Development of new four-wheel drive system with outstanding fuel economy and traveling performance handling instant change in road surface friction

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1. Introduction

Automobile all-wheel drive system (AWD) transfers traction to all wheels to improve vehicle performance, however, due to frictional loss, fuel economy is compromised. It was our long term goal to optimize both (Fig 1). During the development of the new AWD system (i-ACTIV AWD), total energy loss of the drivetrain system including wheels was focused and ideal front-to-rear torque split ratio was identified (Fig 2). To maintain ideal torque split ratio which constantly changes with road conditions, technologies to detect real-time road friction and to transfer torque to rear wheels instantly were developed. By minimizing frictional loss, breakthrough to optimize performance and fuel economy was achieved.

2. Details of the technologies

The concept of i-ACTIV AWD is "Transfer traction when and where required". Based on "electronically controlled coupling", ideal AWD system was pursued. Conventionally, it was hard to detect real-time road conditions as tire's slipperiness (instability) changes with road conditions. First, a road friction detection system was developed to calculate tire slip against road surface (tire slip ratio) accurately using various sensors and a new control system and determine road friction based on the relationship between "slip ratio" and "traction reaction force" (Fig 3-1). A system to detect road friction from "steering reaction force" and "steering angle" was also integrated (Fig 3-2). 200 computations per second with 27 sensors enable subtle slip to be detected preemptively in imperceptive zone (Fig 4). This permits highly accurate road friction detection in real time when the vehicle is standing still or running.

Next, backlash of the rear drive system causes time lag to transfer torque to rear wheels. To solve this, "0 time lag system" was developed to transfer minimal torque to rear wheels to minimize the backlash.

Furthermore, optimum traction transfer allowed amount and frequency of input torque transferred to power take off unit (PTO) and rear differential unit (RDU) was reduced and thus, downsizing was achieved. With newly developed low viscosity oil, torque loss was reduced by 82% (Fig 5-1) and weight was reduced by 46% (Fig 5-2) compared to previous AWD.

3. Conclusion

Above technologies led to high levels of fuel economy and performance of i-ACTIV AWD. The AWD is installed in all major models manufactured after 2012 and provides customers with outstanding fuel economy, safety and security.

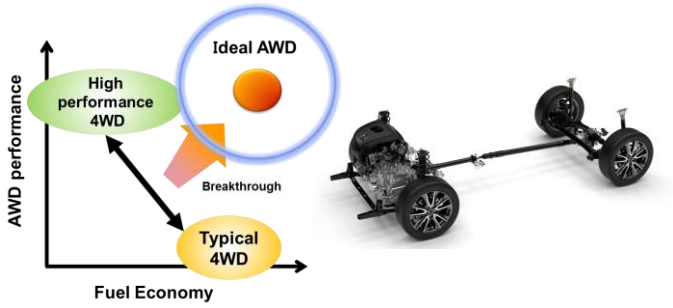

Fig 1 Ideal AWD system

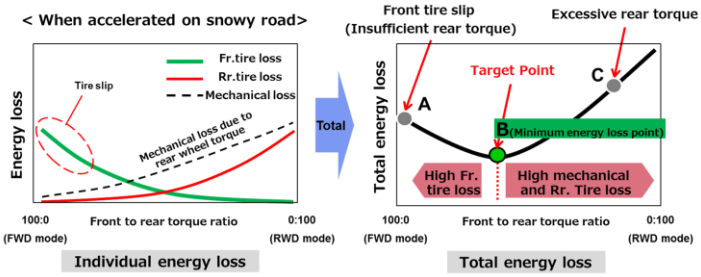

Fig 2 i-ACTIV AWD technology concept

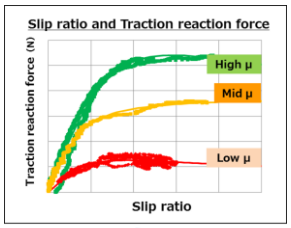

Fig 3-1 Road friction determined from traction reaction force

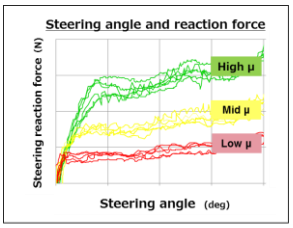

Fig 3-2 Road friction determined from steering reaction force

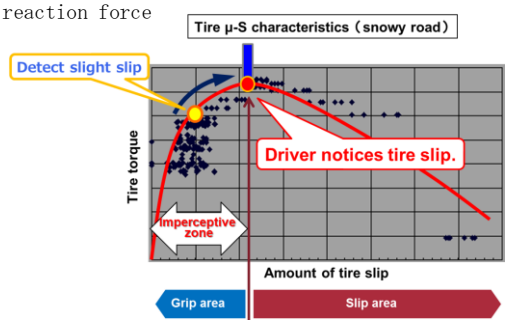

Fig 4 Tire slip ratio and imperceptive zone

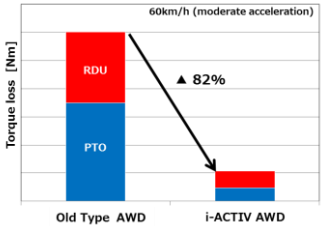

Fig 5-1 Comparison of torque loss

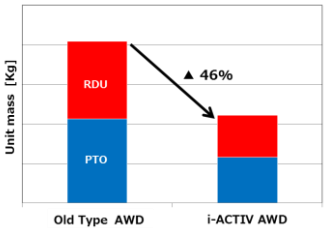

Fig 5-2 Comparison of unit mass