Cool curtains

Air curtains have been around forever but R&D at MIRA, aimed initially at improving Dearman's zero-emission refrigeration system, could transform cold chain efficiency across the board. Brian Tinham reports

It seems almost incredible that a device as mundane as an air curtain might significantly increase the efficiency of refrigerated vehicles on frozen distribution. However, that is the claim being made by none other than respected vehicle engineering specialist Horiba MIRA.

And we're not talking single-digit performance upgrades. Principal engineer Richard Morris reckons 50–80% improvements are readily available regardless of refrigeration unit type. That translates to an average approaching 4,000 litres of diesel fuel saved per vehicle per annum, as well as the associated emissions.

So why aren't air curtains all over refrigerated transport like a rash? Step back a moment. MIRA's R&D with transport air curtains goes back nearly three years to when the organisation was approached by clean-cool technology firm Dearman to help advance its liquid nitrogen engine. Inventor Peter Dearman had already built his first prototype with engine development giant Ricardo, but Horiba MIRA suggested that, while motive power was one application, there was also a clear case for refrigerated transport.

"Of course, you could just evaporate liquid nitrogen to achieve cooling," agrees Morris. "But why waste the fact that the gas is rapidly expanding? Why not harness that energy, using Dearman's liquid nitrogen engine to do some mechanical work by also driving a compressor in a conventional refrigeration cycle? That way, you achieve both cooling benefits and, importantly, you also eliminate any requirement for conventional diesel refrigeration power."

TOO COOL

So the Cool-E project was born, under the auspices of the government's Innovate UK programme and a consortium involving Horiba-MIRA, Dearman, Air Products and Loughborough University. However, while the concept was unassailable, it wasn't without challenges. "Very early on we recognised that a significant drawback with liquid nitrogen was that any evaporator would get very cold and rapidly ice up," recalls Morris. "And whereas in conventional systems a defrost cycle would ensure reversal, that wasn't going to be possible."

Potential solutions might include a separate heating system and drain mechanism – but that would be wasteful, expensive and heavy. So, initially, Dearman accepted it would need to run with a relatively large evaporator so that icing would be progressive along its length, enabling the system to keep cooling the truck contents. Again, however, that solution was heavy and bulky.

So, given that the root cause of the problem is primarily warm vapour ingress – but also cold air egress – from door opening, attention turned to the rear of the truck. And, with plastic curtains rapidly discounted, air curtains presented an obvious solution – despite their hitherto chequered history in refrigerated transport.

"Existing truck systems were not particularly effective or efficient," agrees Morris, "but our thinking was that's largely because most require the doors to be opened before they're switched

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Richard Morris

on." Clearly, that leads to losses before the curtain establishes – but how much? Also, which works best: external curtains blowing ambient air across the door face, or internal units delivering a cold air barrier? And would either deliver a return on investment?

Hence Horiba MIRA's trials using a donor refrigerated truck. "It turns out there's not much difference between internal or external air curtains, in terms of effectiveness," states Morris. "But our modelling shows what really matters is switching the system on before opening the doors."

As for the economics, he says power requirements are 160W while losses without an air curtain average at 19kW – just over two orders of magnitude difference. But there's still the equipment weight, bulk (and hence payload penalty) and installed cost.

Morris concedes that MIRA's prototypes were heavy, but says they were over-engineered and fabricated from stainless steel. He expects mass produced units to come in at about 15kg and explains that one will be adequate for most applications. He also says they need not be bulky. The only variable is installation method: air jets must be sited as close as possible to the door so this depends on body and door closure geometry, as well as space available behind the frozen load.

RAPID RETURNS

So the bottom line? Morris reckons installed price of production units would be some £1,500. That is startlingly low. And not just for a future with liquid nitrogen, but also for conventional installations in the here and now.

If we assume deliveries take 10 minutes each, then, without an air curtain, Morris reckons energy lost per delivery is 16,600kJ. That requires 1.55 litres of diesel for temperature recovery. "For 10 deliveries per day, five days a week, 50 weeks a year, that's 3,875 litres of diesel per annum wasted. It's also 10.3 tonnes of CO_2, as well as the NOx and particulates emissions from [mostly] poorly regulated engines."

At 40p per litre for red diesel, that's £1,550, meaning an ROI easily as short as 15 months. If you're using regular diesel, ROI would be far quicker. And bear in mind, that calculation takes no account of savings associated with preventing product degradation due to temperature cycling between ambient and -20°C.

As government focus on emissions intensifies under pressure from the European Commission, it becomes increasingly likely that a technical solution as simple as an air curtain may be the precursor to new domestic legislation. Either way, air curtains look like a win-win. Adding the Dearman aspect is the icing on the cake. TE

Dearman in motion

The Cool-E project (right) is not to be confused with the CE Power project. This also involves Innovate UK funding and partners Horiba MIRA, Dearman, Air Products, but additionally the Manufacturing Technology Centre, low-carbon transport specialist Productiv, Cenex (the UK's centre of excellence for low-carbon and fuel cell technologies) and TRL (Transport Research Laboratory).

This project is focused on achieving cleaner motive power, specifically developing and proving a hybrid diesel- and liquid nitrogen-driven bus, with Dearman's engine delivering the latter component. The concept is to use the liquid nitrogen expansion engine during acceleration from zero and at speeds up to 20mph, where conventional diesel engine emissions (NOx, particulates and CO_2) are at their highest.

Clearly, this approach leads straight to zero emissions throughout stopping, starting and low-speed operations. Essentially, the Dearman engine takes over the role to date performed by electric machines or flywheels – with liquid nitrogen simply stored in on-vehicle, low-pressure insulated cylinders.

The project partners argue that this approach offers several advantages over conventional hybrid buses. Liquid nitrogen engines deliver longer life than electric machines; they enable local nitrogen production and fast, easy refuelling; and weight is reduced. It is also the case that any requirement for rare metals – such as neodymium or lithium – is eliminated, along with lengthy battery charging phases.

Horiba MIRA's role in the project includes systems integration, vehicle dynamics modelling and overall vehicle control, ensuring the liquid nitrogen system operates seamlessly and safely with its matched diesel engine. The project is due for completion before year end.

"This project is a first for liquid nitrogen in hybrid buses," comments Derek Charters, technical lead at Horiba MIRA. "Liquid nitrogen ... can be created worldwide from many renewable sources, meaning its carbon footprint is minimal."