3D CFD Simulations of Hydrogen Engine Combustion
Popular science summary

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Can we run an internal combustion engine with carbon-neutral fuels? Well, Formula 1 aims to achieve carbon neutral by 2030 [1], but what about the everyday transportation? More than 2000 Mt of CO_2 emission in 2021 was caused by buses and trucks [2]. To decrease carbon emissions, changes in the fuel need to be made. Hydrogen, whose combustion product is only water, can be a good alternative.

In the transport industry, every percent of the engine efficiency counts. To achieve high engine efficiency, diesel-type engines are preferred. In these engines, typically diesel fuel is injected into the cylinder and autoignition takes place. The chemical energy in the diesel fuel is transformed into heat and then work.

However, things are not quite the same for hydrogen in such engines. Hydrogen has higher autoignition temperature than diesel, so conventional diesel combustion method is not applicable to hydrogen. What can we do?

In this work, a solution called pilot diesel injection is applied. We inject a small amount of diesel to create a hot atmosphere so that the hydrogen can ignite. 3D CFD simulation is performed to study the process. Smooth diesel-like hydrogen combustion can be achieved with this method and high engine efficiency and low CO_2 emission can be observed.

Such engines still need diesel pilot to trigger H_2 combustion. Is there a solution to eliminate the diesel fuel? The answer is yes under some operating conditions. Normally, the engine uses intercooler to cool the intake air. If some of the hot air bypasses the intercooler, hotter atmosphere can be provided and hydrogen autoignition can be achieved. Such solution is called as inlet preheating. However, with only one hydrogen injection, much inlet preheating is needed, resulting in lower engine efficiency. To increase the efficiency, we introduce a pilot H_2 injection. This H_2

injection helps the autoignition and less inlet preheating is needed. In this way, higher engine efficiency can be observed and zero CO_2 emission can be achieved.

References

[1] Formula 1. *Formula 1 announces plan to be Net Zero Carbon by 2030*. 2019. URL: https://www.formula1.com/en/latest/article.formula-1-announces-plan-to-be-net-zero-carbon-by-2030.5IaX2AZHyy7jqxl6wra6CZ.html.

[2] International Energy Agency. *Trucks and Buses*. 2022. URL: https://www.iea.org/reports/trucks-and-buses.