Periodic Report Summary:
TIFFE (Thermal systems integration for fuel economy)

Abstract: Project context and objectives:

The project is devoted to the development of an innovative integrated vehicle thermal system based on the integration of vehicle thermal systems to improve the on board thermal management and the energy efficiency. The major project contents are:

- dual loop air conditioning: one loop transfers the cooling power and one rejects the heat;
- two-level temperature heat rejection system: one temperature to reject the high-temperature heat (e.g. engine waste heat) and one temperature to cool locally the vehicle auxiliary systems;
- innovative heat exchangers: new generation of compact fluid-to fluid heat exchangers and application of innovative technologies for fluid-to-air heat rejection;
- use of innovative coolants (e.g. nanofluids) to improve the heat rejection and redesign the heat exchangers.

TIFFE benefits can be summarised in a cost reduction (due to resize of the systems and their integration) and fuel economy increase of 15 % on real use thanks to the:

- improvement of the aerodynamics due the new front end design;
- increase of auxiliary systems efficiency thanks to the local cooling;
- engine overall efficiency thanks to a fine control of heat exchange, local cooling (turbocharger, fuel) and improvement of the engine intake;
- the reduction of engine re-starts on hybrid or Stop&Start vehicle due to cabin thermal comfort: the dual loop air conditioning with a designed thermal inertia guarantees thermal comfort when the thermal engine is off;
- compact refrigeration unit compliant with low Global warming potential (GWP) refrigerants - R-744 or flammable (R-152a, HFO-1234yf, R-290).

Two prototypes will be realised and validated:

- a gasoline passenger car with Stop & Start function;
- a diesel Light Commercial Vehicle with hybrid power train.

Both will undergo to a complete series of road and climatic chamber tests and road tests to verify the reliability and effectiveness of the system and to promote its exploitation.

Project results:

During the second part of the Project the most relevant results can be summarised as follows:

- A second IVECO Daily TIFFE demonstrator has been realised (F1A engine) with improved components (liquid cooled condenser, liquid cooled charge air cooler and front thermal module) and fully validated. The results are very promising showing a fuel economy increase of up to the of 5 %.
- A specific active shutters system has been designed and prototyped for the Low-combination vehicle (LCV) application.
- The system control strategies have been defined and implemented on the LCV application.
- The system architecture has been refined for both the applications.
- The Compact Refrigeration Unit has been designed, prototyped and validated in laboratory. Two units will be then realised for the LCV and passenger car application.
- A passenger car TIFFE demonstrator (Ford Focus) has been realised and will undergo to the experimental validation before the end of the project.
- The flat heat exchanger technology has been further developed and refined refined realising a new aerodynamic underbody and engine hood based on the roll bond heat exchanger technology while a different technology is under testing for mudguards.
- To promote the TIFFE contents and concept several publications and presentation have been made within international congress and events, among those the most relevant event is the session devoted to the TIFFE project within the 4th European Workshop Mobile Air Conditioning and Vehicle Thermal Systems 201, Centro Congressi Torino Incontra, 1-2 of December 2011, Torino, Italy.

Potential impact:

The TIFFE system aims to reduce the overall vehicle fuel consumption in real use of about the 12%.

For a passenger car and for a Light Commercial Vehicle, it is estimated that TIFFE can reduce the fuel consumption and CO2 emissions by around 15% in real use, following this deployment:

3 % through the use of more efficient components such as heat exchangers, fans;
1 % due the reduction of the cooling drag;
- 4 % thanks to the optimisation of the working temperature subsystems: charge air cooler, engine, gas cooler/condenser, alternator;
- 4 % by means on overall and systemic thermal energy management strategy;
- 3 % as effect of the specific design dedicated to Stop&Start (e.g. air conditioning) and Hybrid Powertrain that will reduce the need to re-start the thermal engine.

Besides the impact on vehicle fuel economy, the TIFFE system will assure better thermal comfort performance due to the new approach to the air conditioning and the safe use of any low GWP refrigerants compliant with the incoming EU regulations and the worldwide scenario.

Moreover the TIFFE system will assure an increase of the air conditioning efficiency of about 15 % (reference baseline systems), contributing to the overall vehicle fuel economy increase in real use.

This improvement can be higher (up to 25 %) in case of Stop & Start or hybrid vehicle, because of the increased thermal inertia of the air-conditioning system that reduces the need to activate the thermal engines to keep the thermal comfort at acceptable levels. In addition the re-design of the engine bay will have benefit on:

- pedestrian impact performance, enabling more degree of freedom of the vehicle front end;
- overall vehicle aerodynamics, thanks to less severe constraints on the frontal part of the vehicle and the use of function underbody shields.

The performance will be assessed realising two demonstrator vehicles based on:

-passenger car with Stop & Start function;
- light commercial vehicle with hybrid power train.

Both the two vehicles will be, at first fully characterised before any change or modification following the procedure identified in the Work package one (WP1), then each vehicle will be equipped with a dedicated version of the TIFFE system becoming two prototype demonstrators. The two prototypes will be, then, tuned and optimised and validated experimentally following the same testing procedure defined in WP1.

After that the two vehicles will be submitted also to significant road test to assess the system reliability and effectiveness.

List of websites: http://www.tiffe.eu

Subject Descriptors: Heat transfer; Transport

Subject Index Codes: Transport; Energy Storage, Energy Transport

Collaboration Sought: N/A

Remarks: Source: SESAM