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APPARATUS FOR IDENTIFICATION OF FRICTIONAL AND THERMAL CHARACTERISTICS OF A WET CLUTCH

Seungin Shin[1)], Dong-Hyun Kim[2)] and Seibum B. Choi[1)*]

[1)]Department of Mechanical Engineering, KAIST, Daejeon 34141, Korea
[2)]R&D Division, Hyundai Motor Company, 150 Hyundaiyeonguso-ro, Namyang-eup, Hwaseong-si, Gyeonggi 18280, Korea

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ABSTRACT–This paper describes the configuration of an apparatus for fundamental research on frictional characteristics for wet clutch control. The friction coefficient usually varies depending on the friction speed, the temperature of the friction surface, and the pressing force. The design and configuration for accurately measuring each major variable were presented. There is a fluid circulation system to implement an environment similar to an actual wet clutch system. It is designed to analyze the friction characteristics by maintaining the fluid film dynamics in a steady-state or to simulate the clutch engagement by controlling the speed of the motor. A friction coefficient map for any multi-disc clutch could be obtained with the presented apparatus, and a map of an automatic transmission clutch is obtained as an example. The experimental result shows the variables of the friction coefficient were the friction speed and the temperature of the friction surface, and in particular, it increased linearly with the temperature of the friction surface within the experimental range.

KEY WORDS : Wet clutch, Friction coefficient, Clutch temperature, Test bench

NOMENCLATURE

x_p : piston position, m
h : nominal separation between clutches, m
N_c : number of clutches
z : film thickness, m
β : asperity tip radius, m
σ : RMS roughness of friction material, m
p_h : hydrodynamic pressure, Pa
p_c : contact pressure, Pa
R_{eff} : torque effective radius of clutch, m
υ : mean slip speed of clutch, m/s
R_o : outer radius of clutch disk, m
R_i : inner radius of the clutch disk, m
$\Delta\omega$: clutch rotational slip speed, rad/s
τ : clutch torque, Nm
τ_c : asperity contact torque, Nm
τ_υ : viscous torque, Nm
μ_f : asperity friction coefficient
μ_υ : dynamic viscosity of the fluid, mPa·s
$\bar{h}$: average fluid film thickness, m
T : mean temperature of friction surfaces of clutches, °C
$\mu_{\upsilon1}$, $\mu_{\upsilon3}$: dynamic viscosity parameters, mPa·s
$\mu_{\upsilon2}$, $\mu_{\upsilon4}$: dynamic viscosity parameters, K^{-1}
m : mass, kg
c_p : specific heat capacity, $J{\cdot}kg^{-1}{\cdot}K^{-1}$
k_1 : generalized thermal conductivity of convection, W/K
k_2 : generalized thermal conductivity of conduction, W/K

1. INTRODUCTION

Research on the improvement of fuel efficiency and riding comfort in the vehicle field is continuing. The transmission is directly related to the fuel efficiency of an internal combustion engine vehicle, and an undesired impact during vehicle launch or gear shifting may cause discomfort to the driver. There are transmissions using various mechanisms such as automatic transmission (AT) using planetary gears, dual-clutch transmission (DCT), and continuously variable transmission (CVT), and each is used based on different advantages and disadvantages. Among them, the AT uses a hydraulic system and a wet clutch and has a very smooth gear shifting thanks to the torque converter.

Although the proportion of AT in the total vehicle is decreasing, the need for precise control of the wet clutch is increasing. The operation of the fluid coupling is being developed to minimize the operation due to the disadvantage that inevitably consumes energy. When the use of the fluid coupling is minimized, the control of the clutch during gear shifting needs to be more precise to prevent shift shock, shudder and excessive slip. At the same

**Corresponding author*. e-mail: sbchoi@kaist.ac.kr