

## II Development of Fuel Utilization Technologies

To meet domestic demand for petroleum products while reducing crude oil processing amounts and reducing carbon dioxide emissions over the medium to long term, in the harsh environment surrounding future petroleum products such as increases of residual oil due to heavier crude oil and reduction of residual oil demand because of environmental regulations and so on, we are conducting impact assessment tests for automotive use of fuel with a higher mixing ratio of fractions obtained by cracking residual oil and so on. To comply with global regulations for sulfur in marine fuel and accomplish stable supply of marine fuel, we are conducting combustion tests in order to determine whether the change in oil properties associated with sulfur content reduction may impact on marine engines using current C fuel oil.

### 1. Automotive Fuel and Marine Fuel

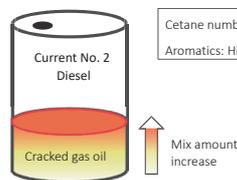
Japan Auto Oil Program: JATOP is a collaborative research project between the automobile industry and the petroleum industry that aims to solve technical issues regarding future automobiles and fuels. Following JATOP I (2007-2011) and JATOP II (2012-2014), we have worked on the JATOP III project, a three-year plan from 2015.

As domestic petroleum product demand is predicted to decline significantly for heavy oil, and because the ratio of cracked fractions will increase through enforcement of the Act on Sophisticated Methods of Energy Supply Structures, further study for the effective use of cracked fractions as automobile fuels was deemed necessary, leading us to conduct studies on the use of cracked gasoline as automobile fuels, in addition to studies on the use of cracked gas oil as automobile fuels from JATOP II.

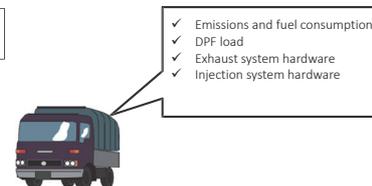
#### JATOP III achievements (1)

- Diesel vehicle research achievements
- [Fuel-related]  
It was found that even though aromatic content increases as the blending ratio of cracked gas oil (Light Cycle Oil : LCO) increases, converting to a lighter product through distillation while maintaining a certain level of cetane number is effective as a countermeasure against the DPF load on the fuel side and contributes to increase the blending amount of cracked gas oil. On the other hand, it is important to note that NOx emission might increase due to cetane number improver.
- [Vehicle-related]  
The urea SCR system was found to be effective not only for NOx but also for the DPF load.

[Characteristics changes due to the increased blending of cracked gas oil]



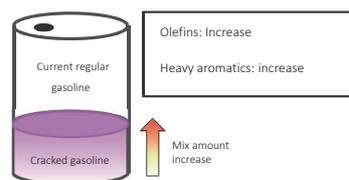
[Concern about vehicle performances]



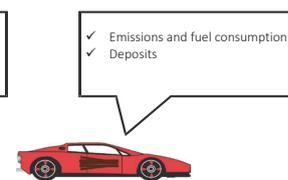
#### JATOP III achievements (2)

- Gasoline vehicle research achievements
- Although the amount of olefins increases to about 30 vol% due to the increase in cracked gasoline, emissions and deposits are not a concern if heavy aroma is equivalent to the current market upper limit.
  - As the amount of olefins increases with the increase of cracked gasoline, the amount of total aromatics decreases by transfer. Therefore it was found out that PN increase can be suppressed even when heavy aromatics increases. For example, if the amount of total aromatics is reduced by 5 vol%, even if the amount of C11A (Aromatics of carbon number 11) increases by 1 vol%, PN (Particle Number) is considered to be equal to or less than the amount before the cracked gasoline increase.
  - Even though olefins increases significantly to about 40 vol% as cracked gasoline increases, emissions and deposits are not a concern if the amount of heavy aromatics is equivalent to the current market (C11A of about 1 vol%).

[Characteristics changes due to the increased blending of cracked gasoline]



[Concern about vehicle performances]



From 2018 onward, we conduct research on technological issues in the next-generation automobile fuel field as well as research on fuel utilization technologies for low-sulfur marine fuel. The project name is 'Japan Marine and Auto Petroleum program: J-MAP'.

In automobile fuel research, we are working on solutions to issues that were identified in JATOP III.

Further, as research on marine fuel quality that meets low-sulfur requirements for marine fuels in general sea areas (current 3.5% sulfur concentration limit to be reduced to 0.5% by 2020), we are studying the impact of marine fuel property changes resulting from sulfur content reduction on the combustion performance of marine engines.

