Multiphysics Modeling and Optimization of Automotive Heat Exchanger for Exhaust Heat Recovery

Asutosh Prasad* and Raj CN Thiagarajan
*Corresponding author: ATOA Scientific Technologies Pvt Ltd, 204 Regent Prime, 48 Whitefield Main Road, Whitefield, Bengaluru 560066, India, www.atoa.com, corp.hq@atoa.com.

Introduction: An Internal Combustion Engine (IC Engine) is a major source of waste heat energy. It does not efficiently convert chemical energies to mechanical energy. Approximately 70% energy is wastage while remaining 30% used for vehicle operation which is a huge loss in terms of fuel efficiency. Recovering waste heat from exhaust gas by help of an optimized exhaust system is a promising solution to reduce energy loss.

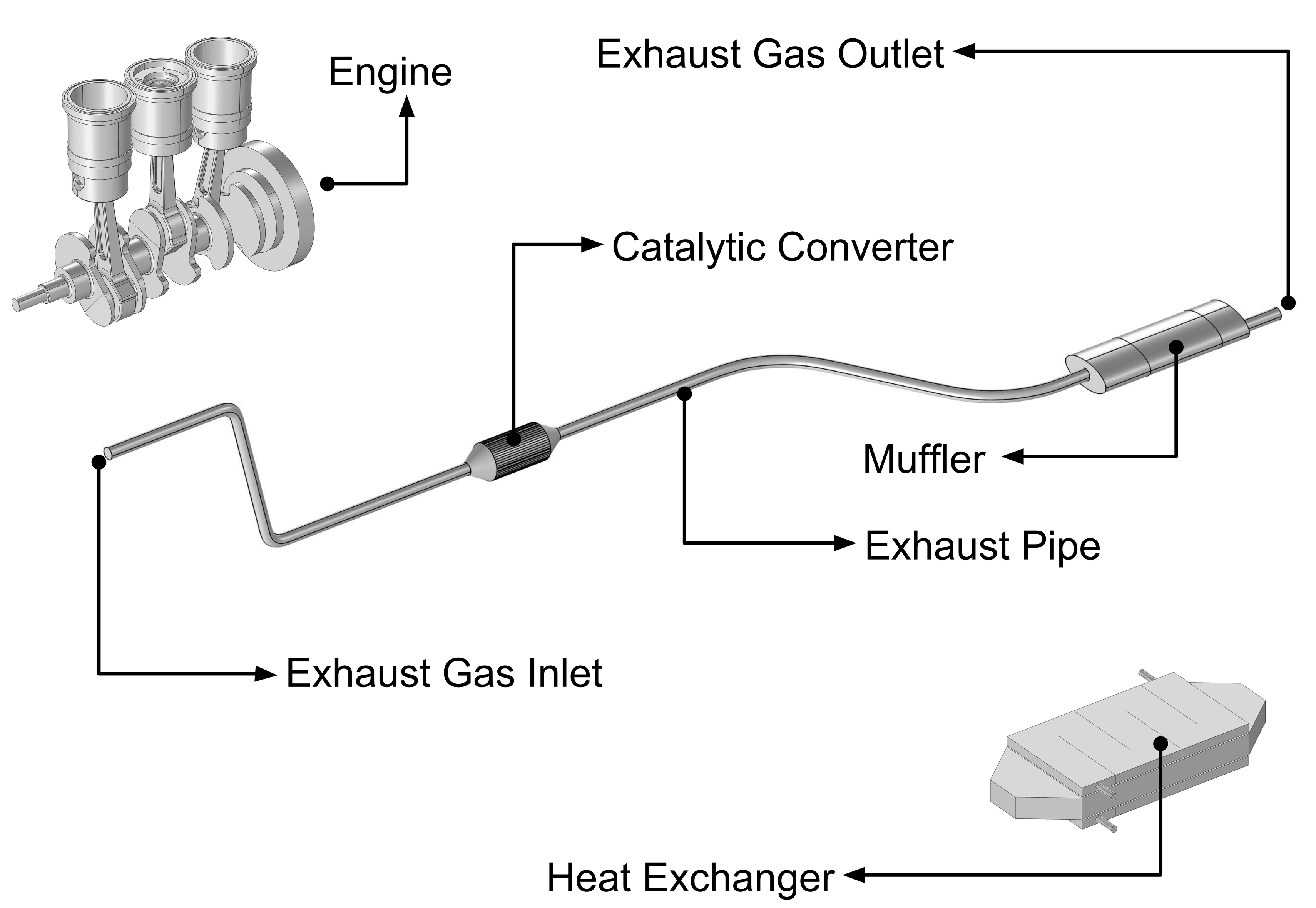

Fig 1. Automotive Exhaust System

Computational Methods: Multiphysics CAE Model of an automotive exhaust system is developed using COMSOL 5.2. The numerical problem is solved using Heat Transfer and Fluid Flow Module in temperature range upto 400^{C}. The governing equations are mentioned below.

(1) Heat Transfer in Solid

$$\rho C_p u.\nabla T + \nabla.q = Q + Q_{ted},\ q = -k\nabla T$$

(2) Heat Transfer in Fluid

$$\rho C_p u.\nabla T + \nabla.q = Q + Q_p + Q_{vd},\ q = -k\nabla T$$

(3) Fluid Flow

$$\rho(u.\nabla)u =$$

$$\nabla.[-pI + \mu(V u + (\nabla u)^T) - \tfrac{2}{3}\mu(\nabla.u)I] + F$$

$$\nabla.(\rho u) = 0$$

Results: Simulation results shows the temperature distributions of the optimized automotive exhaust system in the specified temperature range. The temperature range of 100^{C} to 400^{C} predicted on different locations of exhaust system, while the maximum temperature occurs near to the engine.

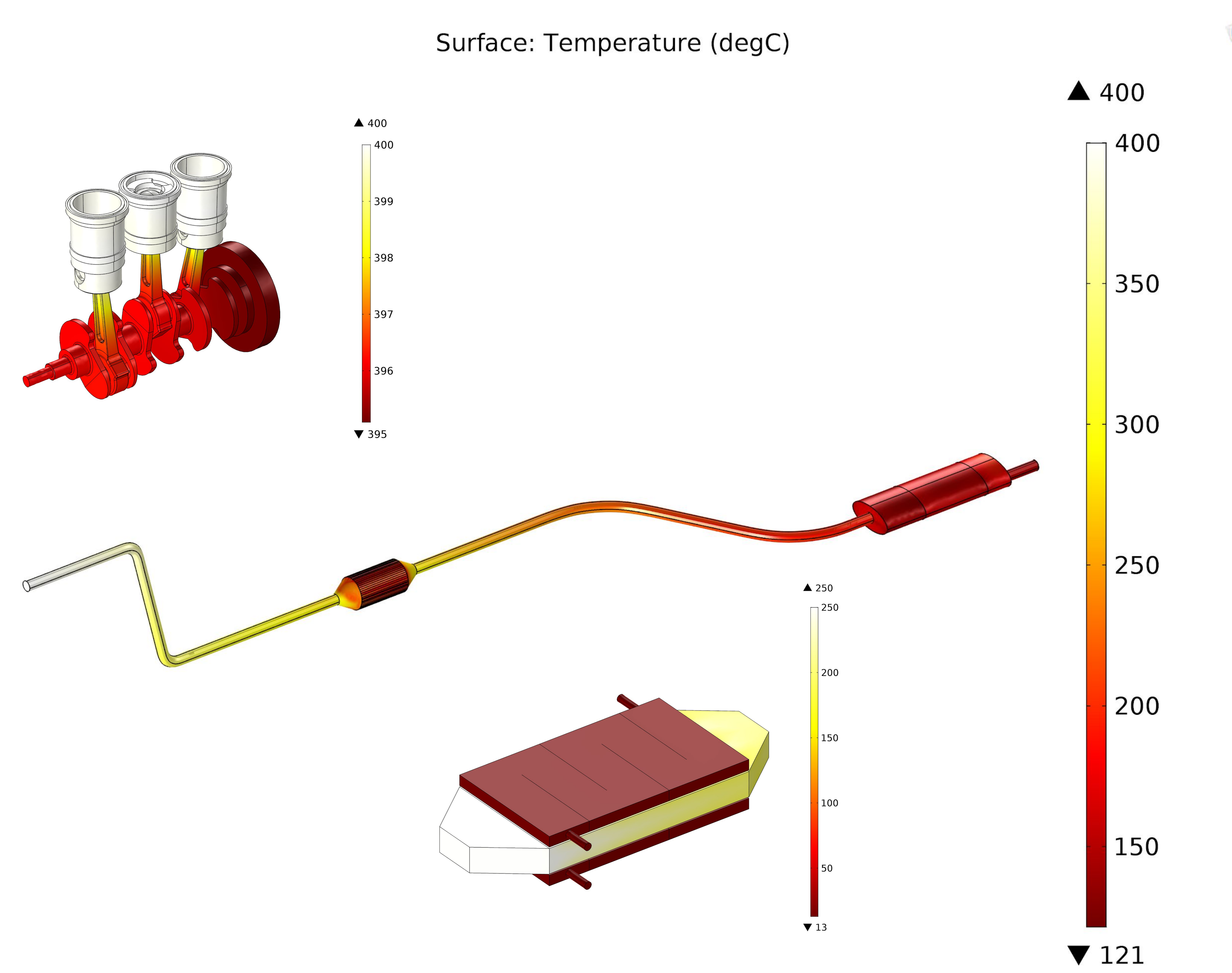

Fig 2. Exhaust System Temperature Distributions

Conclusions: The multiphysics modelling techniques helped to design an automotive exhaust system for exhaust heat recovery. The temperature distribution results can be use to predict proper placement or location of the heat exchanger on exhaust system. This exhaust system and heat exchanger model can further be optimized for maximum waste heat recovery.

References:-

1.Fundamental of Heat and Mass Transfer, Frank P. Incropera.
2.Waste Heat Recovery Technologies, US Department of Energy, March 2008.