COMPUTATIONAL FLUID DYNAMICS ANALYSIS OF A RAPID COOLING SYSTEM FOR VERTICAL GALVANIZING LINE

G. Carozzo, C. Cravero / D.I.M.E. Università degli Studi di Genova, Italy
M. Mazza / Danieli Centro Combustion Genova, Italy

In **the galvanizing process**, the jet cooler is a device that provides a rapid cooling of a moving metal strip. The performance of those devices has a considerable effect on the material properties of the strip. **The aim of this work** was to develop a CFD model to check the performance of a galvanizing cooling line based on jet impingement.
ICEM and FLUENT have been used for the simulations. First of all, an in depth research on **jet impingement** literature was done, being the flow physics mechanism that characterizes the jet cooler. Validations have been done for the CFD model studying the single-jet and the multi-jet cases. Detailed experimental data from open literature have been used to set up and **to validate the CFD approach.**
The work was developed in cooperation with Danieli Centro Combustion and the DIME Department in the University of Genova.

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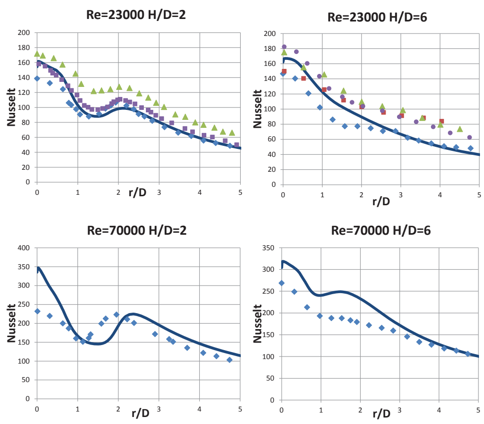
2D and 3D jet impingement validation models

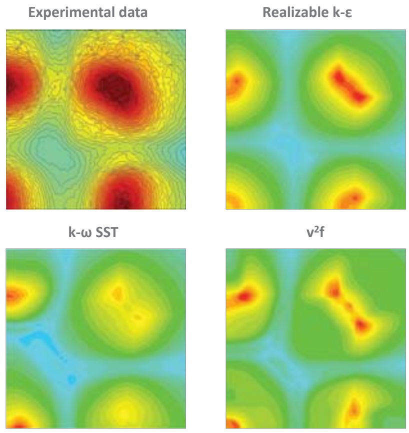


2D models

A 2D axisymmetrical model was created, in order to check the influence on the heat transfer process of the jet outlet velocity, and of the distance between the nozzle exit and the target surface. A very good match between CFD and available experimental data has been obtained for the heat transfer distribution.

3D model

A 3D model with multiple jets has been set up to validate the CFD approach in the case of jet interaction. The configuration had 9 round jets in a squared distribution. Taking advantage of the symmetry, the model consisted of one fourth of the real geometry. Three different turbulence models were tested , v2f, k-ω SST and the realizable k-ε. Best results have been obtained with the realizable k-ε model, which predicts a better distribution of the heat transfer with a 10% error compared to the experimental data.



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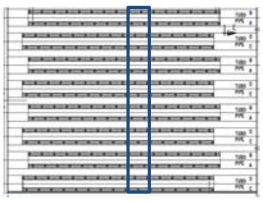
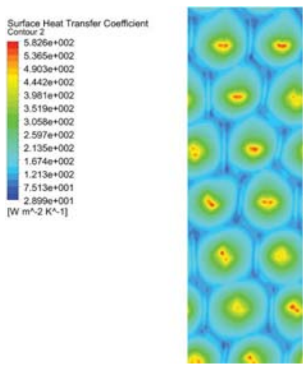
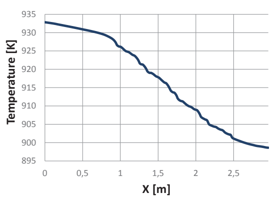
Industrial model

In order to simulate the real operating conditions of the jet cooler, a model representing a periodic section of the entire jet cooler was developed.

The **frame motion option** was applied to the volume representing the strip. With this option, the real transient cooling of the strip passing through the jet cooler can be taken into account



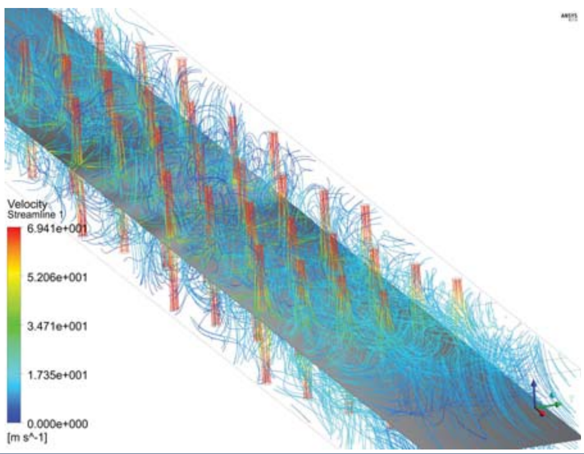




The overall output data from CFD compare well with those from the algorithm used by the company for design purposes.

Jet cooler performances

ΔT_{in-out}	$35°C$
Cooling rate	$-39.41\ °C/s$
Nu_{avg}	83.39
Convective heat transfer coefficient	$171.31\ \left[\frac{W}{m^2K}\right]$



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Conclusions

The study has obtained the following results:

- Good **know-how** on accurate jet cooling modelling using CFD;
- critical analysis of **semi-empirical correlations** for jet cooling heat transfer to be used in the industrial design phase;
- **Understanding** of detailed jet impingement and heat transfer structure for the application case.

References: Carozzo G., 2016, *CFD analysis of a fast cooling system for vertical galvanizing line, master degree Thesis, Università di Genova.*