Dynamic Motion Simulation of Crankshaft System

HONDA R&D Asaka Center

Tadashi Niino

1□ In the beginning

Motorcycles are widely used in the world for practical use, leisure and sports.Motorcycles are efficient in the fuel consumption. As the worldwide environment problems are the focus of the interest, the requirement for low fuel cost and low emission is increased. Further more the needs of users are diversified. The short time development is highly needed and CAE simulation using 3D data is actively used. Based on this background, CAE simulation method and application example for the crankshaft design of motorcycle's engine is being presented.

4 stroke Scooter

In-Line 4 Cylinder CBR600

Horizontal opposed 6 Cylinder GL1500

2□ Characteristics of Motorcycle Engine

- The displacement range is wide from practical use 50cc to leisure and sports use more than 1500 cm^3.
- A single cylinder is mainly used for practical use. For leisure and sports use, the cylinder disposition is L(in-line)2, L3, L4, V(V Shape)2, V4, F(horizontal opposed)2, F6.
- For sport the high revolution and high generating power type water-cooled multi cylinder is mostly used. Figure 1 is L4-600” engine as example.
- Light and compact. The specific power is high. Figure 2 shows the comparison of the generating power between motorcycle engine and passenger car engine.

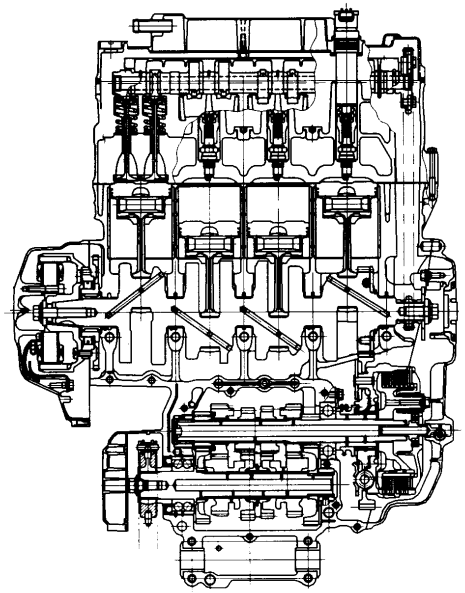


Figure 1. 600 cm^3 line 4cylinder engine

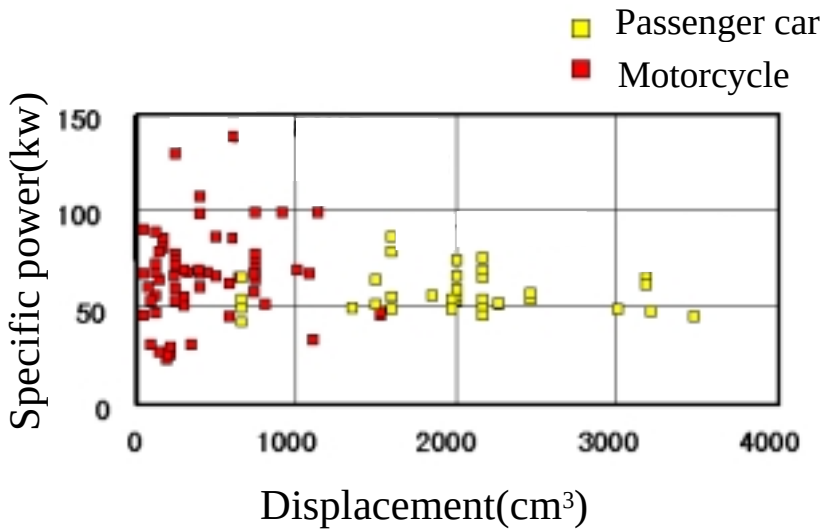


Figure 2. Power comparison B/W Motorcycle and Passenger car

3□ Objectives of Crankshaft system Simulation tool

Shown in Figure 2, the sport type multi-cylinder crankshaft requires high revolution and high generating power, light and compact. On the other hand, the needs of users are diversified and the environmental problem on the earth is faced. Shown in Figure 3, the crankshaft related layouts have been exceeding conventional limits. Based on this background, we have improved the component level CAE simulation which has been mainly used traditionally and have developed a system simulation tool aiming at the durability evaluation of crankshaft.

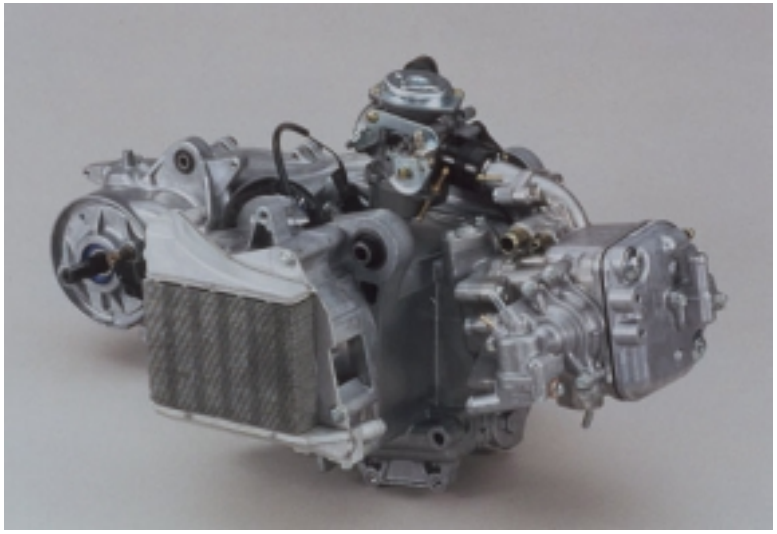
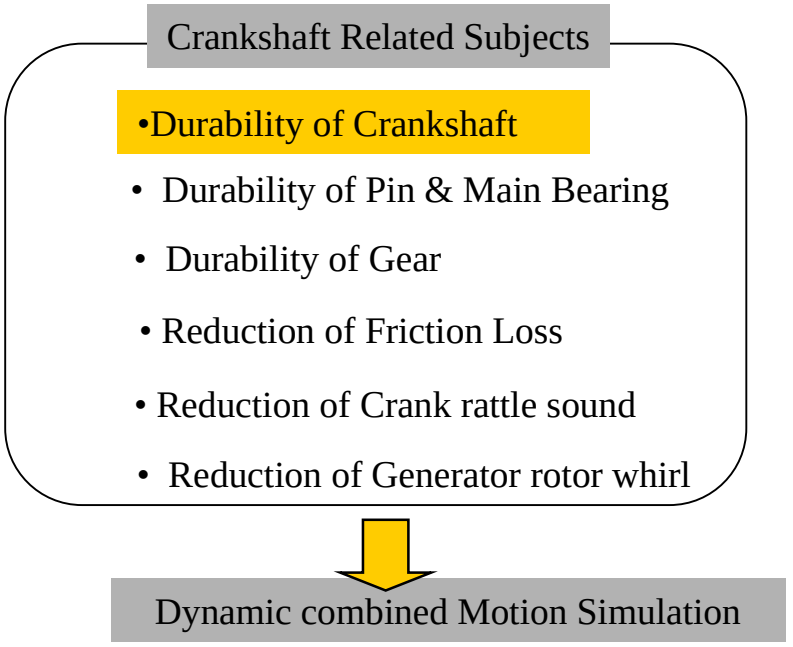


Figure 3. Scooter 50 cm^3 Engine Water-cooled 4 Strokes



Aim of this simulation tool

4□ Analysis Procedure

- ○ Creating a finite element model from 3D CAD data.
- ○ For the acquired finite element model, reduce freedom in the limit which does not lose the necessary characteristics.
- ○ For the finite element model and each part, create connecting conditions, create loads and build the whole model shown in Figure 4.
- ○ Execution of the dynamic motion simulation
- ○ From the simulation result, analyze the motion by animation and plots, find weak points and study the optimized balance of stiffness. Figure 5 shows an example.
- ○ By the mode shape and the modal displacement of the finite element model, calculate the stress recovery and evaluate the durability. Figure 6 shows an example.

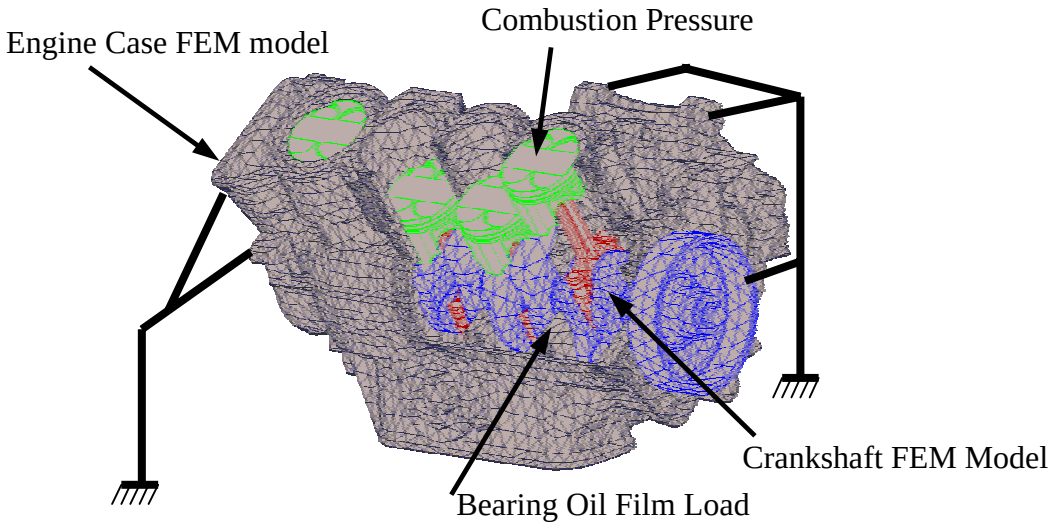


Fig. 4. Dynamic motion simulation model of L4 Crank shaft

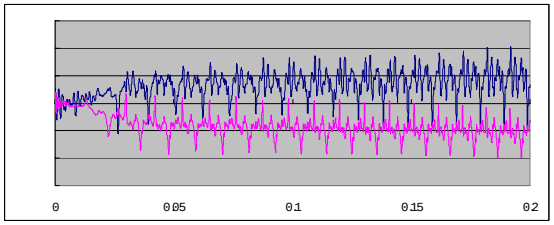


Fig5. Crank Web Open angle

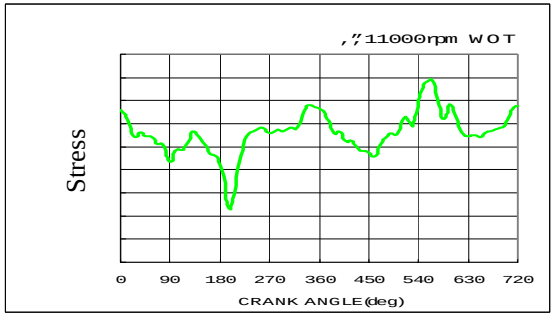
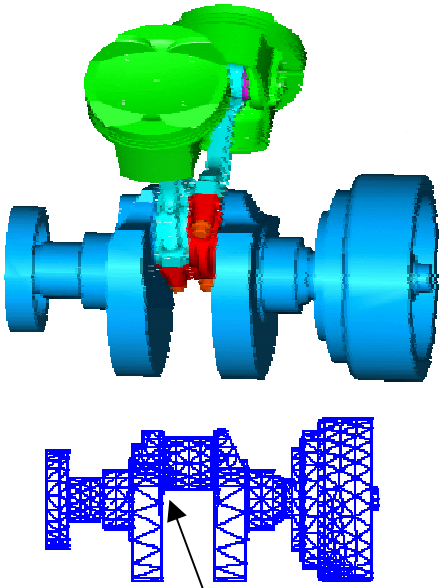


Fig. 5.Stress result of Crank Journal Fillet portion

5□ Application

The result of CAE simulation for V2-1000” engine crankshaft is shown in Figure 7. From the comparison between measured data and CAE results of the stress at the crank pin filet where the stress is the severest, the CAE stress is simulated well. The simulation result of Generator rotor whirl vibration for scooter 50” engine is shown in Figure 8. Bending resonance of Crankshaft system and whirl divergence caused by unbalance of ACG rotor are simulated well.



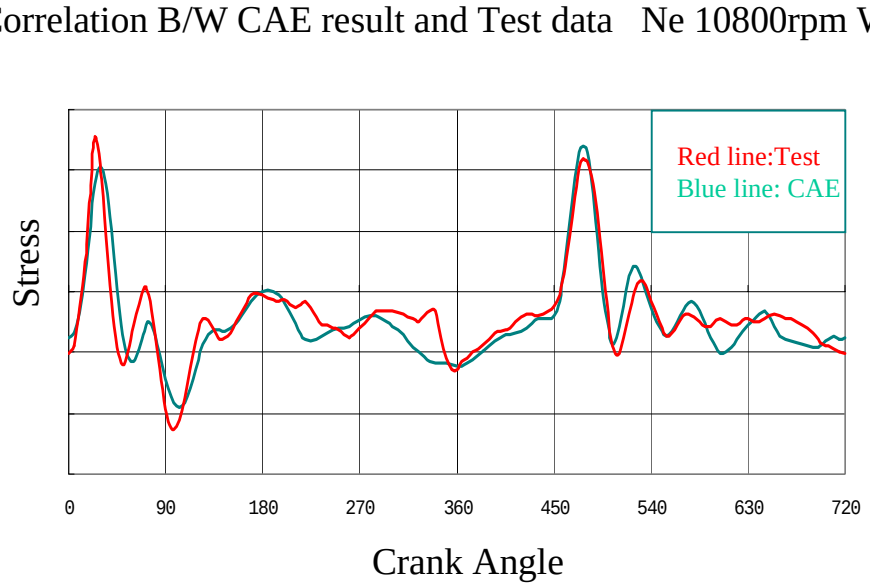


Figure 7. Crankshaft Pin Journal Stress Analysis result of V2 - 1000cm^3 Engine

Correlation B/W CAE result and Test data during Sweep operation

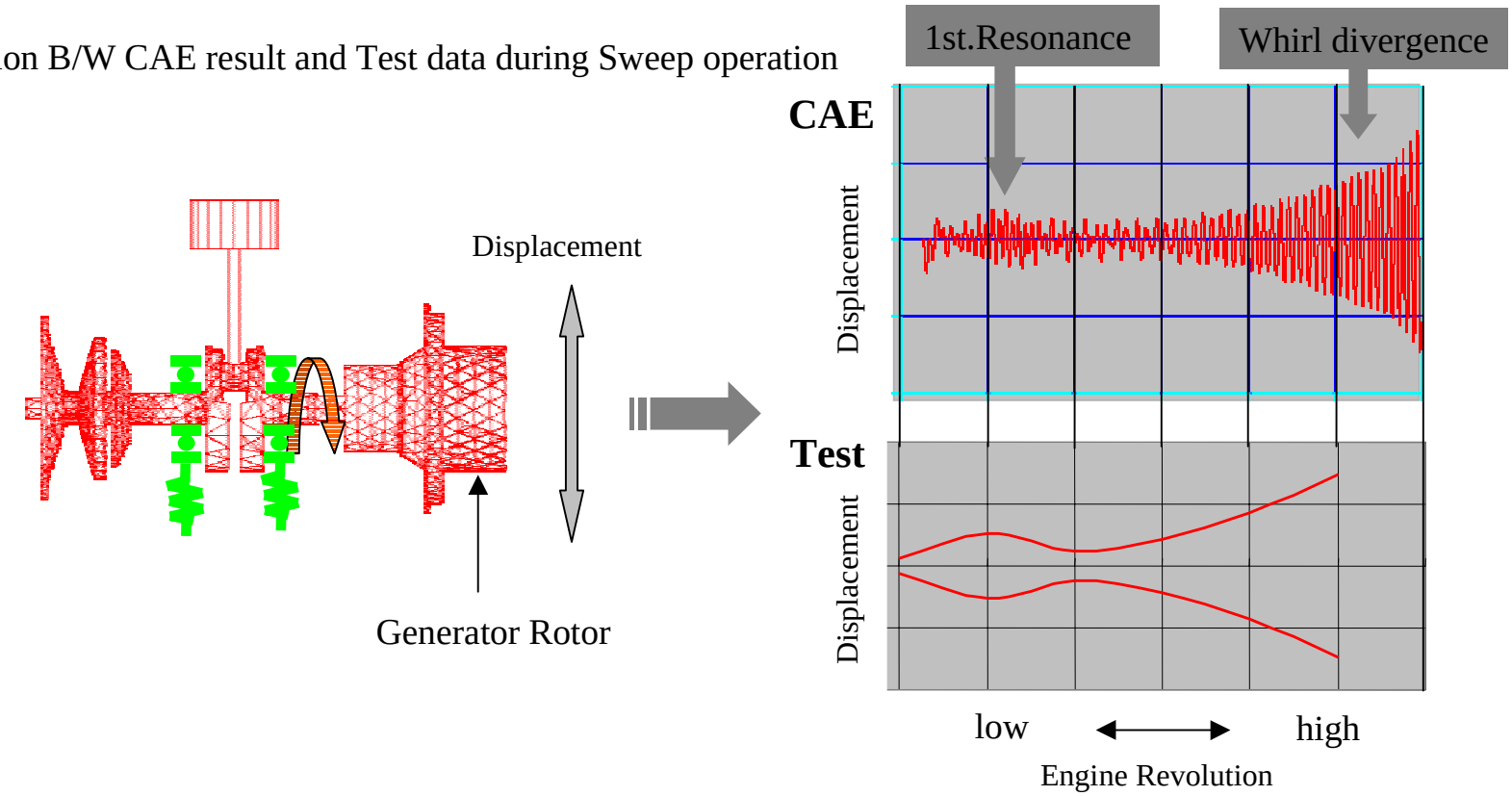


Figure 8.Generator Rotor Whirl result of 50 cm^3 Engine for Scooter

6. Conclusion

Using ADAMS, Crank shaft Dynamic behavior simulation with 3D FEM model was implemented.

Good correlation between simulation stress result and experimental data

This simulation tool is effective in evaluating the strength of crankshaft at design stage.