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**Title: Multi-purpose Novel Exhaust Gas Test Rig
(High temperature exhaust gas simulator and Soot/SOF generator)**

Abstract:

To satisfy the enforced exhaust gas regulation nowadays, various exhaust gas treatment systems such as Cooled EGR, DPF, SCR, LNT, DOC, TWC and high temperature sensors to meet the OBD criterion such as O₂, NO_x, T, ΔP are necessary, due to this situation, cost increase and reliability/durability problem is the hot issue of after-treatment technologies

To develop these after-treatments systems and to verify the performance of parts, we are using basically real engine and engine dynamometer to test and evaluate the components. But this method requires a lot of time and cost, in addition this engine test method is a difficult method to test and evaluate the characteristics of parts such as the parametric test according to the associated parameters such as temperature, mass flow rate, oxygen contents, toxic gas concentration, soot and SOF

This high temperature exhaust gas simulator can make up for the shortcoming of the engine dynamometer test and this simulator has a capability of characteristic test according to the variables such as precisely and independently controlled temperature and mass flow rate and oxygen concentration and soot/SOF deposition.

Especially this simulator has a capability of fast aging test and reliability test and the simulating test of steady state D-13 mode engine test to verify the required performance of OEM.

This simulator was appraised as an instrument reducing the R&D duration and cost from many Korean parts company and OEM and also proved having a Long life cycle and High speed response, Precise control of Temperature and Mass flow rate and also gives a capability of GUI base Computer controlled test simulating the Engine dynamometer.

For the last 10 years, by using this simulator we developed the EURO-4, EURO-5 and EURO-6 technologies like as ;

- EGR Cooler and EGR Valve:** Pressure drop, effectiveness, thermal shock, reliability, fouling test of soot/SOF
- Catalyst(TWC, DOC, SCR, LNT):** Conversion efficiency, thermal shock, durability, aging effects
- Particulate filter(DPF, GPF, pDPF):** Pressure drop, oxidation rate of PM, regeneration, thermal shock, durability
- High Temperature sensor(O₂, NO_x, T, delP):** Response time, interference, stability, thermal shock, durability, weak point detection and failure scenario check

Short CV:

- CEO of Dalum Technology Inc.(www.dalum.co.kr) and
- Executive Adviser of Automotive Convergence Parts Technology R&D Division, KATECH(Korea Automotive Technology Institute)
- Ph.D. in Mechanical Engineering of KAIST 2005

Multi – purpose Hot Gas Test Rig (High Temperature Exhaust Gas Simulator and Soot/SOF Generator)



10-years Experience using this Test Rig for a Aftertreatment Parts
- Long life and Precise control of Temperature and Mass flow rate
- GUI and Expert S/W base Computer controlled test facilities

Chun-Beom Lee¹, Kwang-chul Oh²

¹ Dalum Technology Technology Inc., ² Korea Automotive Technology Institute, 303 Pungse-ro, Dongnam-gu, Cheonan-si, Chungnam-do, South KOREA, 303-912

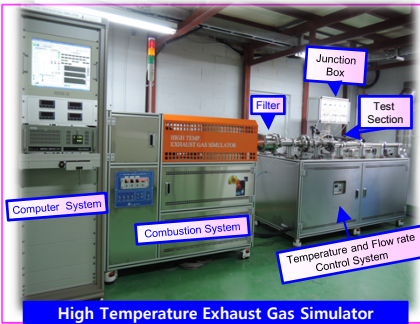
To satisfy the enforced exhaust gas regulation : Cooled EGR, DPF, SCR, LNT, DOC, TWC, Sensors and OBD
☞ Increase of cost & development period & reliability & durability problem

To develop and verify the performance of aftertreatment parts
☞ using real engine & engine dynamometer: requires a lot of time and cost

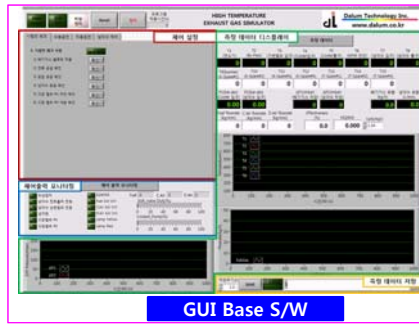
This multi-purpose hot gas test rig and soot/SOF generator can make up for the shortcoming of the engine dynamometer test
☞ characteristic test, fast aging test and reliability test and the simulation test of steady state engine test, GUI S/W(parts dedicated expert S/W)

This multi-purpose hot gas test rig and soot/SOF generator ~~~

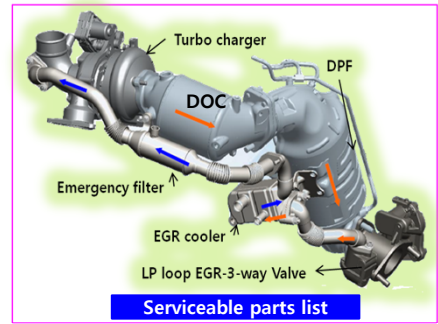
- ☞ capability of characteristic test according to the variables such as precisely and independently controlled exhaust gas temperature and mass flow rate and O₂ concentration and soot/SOF deposition
- ☞ capability of fast aging test and reliability test and the simulation test of steady state engine test to verify the requirements of OEM
- ☞ appraised as an instrument reducing the R&D period and cost from many Korean parts companies and Hyundai Motor
- ☞ having a parts dedicated expert S/W(GUI base Computer control)



High Temperature Exhaust Gas Simulator



GUI Base S/W



Serviceable parts list

Performance and Advantages

- Alternative Tool for Engine Dynamometer Test
- GUI and Expert S/W base Computer control Test Rig
- Independent Control of Temperature, Flow Rate, Soot/SOF, O₂ and Regulated Gas Composition
- Verification Test Tool for Fast aging, Weak Point Detection and Failure scenario check

Operating Range

- Temperature : 100°C ~ 1,100°C
- Mass Flow Rate : 150 ~ 1,000kg/h
- O₂ Concentration : 0.5 ~ 18%(Gasoline/Diesel engine)
- Toxic gas control : NO/NO₂/CO/HC with MFC
- PM control by Diesel Soot /SOF generator
- Aging Effects of Rub. Oil or High Sulfur Fuel

Application example and it's Test items

- **EGR Cooler and Valve** : Pressure drop, effectiveness, thermal shock, reliability, fouling effects of soot/SOF, weak point detection and failure scenario check
- **Catalyst(TWC, DOC, SCR, LNT)** : Conversion efficiency, thermal shock, durability, aging effects
- **Particulate Filter(DPF, GPF, pDPF)** : Pressure drop, oxidation rate of PM, regeneration, thermal shock, Durability
- **High Temperature sensor(O₂, NO_x, T, ΔP)** : Response time, interference, stability, resolution, thermal shock, durability, weak point detection and failure scenario check

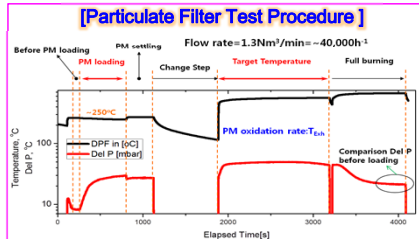
Soot generator+PM feeder: Soot Particle size Control, SOF control, Aging test with Sulfur/Lub.Oil

- Generate soot particles from diesel fuel pyrolysis for simulating real soot particle
- Soot particle size and number Distribution Control and SOF(Soluble Organic Fraction) composition
- Evaluation of the Fouling Effects and Particulate Deposit Characteristics on the Cooler surface
- Evaluation of the Sulfur and Ash aging effects
- Evaluation of the Catalyst performance due to the Soot and SOF or VOF

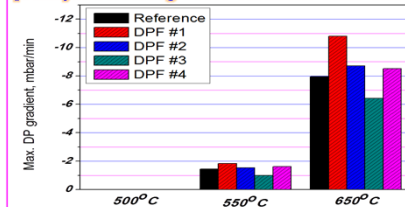


T&E of Particulate Filter (DPF, GPF, pDPF)

- Regeneration(conditional, unconditional, DTI (Drop To Idle)) test and PM oxidation rate according to substrate and catalyst



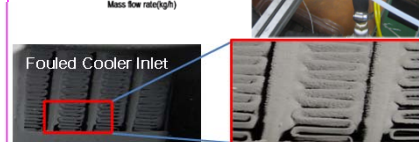
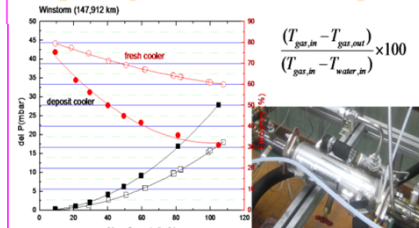
Catalyst Screening Test : Oxidation Rate Check



T&E of EGR V/V and EGR Cooler

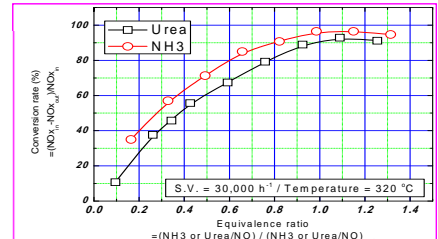
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Soot deposit effects of EGR Cooler



Catalyst(TWC, DOC, SCR, LNT)

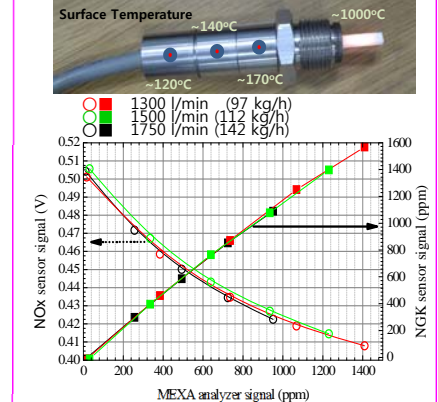
- Conversion efficiency, thermal shock, durability, aging effects of sulfur or lub. oil



Sensor @exhaust system(O₂, NO_x, T, ΔP)

- Response time, interference, stability, resolution, thermal shock, aging factor, durability, weak point detection and failure scenario check

Nox sensor characteristics vs mass flow rate and T



Products and options

- for DPF : Hot Gas Test Rig + PM feeder ++
- for SCR : Hot Gas Test Rig + Dozing unit
- for Cooler : Hot Gas Test Rig + Cooling water ++ controller + PM feeder ++
- for sensors : Hot Gas Test Rig + Interference Gas ++
- **SG(Soot generator)** : Testing of the fouling effects of EGR Cooler, sensor and catalytic effects of soot and SOF for DPF/SCR/DOC/TWC/LNT
- **GUI S/W** : dedicated S/W for the testing parts
- **EGS(Exhaust Gas Cooler)** : Temp. Control without changing any other gas composition
- **N₂ generator** : Air Fuel Ratio control, Oxygen/NO_x Concentration Control

This system is a multi-purpose high temperature exhaust gas test rig dedicated to the various aftertreatment parts having a long life, and having a high accuracy control of exhaust gas temperature and mass flow rate, GUI base computer control that gives a diverse and convenient test procedure.

- High accuracy multi-purpose hot gas test rig for : Catalyst(TWC, DOC, SCR, LNT) , EGR Cooler and EGR Valve, Particulate Filter(DPF, GPF, pDPF), High Temperature sensor(O₂, NO_x, T, ΔP)
- GUI base Computer controlled test facilities giving a serviceability such as high accuracy performance test of parts and simulation of the ESC/WHSC engine test mode.
- As a result, this system and technique is appraised as an instrument saving the R&D duration and cost from many parts companies and OEM.



Multi – purpose Novel Hot Gas Test Rig (High Temperature Exhaust Gas Simulator and Soot/SOF Generator)



10 years Experience using this Test Rig for the Aftertreatments Parts

- Long life and Precise control of Temperature and Mass flow rate
- GUI and Expert S/W base Computer controlled test facilities

To satisfy the enforced exhaust gas regulation : Cooled EGR, DPF, SCR, LNT, DOC, TWC, Sensors and OBD
 Increase of cost & development period & reliability & durability problem

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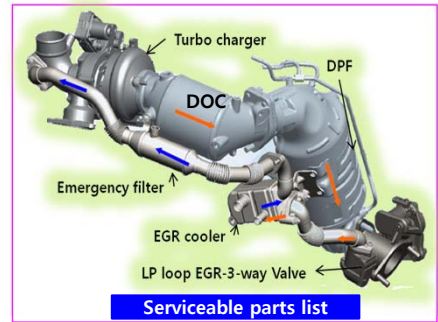
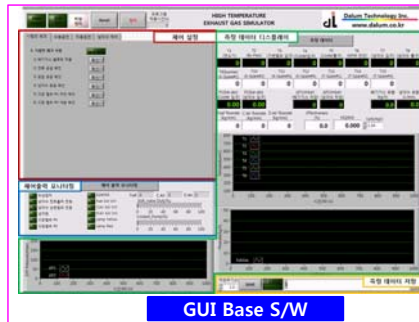
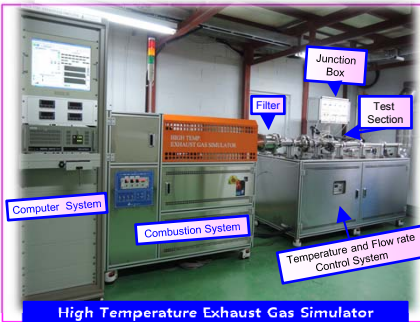
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 * characteristic test , fast aging test and reliability test and the simulation test of steady state engine test, GUI S/W(parts dedicated expert S/W)

Chun-Beom Lee¹, Kwang-chul Oh²

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Performance and Advantages

- Alternative Tool for Engine Dynamometer Test
- GUI and Expert S/W base Computer control Test Rig
- Independent Control of Temperature, Flow Rate, Soot/SOF, O₂ and Regulated Gas Composition
- Verification Test Tool for Fast aging, Weak Point Detection and Failure scenario check
- Operating Range
 - Temperature : 100°C ~ 1,100°C
 - Mass Flow Rate : 150~1,000kg/h
 - O₂ Concentration : 0.5~18%(Gasoline/Diesel engine)
 - Toxic gas control : NO/NO₂/CO/HC with MFC
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Application example and it's Test items

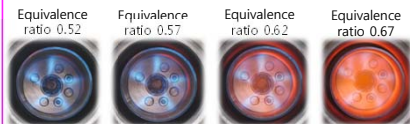
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Sub System: Simulating the diesel/gasoline exhaust gas temperature, flow rate, O₂/NO_x/CO/HC composition and soot

Combustor

- Produce Stable Flame in wide range of A/F ratio: Partially Premixed Dump Combustor

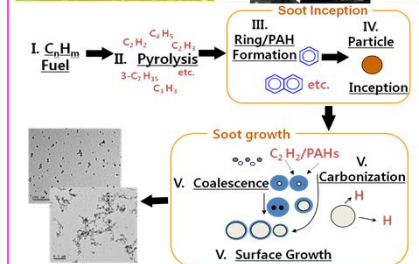
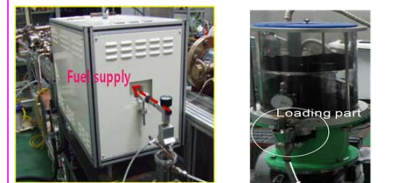
! Insensitive to downstream Condition



- Exhaust Gas Cooler: Continuous Temperature Control without changing any other gas composition
- GUI base Computer control and expert S/W
- N₂ generator: Air Fuel Ratio control, Oxygen/NOx Concentration Control
- Secondary fuel/air injector and Heat Booster

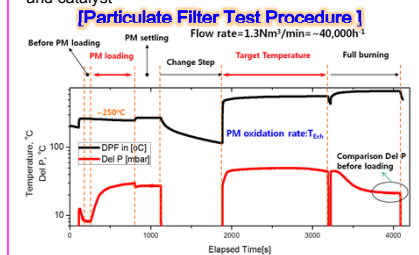
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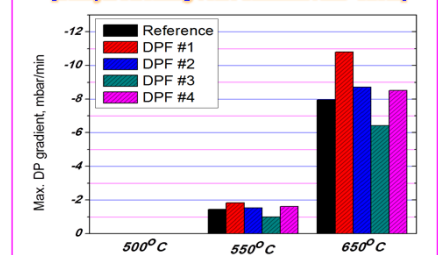


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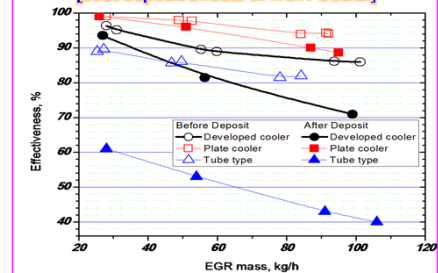
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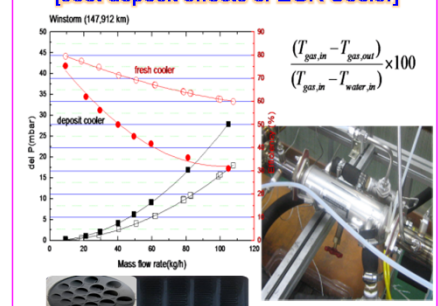
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soot deposit effects of EGR Cooler



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*Catalyst & Sensors : Continue ~~~~

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- High accuracy multi-purpose hot gas test rig for : Catalyst(TWC, DOC, SCR, LNT) , EGR Cooler and EGR Valve, Particulate Filter(DPF, GPF, pDPF), High Temperature sensor(O₂, NOx , T, ΔP)
- GUI base Computer controlled test facilities giving a serviceability such as high accuracy performance test of parts and simulation of the ESC/WHSC engine test mode.
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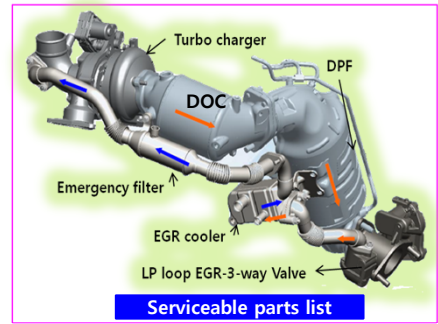
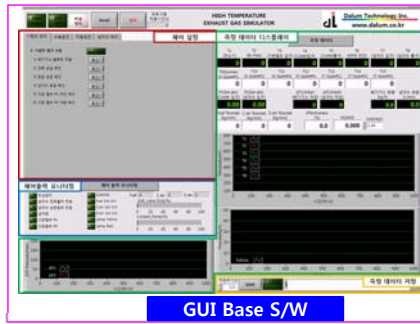
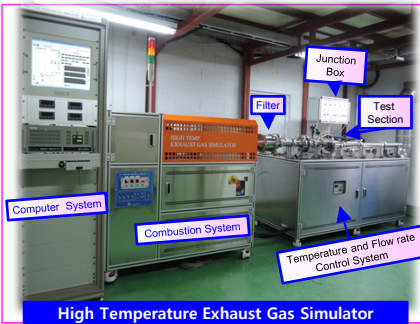
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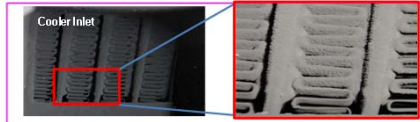
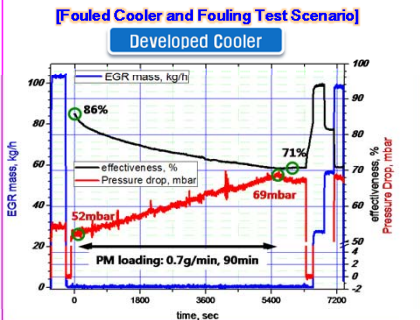


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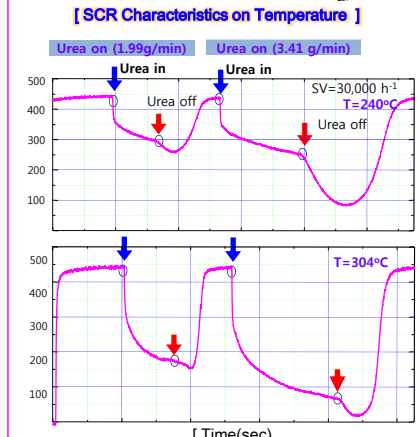
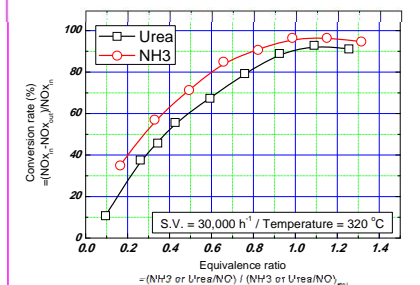
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- T&E of Particulate Filter (DPF, GPF, pDPF)**
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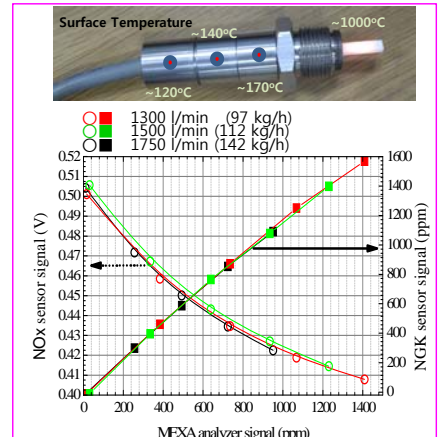


Catalyst(TWC, DOC, SCR, LNT)
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Sensor @exhaust system(O₂, NOx , T, ΔP)
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[NOx sensor characteristics vs mass flow rate and T]



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