SAE Thermal Management Systems Symposium 2015 Report

First of all, I would like to thank the Douglas Bomford Trust for their support which allowed me to attend this event.

Overview

The symposium, organised by SAE International, was held in Troy (Michigan, USA) from the 29th of September to the 1st of October and welcomed 270 attendees from 16 countries. The attendees were a wide mixture of engineers from the automotive industry, Tier 1 suppliers and also academia. The symposium included 48 presentations and 17 exhibitions, all of which were presented by engineers at the cutting edge of thermal management systems development. Naturally, the event was a superb learning opportunity and provided invaluable networking.

Recent Directives aimed at increasing the efficiency and decreasing emissions of vehicles has put a huge strain on the transportation and agricultural industry. Because of this, businesses (particularly within the Tier 1 manufacturing sector) have been investing a great amount of time and money into researching systems to meet these new requirements. This has led to a boom in available technology such as: electronic water pumps, automated front grills to adjust air flow, direct in-car passenger heating to replace entire cabin heating and ultrasonic water disturbance within radiators to improve heat transfer.

The event began with a keynote speaker, Chris Cowland, the current Director of Advanced and SRT Powertrain at Fiat Chrysler Automobiles. Mr Cowland discussed the complexities ahead, pointing out that with the technologies being proposed, an unprecedented leap forward in the required computing power within each vehicle would have to be made. Mr Cowland explained that a production engine would potentially require an estimated 700% increase in sensors and actuators within the coolant system alone. It should be noted that this solution was also one of the simpler systems proposed.
Mr Cowland also stressed that these technologies, although already available, have to wait until the final consumer is prepared to pay for it before it will ever be seen on a production vehicle. It was clear by the end of the symposium that this was by far the most frustrating reality shared by all engineers and manufacturers at the symposium. This, coupled with the issue of packaging all these systems in a vehicle appears to have resulted in a collection of extremely sophisticated technologies being put aside.

Overall, the symposium was a fantastic opportunity to network with other engineers and I learned a great deal about the industry. I believe thermal management will continue to be of key interest, particularly within agriculture as tractors often cannot move away from the heat they are producing. It will be exciting to see who will be the first to harness this heat for useful purposes, be it in automotive or agricultural applications.

Personal Objective

The following sections of this document are confidential and should not be reproduced or shared.

My interest in visiting this event was to research the feasibility of a concept & theory developed whilst at Harper Adams University. The system is based on an organic rankine cycle which powers an electrolysis process generating a secondary fuel for the vehicle. This interested me particularly as energy storage via an alternative fuel is capable of retaining a large amount of power without the large space and weight requirements of batteries.

Many topics were discussed at the event, including a great deal of air conditioning efficiency. Three of the topics were of particular interest; the feasibility of the rankine cycle discussed by an Engineer from Loughborough; subcooled boiling investigated by the Argonne National Laboratory; and exhaust heat recovery systems considered by Honda. All of which will be discussed further below.

Kartik Kulkarni, Organic Rankine Cycle System

Kartik Kulkarni has carried out significant research into the Rankine cycle as a method of recovering waste heat. A key finding in his paper outlines the requirement to keep the system subcritical at all times i.e., below boiling point. This is contrary to how the system would work optimally as you get a far greater pressure increase (driving power for the turbine) when the liquid turns to gas. However, many engineers discussed the danger of phase change within any system, particularly with regards to the longevity of components. To gain maximum efficiency from the subcritical system, Mr Kulkarni proposed a dual loop system consisting of high and low temperature sections. Figure 1 shows the schematic of the dual loop system. All figures are sourced from symposium presentations.

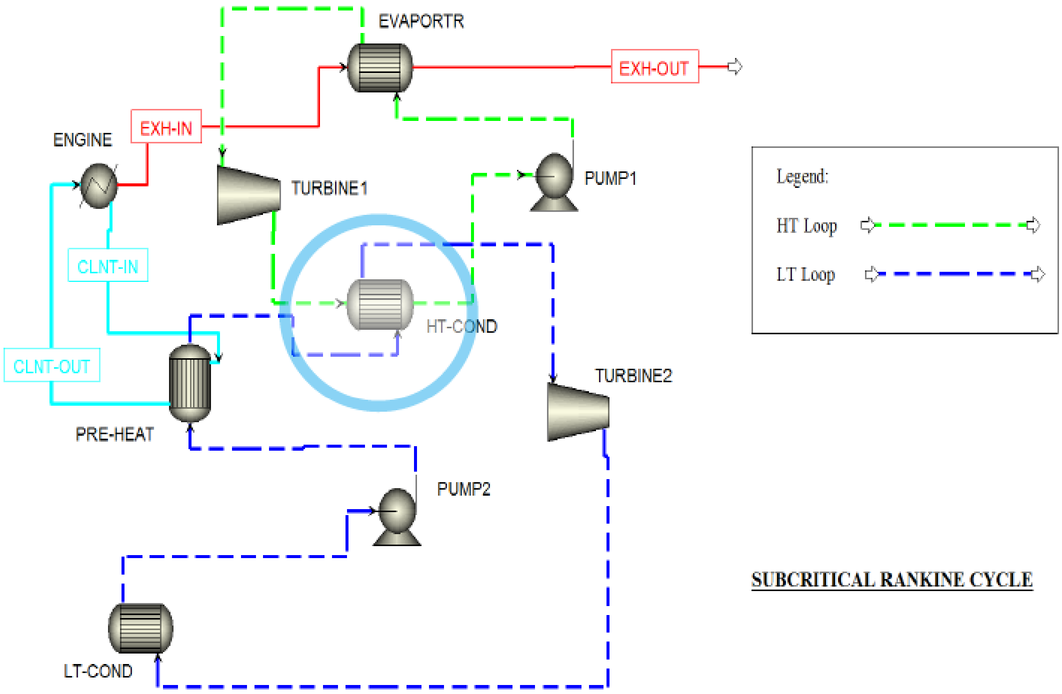

Figure 1 Dual Loop System

The high temperature loop utilises heat from the exhaust gasses and the low temperature from the engine.
His simulations yielded a 10.63% thermal efficiency increase but from a practical integration point, the system would be very difficult to use as it consists of many components taking up a large amount of space.

Weihuan Zhao, Subcooled Boiling System

Weihuan Zhao, from Argonne National Laboratory discussed the results of her, still in testing, subcooled boiling system. However, it was clear that there were many issues not considered within her test. The most important being the use of soluble substances in the coolant which, when boiled, will deposit causing significant damage internally. Figure 2 shows the cooling channels of the subcooled boiling system.

Figure 2 Cooling Channels

It is clear that, with the very narrow channels, deposit build up will have a severe effect on flow. Not only this, the forces present during rapid boiling and condensing will take a serious toll on the physical components.
An engineer from Ford also explained that their testing had shown systems using boiling techniques often suffered from dry areas which are subjected to intense heat differences. Despite this, the subcooled boiling system potentially allows for the dual loop cooling system within a hybrid vehicle to be contained within a single loop, as shown in Figure 3.

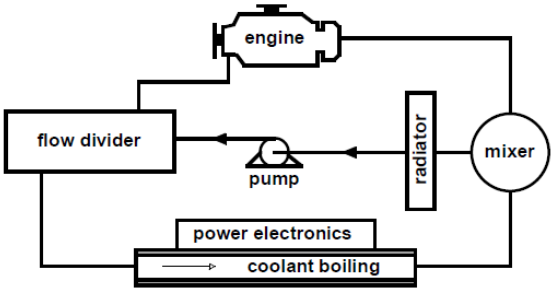

Figure 3 Single Loop Subcooled Boiling System

Honda R&D Co., Ltd, Japan, Thermoelectric System

The company demonstrating the most investment into waste heat recovery appeared to be Honda. However, this was research into a more uncommon form of harnessing heat energy through thermoelectrics.

Honda would not disclose the material used, but after discussing with the presenter, Mr Katsuya Minami and other engineers, it is most likely Skutterudite or something very closely related. This material is used as when a temperature difference is applied to it, the electron density shifts causing a potential difference. Figure 4 demonstrates how the material reacts.

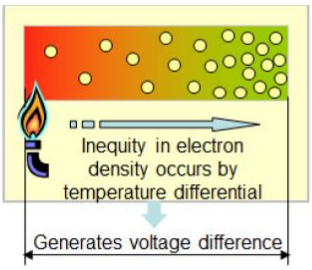

Figure 4 Seebeck Effect

The phenomena of a material reacting to a temperature difference in such a manner is known as the Seebeck Effect.
Some success has been made with this, however, the energy payback is relatively low when considering the investment (around 100 Watts for a single unit installed after the catalytic converter).
Furthermore, because great difficulties have been met with bonding this type of material to an exhaust, unfortunately, Skutterudite is inherently brittle. Even if it survives the manufacturing process undamaged, it is likely to fail well within the expected lifetime of the vehicle. However, this is something that is being investigated by Honda and other Tier 1 manufacturers who are investing in thermoelectric technology.

Figure 5 Fractured Material

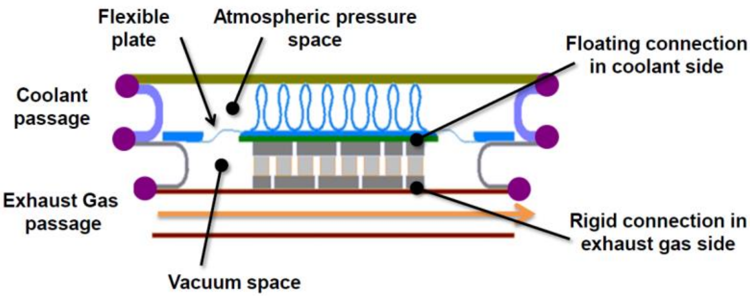

Figure 6 Floating Plate System

Figure 5 shows a Skutterudite block which has fractured during the manufacturing process. Unfortunately, each block of Skutterudite used is linked in series, hence, when one fails, the entire row fails. Figure 6 shows Honda's alternative bonding system which allows one side to float. However this greatly adds to the complexity of manufacturing.

General Observations and Discussions

The primary force which controls all of the innovations discussed at the symposium is the consumer market. It was clear to see at the symposium the frustration felt by Tier 1 suppliers, engineers and innovators alike who were in the process of trying to incorporate or develop these systems with no clear interest from OEMs to invest and use.
The question is, why would the motor companies not buy into these technologies? Technologies that could see efficiency increase dramatically allowing directives not just to be met, but surpassed?
The reality is, with this technology looming, the oil price has fallen dramatically. This means that consumers are not willing to pay more for a vehicle with added efficiency technology as the savings would not be achieved during the lifetime of the vehicle. This circumstance is

particularly prevalent in the United States where the fuel price is comparatively low, 27 pence per litre compared to 98 pence per litre in the UK (on the 22/02/16).
The matter then becomes even more complex when manufacturers are set goals (through legislation) to sell a certain percentage of (for instance) hybrid vehicles.
At a time where Prius sales have dropped 20% and people are not willing to pay extra for a more efficient car, it leads motor companies selling vehicles at a loss.
At the beginning of the symposium, a research engineer looking into the organic rankine cycle as a means to recover energy asked Chris Cowland, “How can OEMs expect us to continue our investment into these systems when there is no guarantee even within the next 5 to 10 years they will be bought?” For this, Mr Cowland had no answer and simply implied that it is an issue which they are well aware of.
It is my belief that the automotive industry is being held as a scapegoat for the global warming crisis, forcing a leap in technology that is not yet actually required on the front line. There will be a time for these systems, just maybe not yet.

As for an organic rankine cycle system, this is already being considered with interest by Tier 1 manufacturers. However, even an OEM manufacturing large truck units for the American market, outlined that the space required to accommodate this type of system is simply not available, I believe this is why Honda are investing purely in the exhaust heat recovery as space under the car around the exhaust pipe, is not as crucial as that under the hood. It was made clear that packaging is a major factor that must be considered when integrating a new system within the automotive and agricultural sectors.

Overall, the trip was extremely informative, provided a fantastic networking opportunity and has been a superb insight into automotive engineering. Once again, I'd like to thank the Douglas Bomford Trust for all their support.

Thomas Lindley
MEng AgEng Student
Harper Adams University