Improvement of knock resistance of spark-ignition gasoline engines using 3D combustion simulation based on the ECFM-RANS model

Tomonori Kuroki [1)] Kazuhito Okui [1)] Yuta Shima [1)] Yasuhisa Ono [1)]

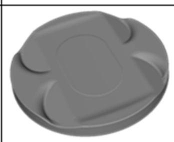
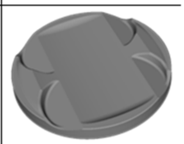
1) Daihatsu Motor Co. Ltd., 1 -2 Yoshimoto, Tanushimaru, Kurume, Fukuoka, 839-1206, Japan

KEY WORDS: Spark ignition engine, Combustion simulation, Knocking, ECFM, RANS

By using 3D combustion simulation to reproduce changes in heat release behavior of 0.66L inline 3 cylinder SI gasoline engine due to various changes of piston crown shape shown in fig.1. In this study, a combination of the RANS model and the ECFM model was used to reduce the calculation time, and one cycle calculation was performed with simplified boundary conditions. The calculation results were compared with the results of knocking measurement in the actual engine.

Piston A shows the hightest knocking resistance in the experiment, and uniform and high-speed combustion was predicted in the caliculation result. In the piston C, the flow toward the intake side was slow, and the propagation of flame to the intake side was also slow as shown in fig. 2. It was considered that the movement of this flame could be evaluated by the tumble ratio near the ignition position. In the piston B, as a result of flow deviation due to the difference in height between the front and rear of the combustion chamber, it was found that a horizontal vortex was generated near the intake valve recess and flame propagation was suppressed and it was considered that this tendency can be evaluated by the ω swirl ratio. Therefore, we improved the piston by using near ignition position tumble ratio and swirl ratio as new indices for knocking resistance.

As s result, a new shape with a higher compression ratio was designed as shown in fig.4, and it was confirmed that fuel consumption improvement effect could be obtained without sacrificing performance in the actual engine. In addition, the predicted heat release behavior was in good agreement with the actual engine, and it was shown that It was shown that the calculation conditions used in this study are has enough acculacy for the evaluation of piston shape before prototype production.

Piston Type	Base	A
Crown Shape		
Compression Ratio	11.5	
Note	Production model for the base engine	Cylindrical cavity at the center of the crown

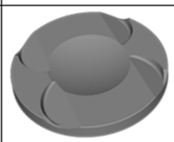
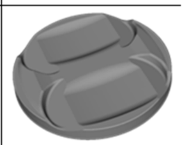
Piston Type	B	C
Crown Shape		
Compression Ratio	11.5	
Note	Spherical cativy at the center of the crown	Saddle-like shape added to piston A

Fig.1 Crown shape of examined pistons

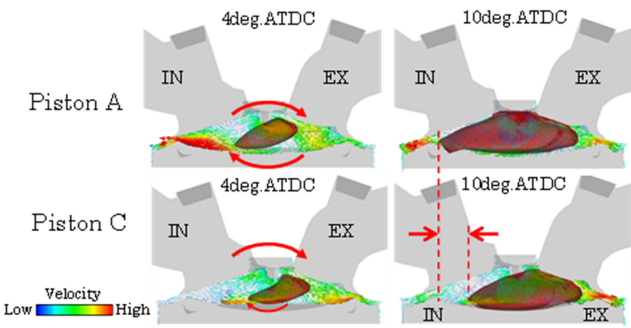


Fig.2 Comparison of calculated results for flow and flame surface shape for piston shapes A and C

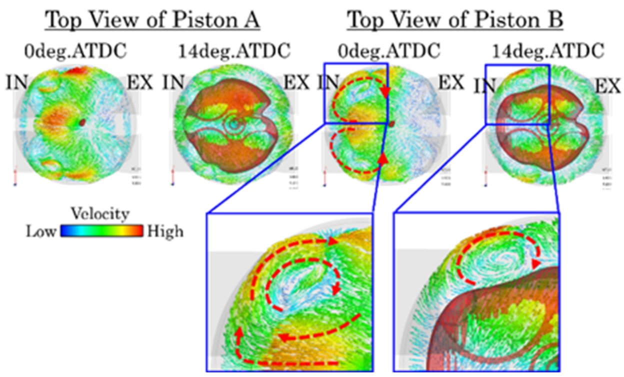


Fig.3 Comparison of calculated results for flow and flame surface shape for piston shapes A and B

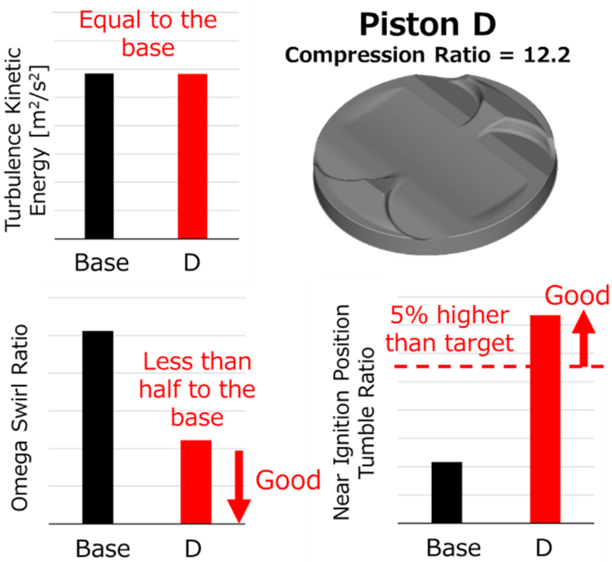


Fig.4 High compression ratio piston D outline and calculation results of evaluation indices