International Journal of Automotive Technology, Vol. 20, No. 3, pp. 465−475 (2019)
DOI 10.1007/s12239−019−0044−5

pISSN 1229−9138/ eISSN 1976−3832

NUMERICAL INVESTIGATION ON OIL PAN DESIGN PARAMETERS TO IMPROVE ENGINE PERFORMANCE DURING OIL COOL DOWN AND WARM UP PERIODS

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(Received 12 June 2018; Revised 30 August 2018; Accepted 1 November 2018)

ABSTRACT−For developing automotive industry, one of the focusing point is reduction of engine friction level to decrease both engine emissions and fuel consumption. Important part of researchers have focused on cold engine start period, which has higher friction loses. Shorter warm up period and faster heating of engine oil help to provide better engine performance. Not only warm up time but also better cool down period after engine stops, dramatically effects engine efficiency. If oil temperature stays hot for longer time during the vehicle key-off duration, it brings an important advantageous at the next start. Main purpose of this study is to investigate oil temperature changes depending on the design parameters of the oil pan. This investigation is done for oil warm up and cool down periods by mathematical model, which is validated for 2.0 L and 4 cylinders diesel engine. Design improvement combinations against base steel oil pan has been examined throughly in terms of oil temperature changes, warm up and cool down time, frictional loses and weight reduction opportunity. As a result, 5 mm thickness plastic oil pan with windage tray application is the best solution option since it brings both 12.5 % friction decreasing in cold start after 2 hours key-off duration, and 43 % weight reduction.

KEY WORDS : Oil pan concepts, Oil warm up, Oil cool down, Engine cold start, Numerical model

NOMENCLATURE

A : surface area of the piston skirt, m^2
a : ampirical constant of engine to calculate friction mean effective pressure
c : main bearing and shaft radial clearance, m
c_{oil} : oil specific heat, J/kg·K
c_p : fluid specific heat, J/kg·K
FMEP : friction mean effective pressure, bar
$FMEP_{fully\ warm}$: friction mean effective pressure for fully warm oil condition, bar
Gr : Grashof number
g : gravity force, m/s^2
H_{oil} : convection heat transfer coefficient, W/m^2K
h_{air} : oil pan wall convection heat transfer coefficient, W/m^2K
$h_{oil\ pan\ wall}$: oil pan wall convection heat transfer coefficient, W/m^2K
$h_{piston\ skirt}$: convection heat transfer coefficient, W/m^2K
k : fluid thermal conductivity, J/m·K
$k_{oil\ pan\ wall}$: oil pan wall thermal conductivity, J/m·K
h_{ref} : reference convection heat transfer coefficient, W/m^2K
L : height of heat transfer surface, m
l : main bearing total length, m
M : frictional torque in main bearing, Nm
n : engine speed, rpm
Nu : Nusselt number
Pr : Prandtl number
r : main bearing radius, m
Ra : Rayleigh number
T_{oil} : engine oil temperature, °C
$T_{piston\ skirt}$: piston skirt surface temperature, °C
Q_{oil} : heat transfer from piston skirt to engine oil, W
ρ : fluid density, kg/m^3
μ : dynamic viscosity, poise
$\mu_{fully\ warm}$: dynamic viscosity for fully warm oil condition, poise
β : fluid thermal expansion coefficient, K^{-1}

1. INTRODUCTION

Fuel economy targets and emission regulations are two important motivation points for automotive industry especially in last years. Efficient engine working by reducing friction loses is one of the main target that is coming from this goal. Approximately 15 % of combustion energy is wasted in friction area for steady state condition

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