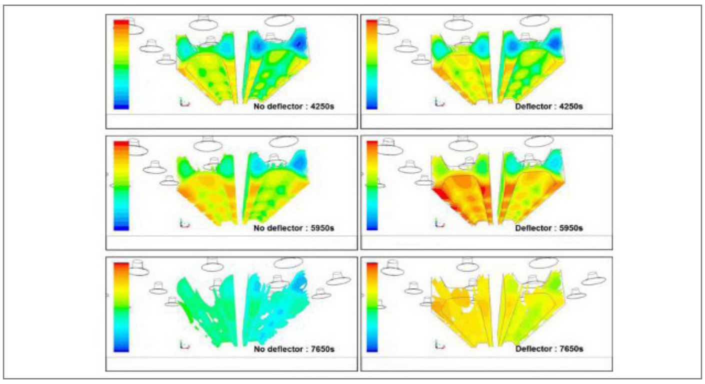
Whilst the CFD software is capable of modelling all of these phenomena and processes, it is not capable of doing so simultaneously, in particular the physical processes combining the opening and closing of the furnace doors, the beam blank motion and the motion of the beam blank supports.

Oprational processes:

- Opening and closing of the furnace doors.
- Loading and unloading of the beam blanks to and from the furnace.
- Beam blank motion in the furnace.
- Motion of the mobile beam blank supports.
- Conjugate heat transfer:
    - from the gas to the beam blanks,
    - from the gas to the beam blank support cooling water, and
    - from the gas to the external air.

The Solution

ArcelorMittal commissioned Renuda to model the heat transfer processes in the Differdange furnace.



- To model this entire domain is not feasible due to the large computational times involved and the associated costs, hence the domain had to be simplified. Renuda applied five simplifications following "standard" ArcelorMittal practice of how ArcelorMittal set up and run their CFD simulations of industrial furnaces.
- Renuda's numerical model simulated time varying flow, mesh motion, turbulence, radiation, multi species flow (combustion products), conjugate heat transfer from the gas to the beam blanks and wall heat transfer using a fixed temperature and a heat transfer coefficient from the gas to the beam blank support cooling water, and from the gas to the external domain.
- In total four steady and transient calculations were undertaken, three for different types of beam configurations and a fourth to optimise the flow in the oven for one of the beam configurations. The steady state calculation flow fields were used to initialise the transient calculations.
- One of the objectives was to optimise the furnace geometry in order to try to homogenise the beam blank temperature distributions. Such action had already been undertaken by ArcelorMittal in the Differdange furnace by the addition of an internal wall or deflector that aims to separate the gas jets emanating from burner zones 2 and 4. It was decided therefore to modify the model geometry to account for this deflector and to model the effect of this deflector on the beam blank configuration 3.

How ArcelorMittal Benefited

- The results of the steady state calculations showed that the numerical model predicts heat transfer rates and wall and chimney losses that are in line with current ArcelorMittal experience, providing confidence in the Differdange furnace numerical model.
- Renuda's model identified that the maximum beam blank temperature occurs as the beam blanks move into burner zones 1, 3 and 4; downstream and upstream of these zones, the beam blanks are cooler. They also showed the hotter and cooler regions of the furnace.
- Renuda's results have shown that numerical simulations are capable of predicting the flow field in the Differdange furnace with a good degree of confidence in the results being obtained. The next step is to optimise the heat transfer to the beams and reduce losses through the furnace walls and chimney. To this end, two possible optimised configurations have been proposed.

Why did ArcelorMittal choose Renuda?

- Value for money: Renuda was selected after a competitive tender because of their overall quality combined with a competitive price.
- Renuda was invited to tender because they had previously worked for ArcelorMittal's R&D operation in Maizières-les-Metz, who recommended them for this project.

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