heat2power

Stand 5444

Waste heat regeneration for internal combustion engines in automotive, truck, power generation, marine and racing

By Randolph Toom, Managing director of heat2power

Heat2power, a young and innovative company based in Paris, France is convinced to have in hand technologies that can really save fuel and reduce CO_2 emissions of tomorrow's cars, trucks, and ships.

When the company founders investigated all possible levers for better fuel economy of internal combustion engines, significant potential was found in improved combustion processes, overexpansion, variable valve actuation but also on re-use of energy that is normally wasted. Analysis of the distribution of power flows made clear that exhaust waste heat represented a major potential for fuel economy because of its high temperatures.

Initially, the idea arose to use a Stirling engine on the exhaust to produce 'free' additional power; that is without extra fuel consumption. However, the Stirling engine was found to be too heavy and too big for the regenerated power in mobile applications. Therefore a search for more convenient technologies was started. Many thermodynamic machines were examined but they also had inconveniences. Mostly because of liquids that had to be added to the vehicle as is the case with Rankine and Organic Rankine Cycles.

Heat2power also closely looked into thermo-electrics (TE) and found extensive research projects going on at universities and renowned engine developers with publications being largely available. Thermo-electrics and the derivatives like thermo-ionic emission and thermo-tunnelling are found to be on a development track similar to solar cell development 20 years ago and heat2power considers it will take a long time to reach reasonable cost and packaging targets. Some Tier 1 suppliers however work seriously on TE and aim for a performance of 1 kW for 300 Euro. Heat2power is seriously convinced that this aim is set too low to make significant fuel economies on a vehicle.

Thermo-chemical technologies were also investigated. Extensive research had already been done since several decades in this domain and it was found that the processes usually rely on generating hydrogen rich gas from a hydrocarbon, water or a combination of the two. The main idea behind this is to use hydrogen both as a fuel and as diesel/gasoline combustion enhancer. The high flame speed can indeed generate a more complete and rapid combustion of the fuel normally used and yield fuel economies of around 6% as was previously shown by Professor Eran Sher from Ben-Gurion University in Israel


Hot exhaust : source for waste heat recovery

Though the technologies are today widely used in the petrochemical industry, and are at the origin of over 90% of the world's hydrogen production (the rest being from electrolysis) the presence of water in the engine and exhaust was often the cause of durability issues and projects never really made it into mass production. Heat2power therefore had decided not to pursue this path.

Turbo-compounding finally was found to have only narrow RPM band of effectiveness at part load and therefore considered to be only modestly interesting for road applications where speeds vary a lot.

Generic passenger car unit

- Add-on module of ~10-20 kW
- Cost target less than 400 €
- Fuel economy 15-30 %

From all the knowledge that was acquired in the search combined with the experience in the automotive mass production the founders concluded that no existing technology was perfectly adapted for regenerating the ICE's waste heat. Where other engineering companies persist in developing Rankine or Organic Rankine machines with the inconvenience of adding liquids to the vehicle and to have to deal with piston blow-by or even thermo-electric devices with high cost and very low output for several years to come, heat2power focussed on developing cost effective technology based on conventional components, without using additional liquids and that is easy to adopt on current engine production lines while at the same time being able to deliver good heat

regeneration efficiency combined with high specific power. A new and now patented concept was developed and has been thoroughly simulated under all driving conditions. The concept is basically a new variant of the hot air engine, but different in a way that high specific power can be developed, so crucial for finding a place in the engine bay that has little space left. The simulations have now been staffed by a major OEM and the company expects its first prototype to confirm the simulated results by the end of 2008.

The understanding of the available enthalpy in the exhaust under various driving profiles enables heat2power to focus on products that closely match OEM's requirements. For example for a middle class vehicle, the required power on motorway driving is at around 25 kW. The WHR system fitted as an accessory onto the engine that heat2power then would propose only has about 10 kW to achieve the maximum regeneration potential for most of the drives. Combining this with a longer gearbox ratio, possible due to the torque added by the WHR system, will allow higher specific load and hence better fuel economy from the ICE itself under the same conditions. The fuel economy benefit then comes from both sides: ICE and WHR system. Such a system is estimated to cost around 400 Euro. Without downsizing of the ICE, NEDC fuel economy is estimated at about 12-15%. When the ICE is downsized by 15% the NEDC fuel economy increases to around 15-22%, and more importantly up to some 30% on extra urban driving. In case the OEM desires a 20 kW unit the cost would only be marginally higher.

The simplicity of the system and the low cost make it a really attractive solution in comparison with other fuel savings technologies. It is also fully compatible and complementary to hybridisation. The heat2power concept actually improves the ICE efficiency of which the hybrid powertrain benefits.

The technology is currently in evaluation by several major OEMs and their comments are very encouraging. Heat2power therefore expects to sign several development agreements in 2008.

As the technology is fully scaleable, applications for full power in racing (Le Mans Series for example), for ships, trucks and for power generation are possible. For big diesel engines in power generation the efficiencies are already very high and hence the fuel economy potential with heat2power is calculated to be only in the 8-10% range. Though this seems low, the interest is huge because these engines run around the clock, almost every day of the year. Therefore return on Investment is obtained in a matter of months.

In racing applications measurements show a very high thermal power in the exhaust of the base engine. In a 3,4 litre V8 between 8000 and 11000 RPM the ratio of thermal power in exhaust over crankshaft power can be as high as 180%. The heat2power device can then add a considerable amount of "free" power to the vehicle. The only drawback is adding some weight at ~1.2 kW/kg. For the vehicles that have to carry ballast in order to comply with regulations the extra mass added by heat2power can be deducted from ballast. Thus the vehicle weight can remain the same and the power to weight ratio is considerably improved. For a track like Le Mans this would give much better benefits than an electro-hybridisation. The first racing application is expected to run in 2009.

Heat2power proposes potential customers first to do joint evaluation of simulations. When the customer is satisfied with the results heat2power can then propose prototype projects and development programs.

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