Development of Low and high Temperature Thermoelectric Generators for Automotive Waste Heat Recovery System

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RAVERS

Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System

Outline

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- Introduction to RAVERS
- Goal and Objectives of R & D
- Technical Approaches
- Experiment and Fabrication results
- Summary and Further works

Introduction to RAVERS

- Research Center for Advanced Hybrid Electric Vehicle Energy Recovery System(RAVERS) at CBNU
- Supported by Korean government (Ministry of Knowledge Economy, MKE) and Chungbuk Provincial government
- RAVERS collaborates with Major Korean motor companies and Battery and Ultra Cap makers for development of TE-HEV and Battery management system of HEVs.

Goal and Objectives of R & D

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- Developing a Low and high Temperature Dual Thermoelectric Generation Waste Heat Recovery System for Light-Duty Vehicles
  - More than 10% Fuel Efficiency Improvement for the light-duty vehicles with Gasoline or LPG engines
  - Target vehicle is a compact passenger car with engine size from 1500 to 2000 cc
  - Developing superlattice TEM for high temp and low cost material as well as an environmentally nonhazardous substance
  - Design Optimization & Performance Analyses for Integrated TE System
  - System-Level Analysis and Testing of Advanced TE Materials

Achievement Plan

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- Phase I (2009 -2010)
  - Developing 1KW TEG for a light-duty vehicle by the end of FY2010
  - Replacing an Alternator of conventional ICE vehicles
- Phase II (2011 -2012)
  - Developing 5KW TEG for a light-duty vehicle by the end of FY2012
  - TE module will be adapted to regenerative breaking HEVs
- Phase III (2013 -2014)
  - Development of TE-HEV for Plug-in HEVs
  - Due to the TE power generation, the engine size can be reduced

Technical Approaches: Phase I

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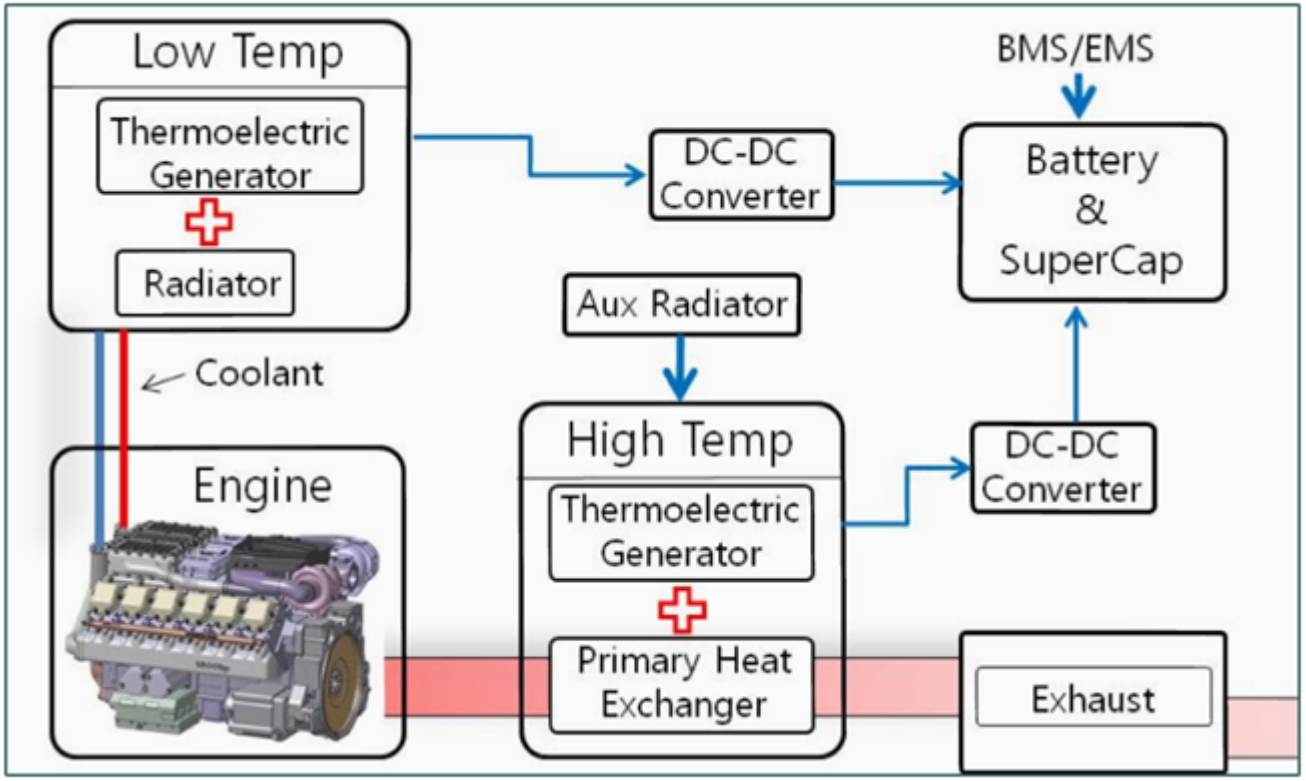
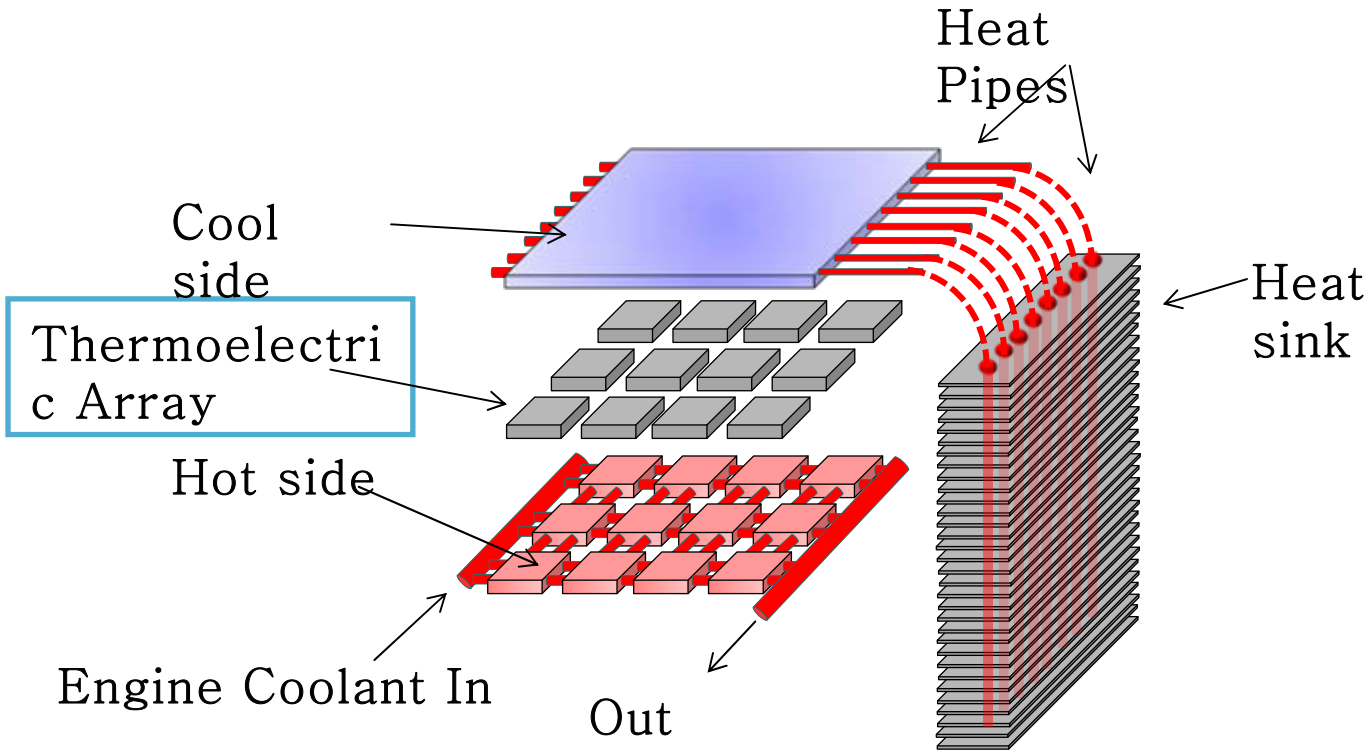
- Dual Thermoelectric Generation Waste Heat Recovery System
  - Low temperature generator using Radiators : ~100W
  - High temperature generator using exhaust gas : ~1KW



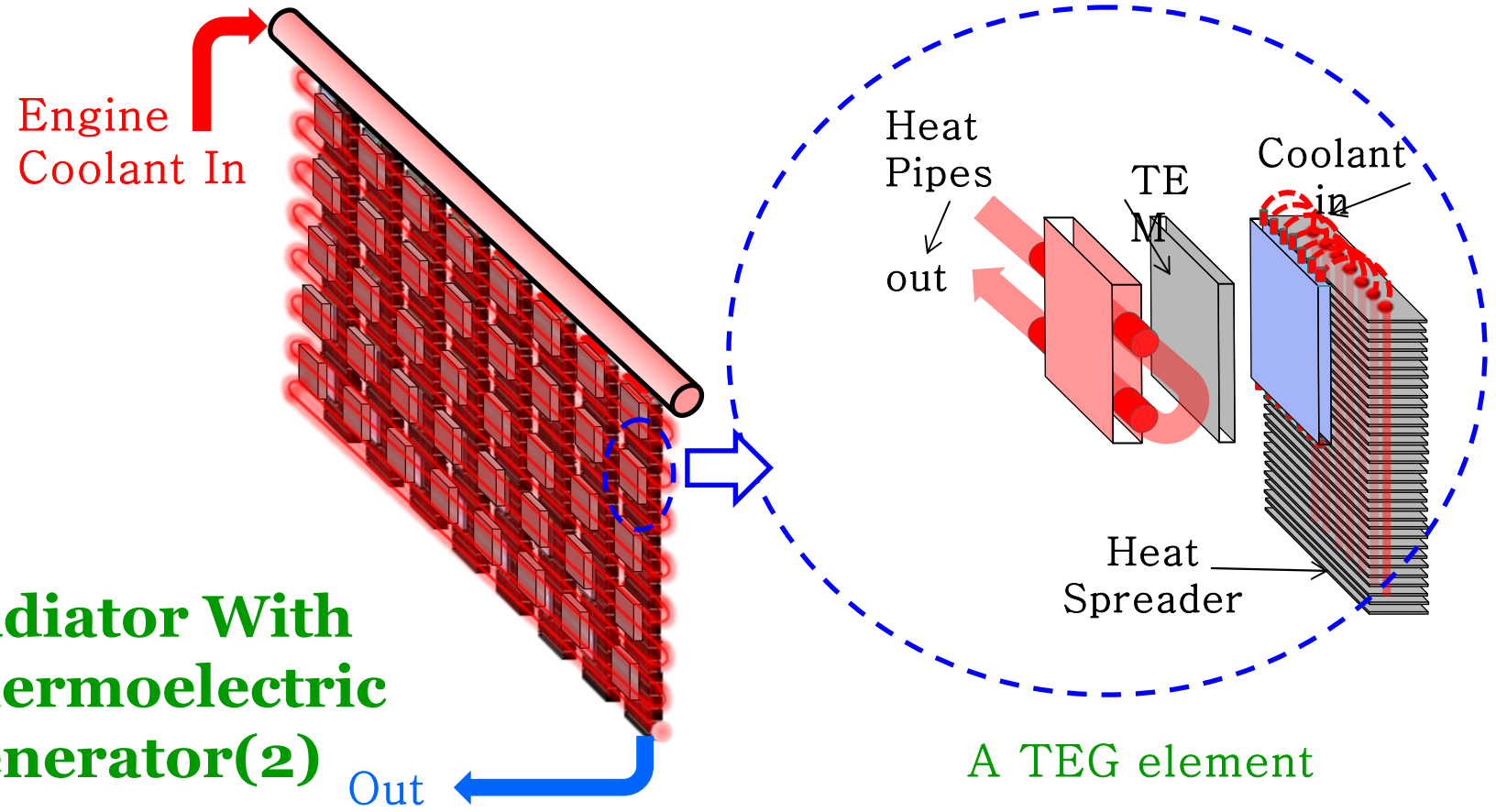
Technical Approaches: TEG-Radiator



Conceptual diagram of Radiator With Thermoelectric Generator (1)

Technical Approaches : TEG-R cont'd

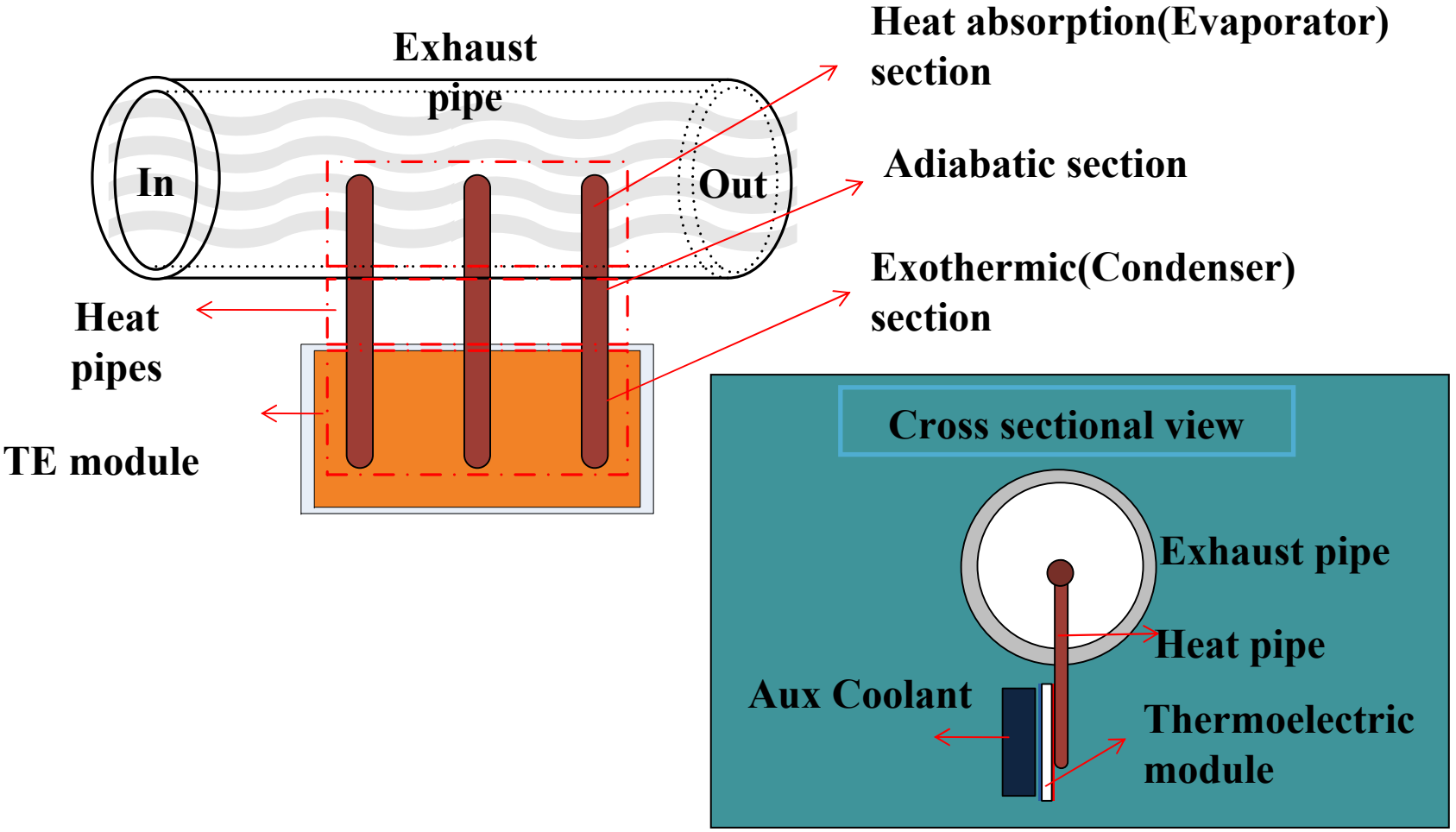
- TEG using Radiator (2)



Radiator With Thermoelectric Generator(2)

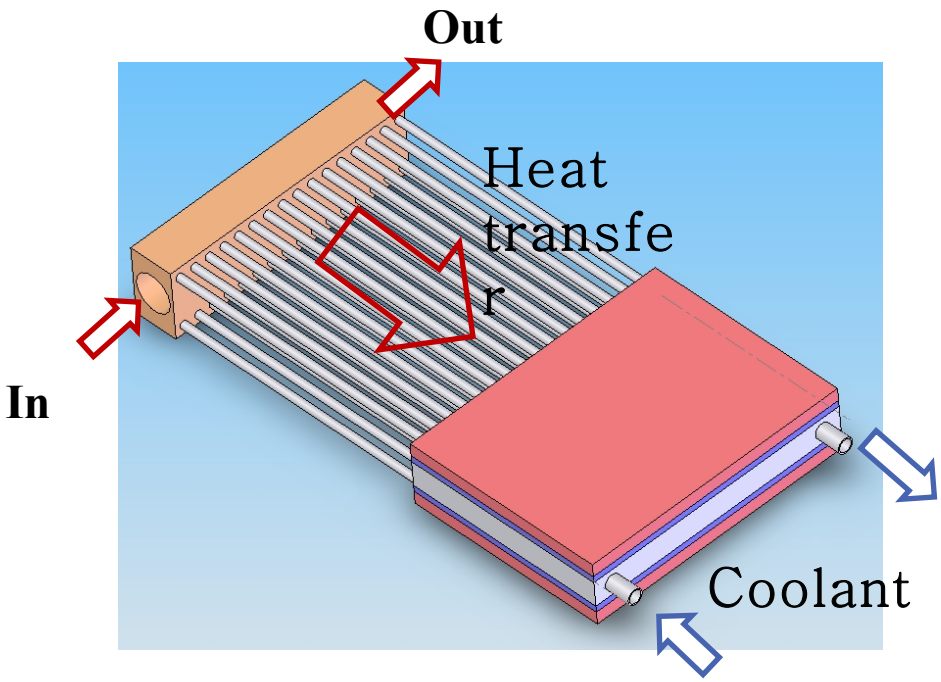
Technical Approaches:TEG-EG

- TEG using Exhaust Gas [1]



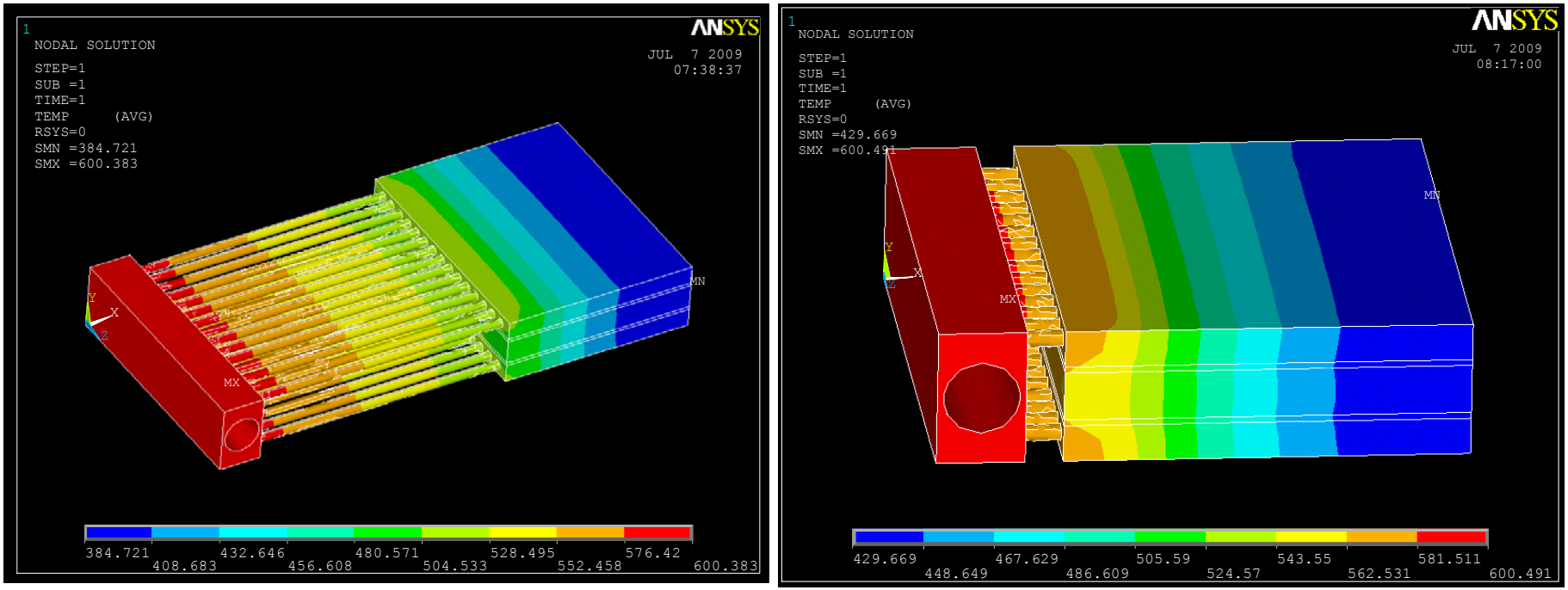
Technical Approaches : TEG-EG cont'd

- TEG using Exhaust Gas [1] :
  - modeling for simulation



Technical Approaches : TEG-EG cont'd

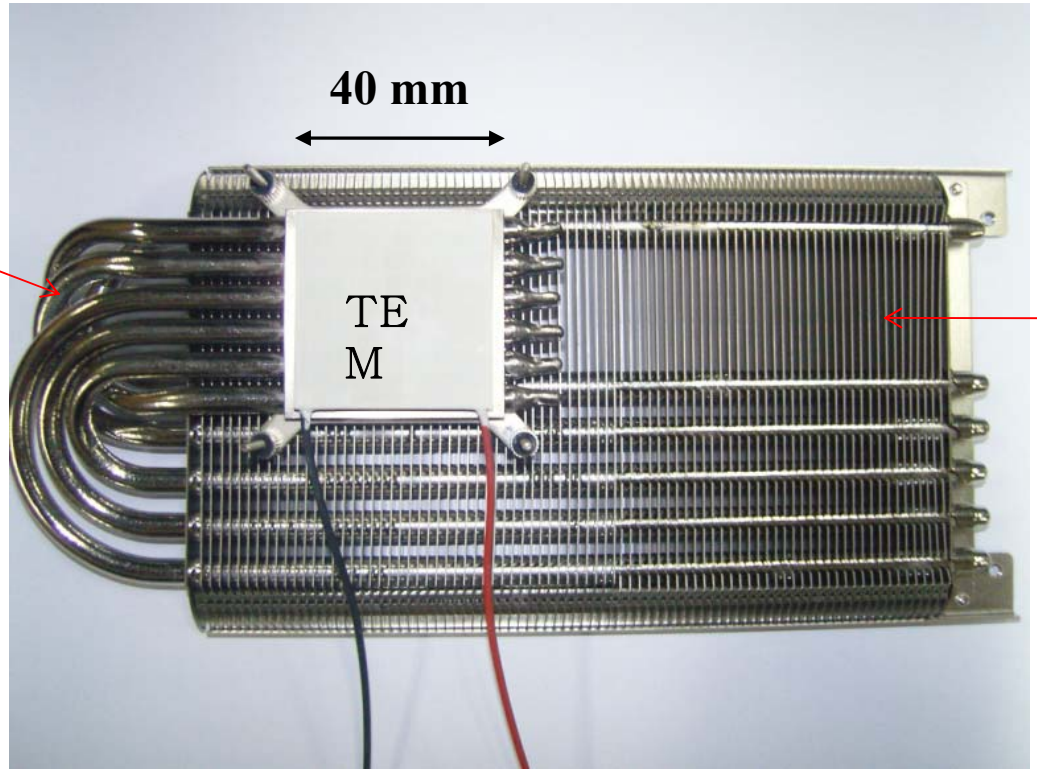
- TEG using Exhaust Gas [1] : simulation results



(a) Using long heat pipes, (b) using short heat pipes

Experiment using cooler with heat pipes

- Thermoelectric Generator with loop thermosiphons and heat spreader for air cooling system



Experiment using cooler with heat pipes (2)

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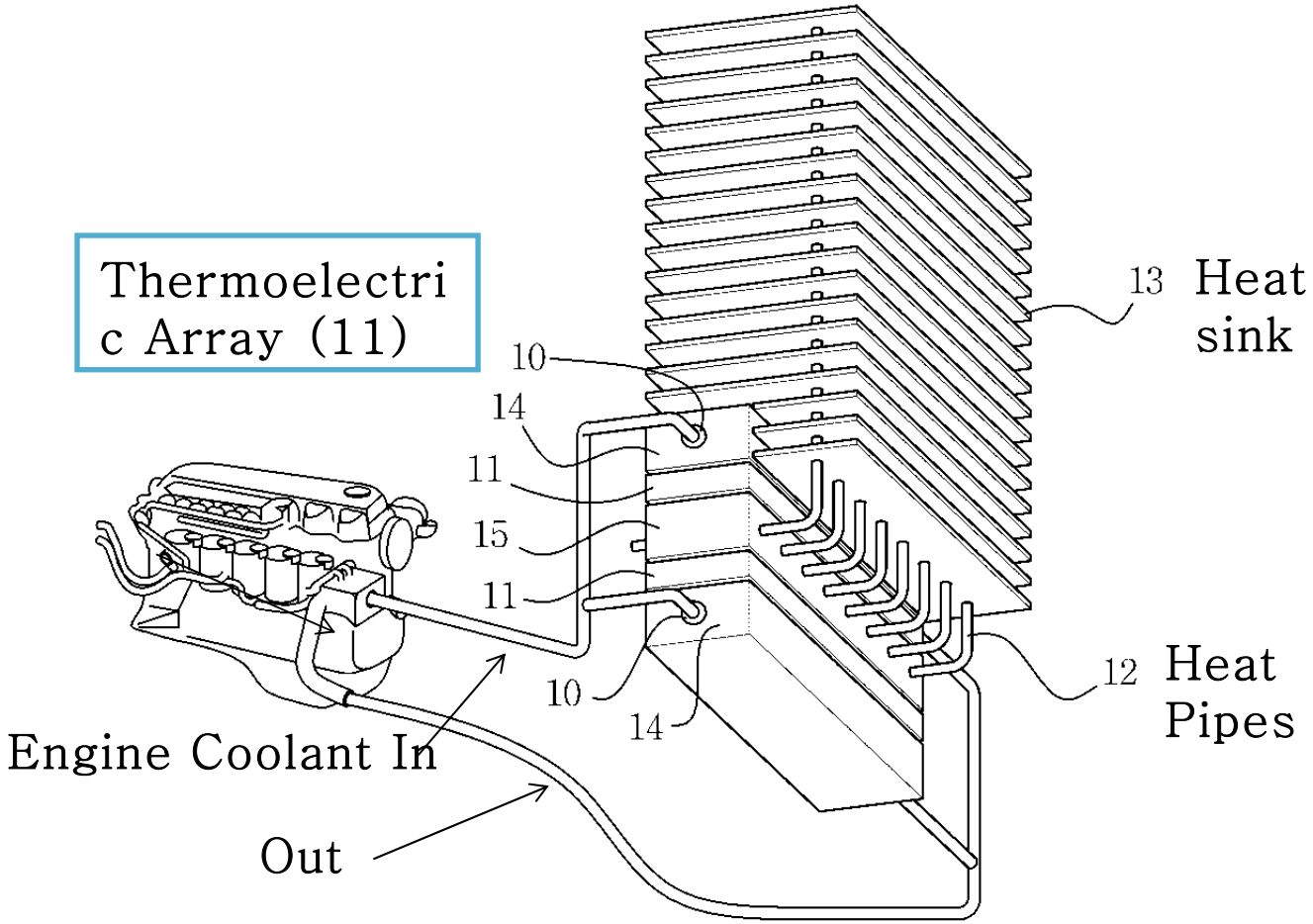
- Experimental Results
  - 4cm x 4cm Bi2Te3 Thermoelectric Device
  - Ambient temperature of Lab is about 30°C

Temp (Hot side)	Power max	V open/I short	Remark
100°C	0.64 Watt	2.2V / 1.2A	Without cooling Fan
100°C	1.44 Watt	3.3V / 1.75A	With cooling Fan
150°C	3.65 Watt	5.2V / 2.8A	With cooling Fan
200°C	5.68 Watt	6.7V / 3.39A	With cooling Fan

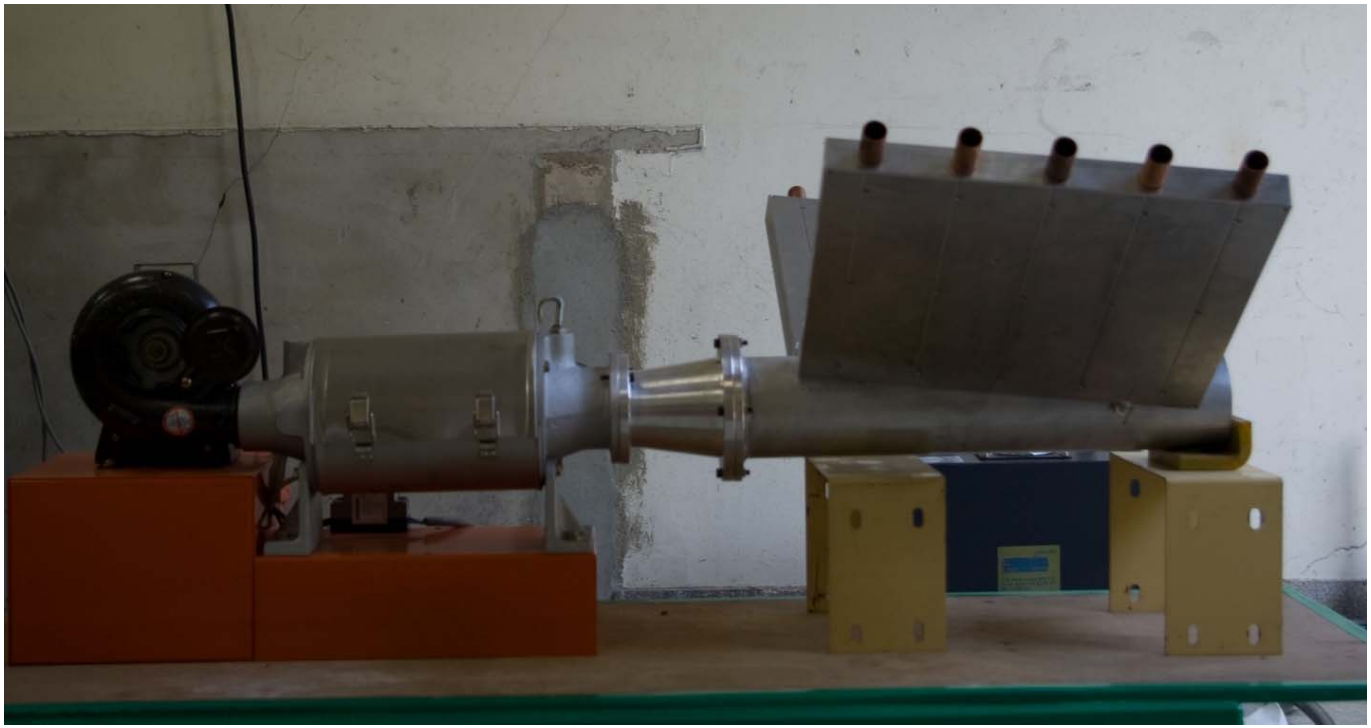
Fabrication of TEG-Radiator



Radiator With Thermoelectric Generator under fabrication

Fabrication of TEG-Exhaust Gas

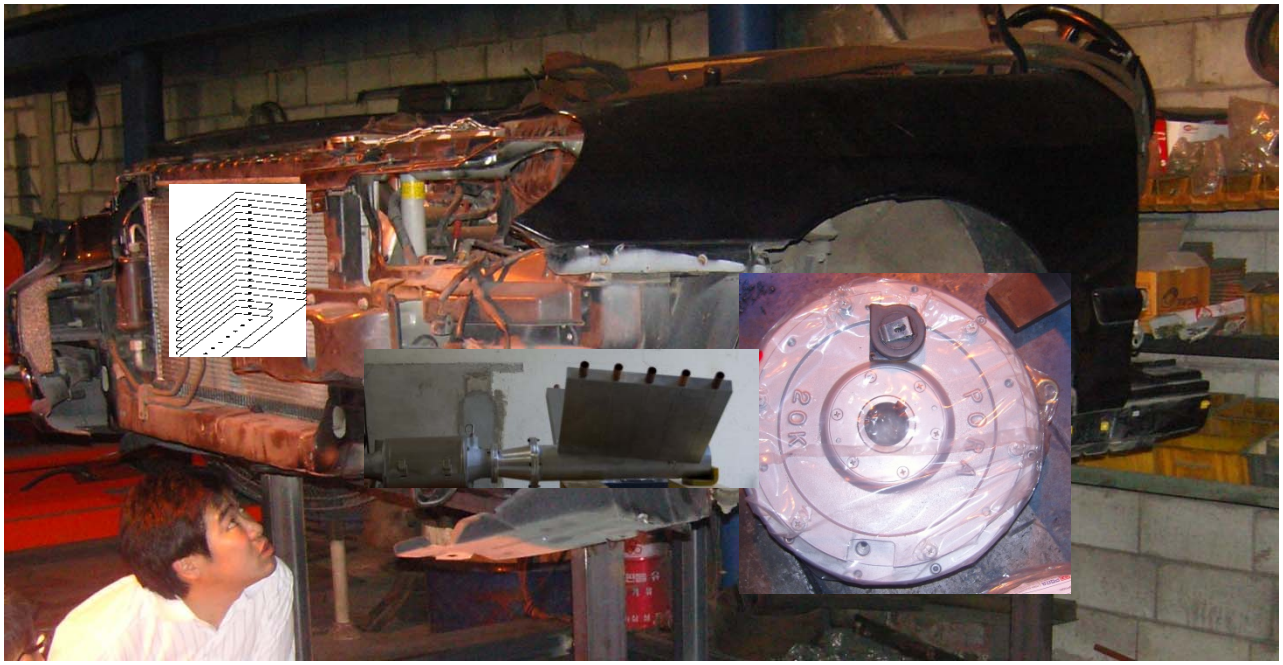
- Fabricated TEG using Exhaust Gas [1] :



Experimental setup for TEG-EG Supplying Exhaust Gas using a Gas Burner

Fabrication of Automobile simulator

- Automobile simulator under manufacturing



Half car having an Engine and front wheel drive train with Electric break system with load control

Summary and Further Works

RAVERS
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- We have developed a Low and high Temperature Dual Thermoelectric Generation Waste Heat Recovery System
  - For compact size passenger Vehicles
  - Primary high Temperature heat exchanger designed to recover waste heat from the exhaust gas
  - Secondary low temperature Thermoelectric Generator using coolant of a Radiator.
- Manufacturing first Prototype of heat exchanger using Thermosypons will be finished at the end of this year
- Development of superlattice for high temp and low cost TE material as well as environmentally nonhazardous material for Phase II

Thank you for your attention

ACKNOWLEDGMENT

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