1. Introduction

For a motorcycle, especially one of those in which a dog clutch type transmission is installed, the rider has to operate the main clutch to shift the gear up or down. Conventionally, in motorsports usage, there is a well-known gear shift technique where the gear can be shifted without operating the clutch and only by means of operation of the accelerator to release the engagement between the dog teeth. Recently, the injected fuel amount, ignition timing and intake air volume are controlled electronically by an Electronic Control Unit (hereinafter referred to as “ECU”) even for the motorcycle. When a gear shift assist control function is implemented in the ECU, a novice rider can shift the gear without operating the clutch thus reducing the rider’s driving load. This gear shift assist control detects the rider’s shift intention and controls the engine driving force so that the dog teeth can be disengaged. However, a time lag between shift operation by the rider and the point where the engine driving force increases to a sufficient level occurred and it was necessary to reduce this time lag to improve shift feeling and achieve quicker gear shift completion.

This digest outlines the gear shift assist control for downshifting that needs instantaneous engine driving force increase.

2. Gear Change Assist Control System Configuration

Figure 1 shows the control blocks of the gear shift assist control, so-called “Easy Gear change System (hereinafter referred to as “EGS”))”. The input signals are acquired from the various sensors in the engine system (accelerator position sensor, throttle position sensor, and crank pulse sensor to calculate engine speed) and in the dog clutch type transmission system (clutch switch to detect clutch engagement, shift sensor to detect a shift request by the rider, and gear position sensor). The ECU detects the shift request by the rider, determines the engine driving condition, calculates necessary engine driving force to release the engagement between the dog teeth, and drives the engine control devices (described later) in accordance with said input signals.

The engine control devices consist of the throttle valve, fuel injector, and ignition coil.
3. Throttle Valve Open Control when Downshifting

Based on the input signals from the clutch switch and the shift force sensor, the EGS initiates the gear shift assist control when the ECU detects a shift request by the rider without clutch operation. In accordance with a determined engine driving condition (described later), the ECU controls engine driving force instantaneously to release the engagement between the dog teeth.

Figure 2 shows the engine driving condition. The engine driving condition is calibrated and memorized in the ECU in advance. The engine driving condition can be distinguished into two states based on engine speed and throttle position – the state where the engine drives the tire and vice versa. The boundary line between the said two states is called the “No Load Line”. When the engine driving condition is in the vicinity of the No Load Line, engagement between the dog teeth is in a quasi-released state. The EGS for downshifting outlined in this digest initiates Throttle Valve Open Control when the engine driving condition is lower than the No Load Line and when the ECU detects shift operation by the rider.

Figure 3 shows the control sequence of the Throttle Valve Open Control. This control consists of three parts of electronic throttle position control.

3.1. Part 1 (Time between t1 and t2)
Before t1, the engine driving condition is the state where the tire is driving the engine. To release the engagement between the dog teeth, it is necessary to increase the engine driving condition toward the No Load Line. Hence, in Part 1, the ECU causes the throttle position to proceed beyond the No Load Line to release the engagement between the dog teeth instantaneously and reliably. By this process, the engine driving condition is changed to the state where the engine drives the tire and engagement between the dog teeth is released completely.

3.2. Part 2 (Time between t2 and t3)
In this process, the throttle position is kept at the No Load Line to maintain the state in which engagement between the dog teeth is released as mentioned in the description of Part 1. With this process, the rider can reliably shift down. With the processes of Parts 1 and 2, engine driving condition can be changed instantaneously and sufficiently to allow the rider to shift down smoothly without feeling any time lag.

3.3. Part 3 (Time between t3 and t4)
At the end of the Part 2 process, downshifting is executed and completed. If the throttle position is

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Fig. 2  Drive state determination data

Fig. 3  Operational state of a throttle valve and state of the dog teeth
returned to the initial state where the tire drives the engine immediately, this may give the rider undue shift shock. In the Part 3 process, the engine driving condition is changed gradually so as not to give the rider shift shock.

4. Conclusions

In the EGS, the Throttle Valve Open Control is performed by the following process;
- Part 1
  The throttle position is opened beyond the No Load Line instantaneously to reduce the time lag to enable downshifting.
- Part 2
  The throttle position is maintained at the No Load Line to allow smooth gear shifting.
- Part 3
  The throttle position is returned to initial opening gradually to reduce shift shock.

As a result, the EGS Throttle Valve Open Control was created that can give the rider ideal shift feeling.

Author

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I would like to continue to be able to provide products with added value that enhance the enjoyment and pleasant feelings in riding a motorcycle. (EBATA)