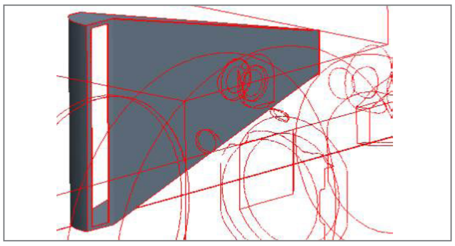
Optimising gearbox cooling: Alstom Transport

The Background



Alstom Transport, a global leader on the rail market, aims to design efficient and sustainable passenger mobility from metros to very-high speed trains. In 2012/13, Alstom Transport led the high and very high speed train sector with sales of over 5.5 billion euros. Alstom Transport also offers service-proven solutions for tramways. The tramway has become far more than a simple means of transport; it is also a means of developing sustainable urban mobility, rethinking cities, revitalising neighbourhoods and enhancing architectural heritage.

The Challenge

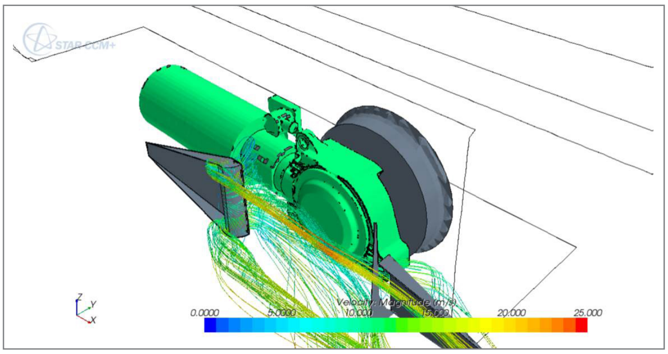
In 2009, Alstom Transport designed two types of tram, Citadis and Dualis, for use in several Cities. These trams use motorised and non-motorised bogeys which are located in bogey cavities underneath the tram. Under certain operating conditions, the reduction gearboxes attached to each motorised could be overheating. Such overheating was having a detrimental impact on gearbox performance, maintenance schedules and operating life.

The overheating was found to be due not only to the design of the reduction gearbox but also to its position. As the gearbox sits in the bogey cavity under the tram, which is a region of virtually stagnant flow, little or no air flows into this cavity. However, Alstom Transport's own experiments revealed that a certain amount of air is required to flow over the gearbox in order to cool it to an acceptable operating temperature (~ 50 - 100°C) and overcome this overheating problem.

Changing the physical structure or surface profile of the tram was not possible because the width of the tram was already at a maximum for its operation. Therefore any cooling system could not be located outside of the current outer physical envelope. Also, space for any proposed alteration in the volume of the bogey cavity is very limited as the bogey can move relative to the tram.

"We asked Renuda to do the CFD simulations because of their proven technical and aerodynamic expertise. Everything went very well."
Denis Cornu, Expert Aéraulique & Thermique, ALSTOM Transport – VPF

"Two things I appreciate considerably about Renuda: their interactivity, keeping us informed about progress throughout the project, and their flexibility – their quick response and autonomy in conducting this project was very important for a large company like us."



One design was subsequently tested for supplying cooling flow to the reduction gearbox, but proved to be unsuccessful due to the complexity of the design itself and the need for this cooling system to function in both directions of travel.

The Solution

Alstom Transport wanted to test whether they could solve the problem by fitting an opening to the skirt and using a NACA profile to induce the desired volume flow. After running several simulations themselves on a baseline design, Alstom Transport commissioned Renuda, whom they had worked with successfully on several previous projects, to help them to try to solve the problem. Renuda was specifically tasked to optimise the baseline cooling system design to see if it had the capacity to induce the required volume flow into the bogey cavity. As an additional constraint, two NACA cooling systems were required to account for the outward and return direction of travel which, due to the design of the tram, was not symmetrical.

> ***"I am completely confident in the quality of Renuda's work; they have proved to be very capable over a long period of time. It's good to have a company whose expertise we can rely upon".***

Renuda tested the possibility that the gearbox temperature could be reduced if the volume flow rate through the NACA profile could be increased by reducing the flow turning angle and/or increasing the design throat area. As a result, the optimisation process concentrated on the following three points:

- Reducing the profile turning angle
- lateral translation of the cooling system to ensure that air flowing through it impacted correctly on the gearbox surface to provide sufficient cooling
- Opening up the system throat area to further increase volume flow

These three points were tested individually and in combinations such that eight configurations were tested for each direction of travel. The combinations tested used, for example, a reduction in the profile turning angle which would then be moved laterally in order to achieve the desired impact point of the air on the gearbox and its cooling.

Results

The results of the numerical simulations showed that using NACA profile could cool the gearbox, but not to an acceptable level:

- The average gearbox operating temperature was predicted to be at least 5°C too high when compared to the acceptable operating temperature of 50 - 100°C.
- This was despite the fact that, for the optimised versions at least, the desired cooling flow rate was achieved or even surpassed by up to 45%.
- Whilst some gearbox surfaces were being cooled sufficiently, others were not because of a near zero air velocity region close to the gearbox surface.

How Alstom benefited

- As a result of Renuda's work, it was shown that it was not possible to satisfactorily cool the entire surface of the reduction gearbox using the proposed cooling system (optimised or baseline).
- Without Renuda's simulations, Alstom Transport would have had to make several prototypes – a much lengthier and more expensive approach.
- An unexpected benefit was that Renuda's simulations made it easier to conclude and justify that it was necessary to redesign the gearbox. The team that was redesigning the gearbox could visualise what needed to be changed, which made it much more efficient for Alstom Transport to brief their design team.

Why did Alstom choose Renuda?

- High standard of previous work: Renuda's consultants have worked on a variety of CFD projects for Alstom Transport every year since 2005, including validation of open source and commercial CFD codes, passenger thermal comfort and ventilation duct optimization.
- Specialist knowledge: Renuda's engineers understand testing and optimizing ventilation flows.
- Speed of response: Renuda was quick to adapt to the changing needs of the project.

- Interaction: Good communication is essential to the success of a project; Renuda's consultants communicate well and as a result there was a good rapport between the two companies.

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