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Development of technology for predicting engine vibration during start-up by applying a model of hydraulic mount characteristics

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The adoption of idling stop (I/S) systems to enhance fuel economy has become common in recent years. When recovering from I/S, engine vibration occurs as the engine starts and its speed rises from zero rpm. This phenomenon occurs when the vibration around the lateral axis of the vehicle passes through the powerplant rigid body eigenvalue, resonance occurs, and that force is transfered to the vehicle. Considering the filters for human sensitivity characteristics prescribed in ISO 2631-1, it is mainly vertical vibration of the vehicle that is sensed.

Honda vehicles with a V type six-cylinder (V6) engine mounted transversely support the weight of the powerplant with mounts placed in front of and behind the engine. Those mounts also function to receive the drive reaction force. For this reason, the mounts located at the front and rear have high spring characteristics, and given the ride comfort performance requirements, hydraulic mounts are used. The vertical spring and damping characteristics of hydraulic mounts are frequency dependent, but it is mainly control of the damping characteristics that is important for ride comfort performance, whereas it is mainly control of the spring characteristics that is important for engine vibration during start-up, and those frequency requirements are close. The frequency dependence of the hydraulic mount varies together with the damping and spring characteristics in tandem. To achieve a balance between these, therefore, it is necessary to consider the matter at the planning stage of vehicle development. However, testing for engine vibration during start-up, in particular, is conducted almost entirely at the actual vehicle verification stage, and there is a need for technology that suggests component characteristics and other such hardware specifications at the planning stage.

While the vibration input during an in-line four-cylinder (L4) engine start-up is mainly in the longitudinal direction, the input during start-up of a vehicle with a V6 engine mounted is a vertical input from the hydraulic mounts located to the front and rear of the powerplant. Consequently, the hydraulic mount characteristics are also made based on one-dimensional models. The model consists of the main body rubber part and the internal sealed liquid part. The main body rubber part was represented with a Maxwell model. For the internal sealed liquid part, a dynamic model using mass damper elements was used in order to represent the vibration damping effect at specific frequencies due to the liquid column resonance effect and as a step to increase calculation speed. By this approach, it became possible to examine the change of spring and damping characteristics in tandem with respect to the frequency dependence of the hydraulic mount.

It is also the case that input during engine start-up varies from moment to moment while passing through resonances because of the increasing engine speed. It is necessary, therefore, to take amplitude dependence into consideration. The model of hydraulic mount characteristics has nine parameters for the main body rubber part and five for the internal sealed liquid part. Optimization software was used in order to speed up the work of identifying those parameters. This made it possible to match the amplitude dependence of the hydraulic mount with the same parameters without taking time.

The technology created through this research has made it possible to examine performance with respect to powerplant changes from the initial stages of vehicle development in terms of the hydraulic mount requirements for enhanced ride comfort performance and, at the same time, in terms of the requirement for enhanced engine vibration performance during start-up.

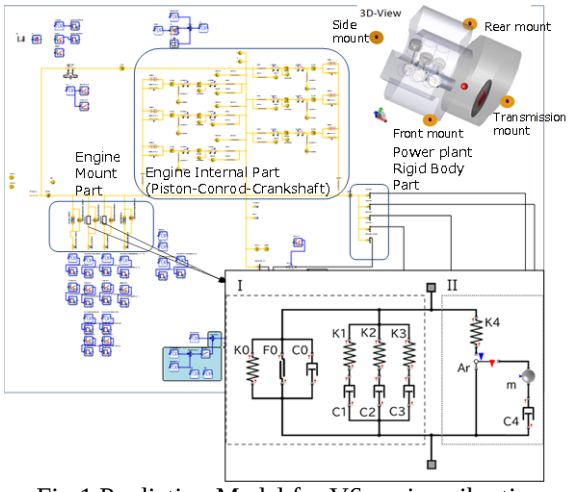

Fig.1 Prediction Model for V6 engine vibration during start-up with hydraulic mount model