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Topic: Online measurement of the piston assembly friction of internal combustion engines

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3	Stage1: Online measurement for vehicle engines
4	Stage2: Online measurement for marine engines



Introduction-Internal combustion engines



- ICEs are still main power equipment for vehicles, tank and ships.
- Low-speed two-stroke marine engines are used by 90%+ of ocean-going ships.
- To solve failures such as cylinder scuffing and reach a better design, it is necessary to deeply understand tribological phenomena.







Introduction-Online Measurement

- For vehicle engines, piston assembly is responsible for about 45% friction losses of the total engine. We have no relevant measurement data for most engines.
 Floating liner method :
 - Cylinder liner is separated from the engine block and an extremely small movement of the liner within engine cylinder is permitted
 - Friction force can be obtained directly from the piezoelectric force sensors









Introduction-Online Measurement

For vehicle engines, piston assembly is responsible for about 45% friction losses of the total engine. It is valuable to measure the piston assembly friction force.

Instantaneous IMEP method:

- The friction force is obtained indirectly from the gas force, the connecting rod force and the inertia forces
- Measured signals: cylinder pressure, connecting rod force, crank angle and engine speed

Minor modifications Co

Commercial engines

Difficulties: (1) High precision; (2) Connecting rod force is hard to measure.



Grasshoppe

linkage



Calibration

- After removing the valves, the connecting rod force is approximately equal to the friction force when manually rotating the engine slowly.
 The experimental data are exciting and close to the expected results.
- 30 30 28 Connecting rod force (N) 26 20 $\widehat{\mathsf{Z}}$ 24 Connecting rod force 10 22 20 0. 18 -10 16 14 -20 12 10 -30 10.2 10.8 10.0 10.4 10.6 12 0 10 time (s) time (s) Small test engine

Experimental connecting rod force when removing valves

Piston friction force measurement of gasoline engine

 On a 2.0L gasoline engine, the connecting rod force, the cylinder pressure and the crank angle are measured at the same time.
 The piston assembly friction force is indirectly deduced.



Friction measurement of 2-stroke marine engine

The measured friction force is consistent with the numerical one, not only the friction of the three friction pairs but also the piston assembly friction.





Conclusion

- The existing results show that the friction force can be measured on-line, and it shows a good accuracy.
- However, engine working conditions are very complicated, the existing measurement technology needs to be further improved.







谢谢 Thank you

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