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Dynamic Analysis and Simulation of Virtual Engine

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Abstract. The purpose of this study was to establish a complete dynamic analysis method for motorcycle engines to serve as course material for study of machine dynamics. Virtual engine software was also developed for users to understand how engine performance is influenced by parameters such as engine accelerator, engine weight, and flywheel. First we applied the vector-loop approach to deduce the kinematic analysis of engine mechanism. We then applied Newton's method to analyze the bearing force and friction of each link. Next, we used a power equation to deduce the equation of motion of the system, and used the Runge-Kutta method to perform normal dynamic analysis. Finally, by combining computer programs with the Open Graphics Library (OpenGL), we developed virtual engine software for users to observe motion and performance of engine. The results of this study provide engineers a computer-aided design program for automatic generation of all optimal pipes. It is beneficial to pipe design ability.

INTRODUCTION

Research on motorcycle and car engines has always been a popular topic. In 1972, Ruhl et al. adopted the finite element method (FEM) to [1] develop a model applied to the rotor-bearing system and proposed promotion and improvement of analytical process. In 1976, Nelson and McVaugh [2] applied the FEM to deduce the dynamic equation of the rotor system and measured its stability and steady-state response. In 1994, Smaili et al. [3] developed a dynamic analysis model of crankshaft according to the theory of Timoshenko. Previous studies have focused mainly on vibration analysis of the engine [4, 5]. Thanks to the rapid growth of computing capacity, verification of theories and technical level have been upgraded. For example, Metatilidis et al. [6] used computers to build a reciprocating machine model with single or multiple cylinders and obtained nonlinear solutions by numerical methods.

Considering the high computing ability of computers, complex virtual engines are to be established using computer-aided design (CAD) to serve as post-processing of the dynamic engine analysis theory. Former methods such as model construction using CAD with the aid of 3D programming technology, or analysis results presented by 3D software, can no longer satisfy the visual and interactive demands of analyzers and users. This explains why virtual reality prevails [7-9]: it seeks characteristics such as interaction, reality, and immersion. The first two characteristics can be presented using the personal computer of the software design engineer due to the advance of computer technology, whereas the last characteristic of immersion demands additional and costly computer hardware and software. Because the characteristic of immersion has limited feedback on a theoretical basis in engineering design and analysis, based on machine dynamics, our study selected a two-stroke engine as the vehicle and deduced its equation of motion and force analysis. The Runge-Kutta method was used to solve the nonlinear differential equation. The results were presented by VB programming and the OpenGL to show a dynamic simulation with a virtual engine, as well as design interactive activities for users to observe the dynamics performance of the engine by changing the engine accelerator and other parameters.

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