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IDAJ CAE Solution Conference

凸轮罩盖油气分离器CFD分析

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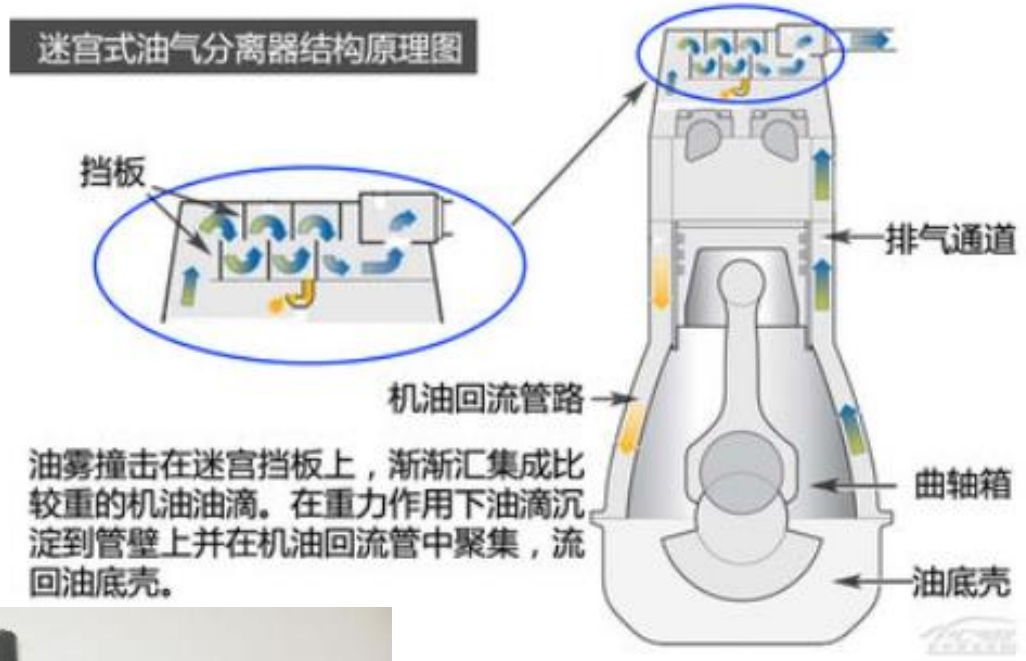
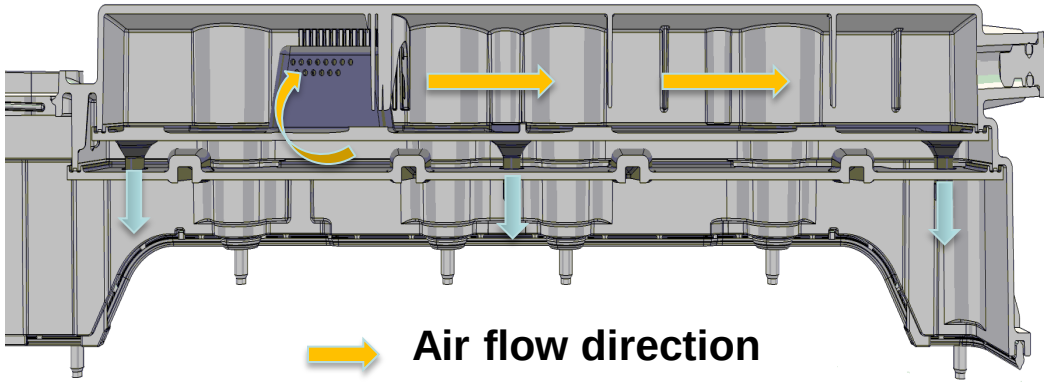
凸轮罩盖油气分离器

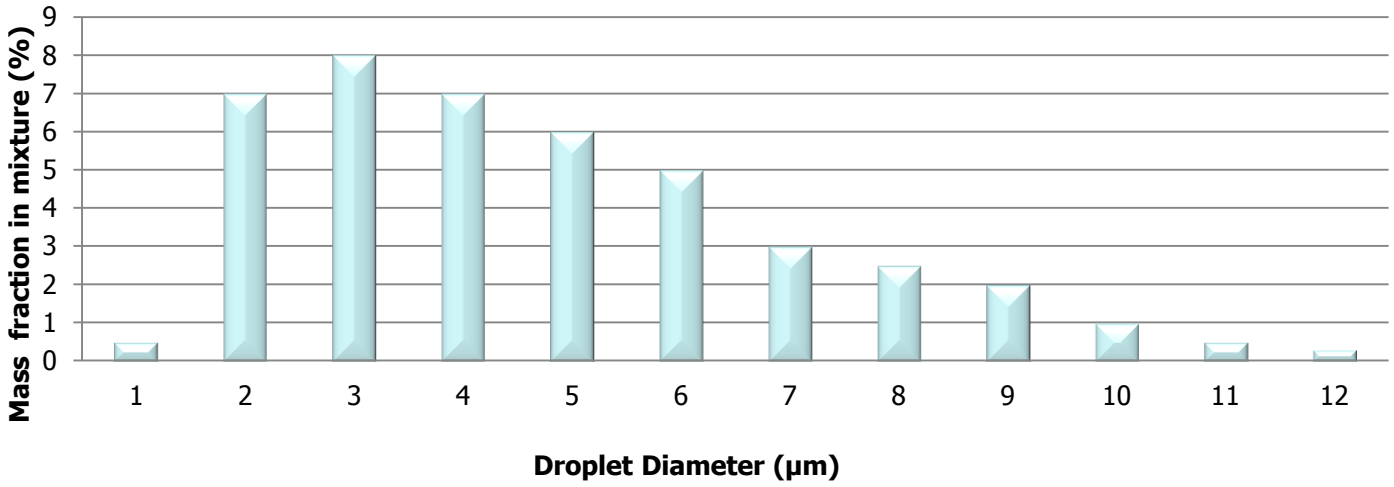


凸轮罩盖油气分离器



油气分离器典型结构

A typical passenger car oil particle distribution (*)



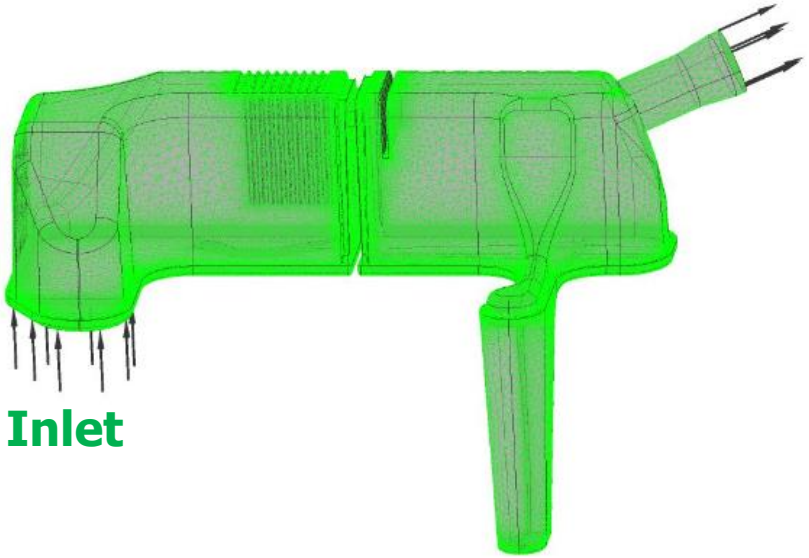
CFD模型

- CFD SOFTWARE: Fluent 16.1, ICEM-CFD
- TURBULENCE MODEL: Realizable k-e model with standard wall function
- MESH GENERATION
  - Tetrahedral mesh /hexahedral with boundary layers by prism element
- DISCRETIZATION
  - Pressure: second order upwind
  - Momentum, turbulent kinetic energy and dissipation rate: second order upwind
- CONVERGENCE CRITERIA
  - Continuity, velocity, pressure: 10e-4
  - K&E: 0.0005
- DPM: DISCRETE PHASE MODEL
  - In the standard formulation of the Lagrangian multiphase model, described in discrete phase, the assumption is that the volume fraction of the discrete phase is sufficiently low: it is not taken into account when assembling the continuous phase equations.

$$\frac{\partial p}{\partial t} + \nabla.\left(p\vec{\vartheta}\right) = S_{DPM} + S_{other}$$

$$\frac{\partial p\vec{v}}{\partial t} + \nabla.\left(p.\vec{v}.\vec{v}\right) = -\nabla p + \nabla t + p\vec{g} + \overrightarrow{F_{DPM}} + \vec{F}_{other}$$

CFD模型



$y+ = \mu * y/u$ =30~120

Skewness<0.7
Boundary layer: 5
First aspect ratio: 10

FLUID	PARAMETER	MAGNITUDE	UNIT	REMARK
AIR	Inlet Mass Flow Rate	65 and 80	[l/m]	Customer required
	Density	1.225	[kg/m³]	Software data
	Viscosity Coefficient	1.789e-5	[kg/m-s]	
Oil	Inlet Mass Flow Rate	1e-6	[kg/s]	Customer required
	Density	inert Fuel-Oil-liquid in CFD Database		
	Viscosity Coefficient			
	Droplet Diameter	1~12	[μm]	From the particle distribution

CFD模型

```
DPM Iteration ....
355
number tracked = 63412, escaped = 21412, aborted = 0, trapped = 34759, evaporated = 0, incomplete = 7241
```

When DPM Iteration= 355, the number of the incomplete particle 7241, and escaped number=21412

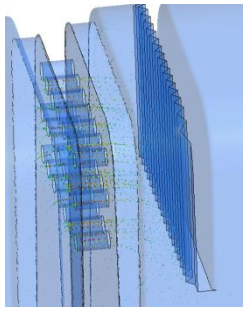
```
DPM Iteration ....
Done.
number tracked = 63412, escaped = 10146, aborted = 0, trapped = 53266, evaporated = 0, incomplete = 0
```

When DPM Iteration finished, the incomplete particle was absorbed by wall or baffle plate, then escaped number=10146

=> The oil separator efficiency= 53266/63412=84%

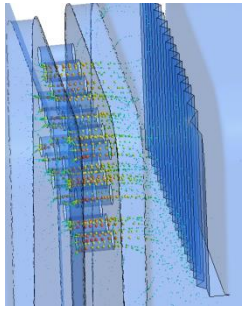
计算油气分离效率的方法

CFD结果



Droplet diameter：1μm

E= Oil Separator efficiency = 72%



Droplet diameter:6μm

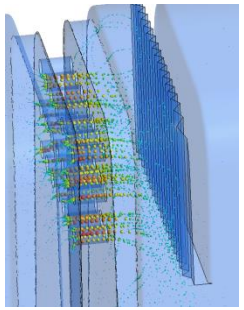
E= Oil Separator efficiency = 87%

$$E = (N_{total} - N_{escape})/N_{total}$$

E: Oil separator efficiency

N_{total} : Total number of droplet

N_{escape} : Number of escape droplet

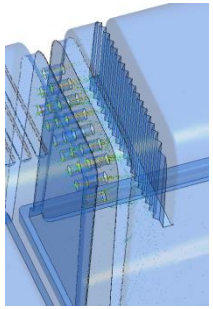


E= Oil Separator efficiency = 97.2%

Droplet diameter：12μm

Case @65l/min AIR FLOW RATE

CFD结果

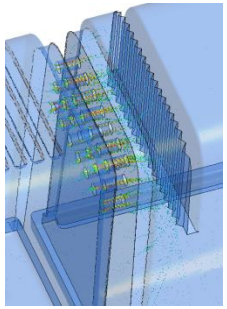


Droplet diameter：1μm

E= Oil Separator efficiency = 78%

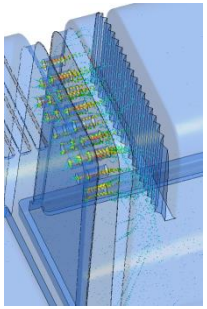
$$E = (N_{total} - N_{escape})/N_{total}$$

E: Oil separator efficiency
N_{total} : Total number of droplet
N_{escape} : Number of escape droplet



Droplet diameter:6μm

E= Oil Separator efficiency = 89%

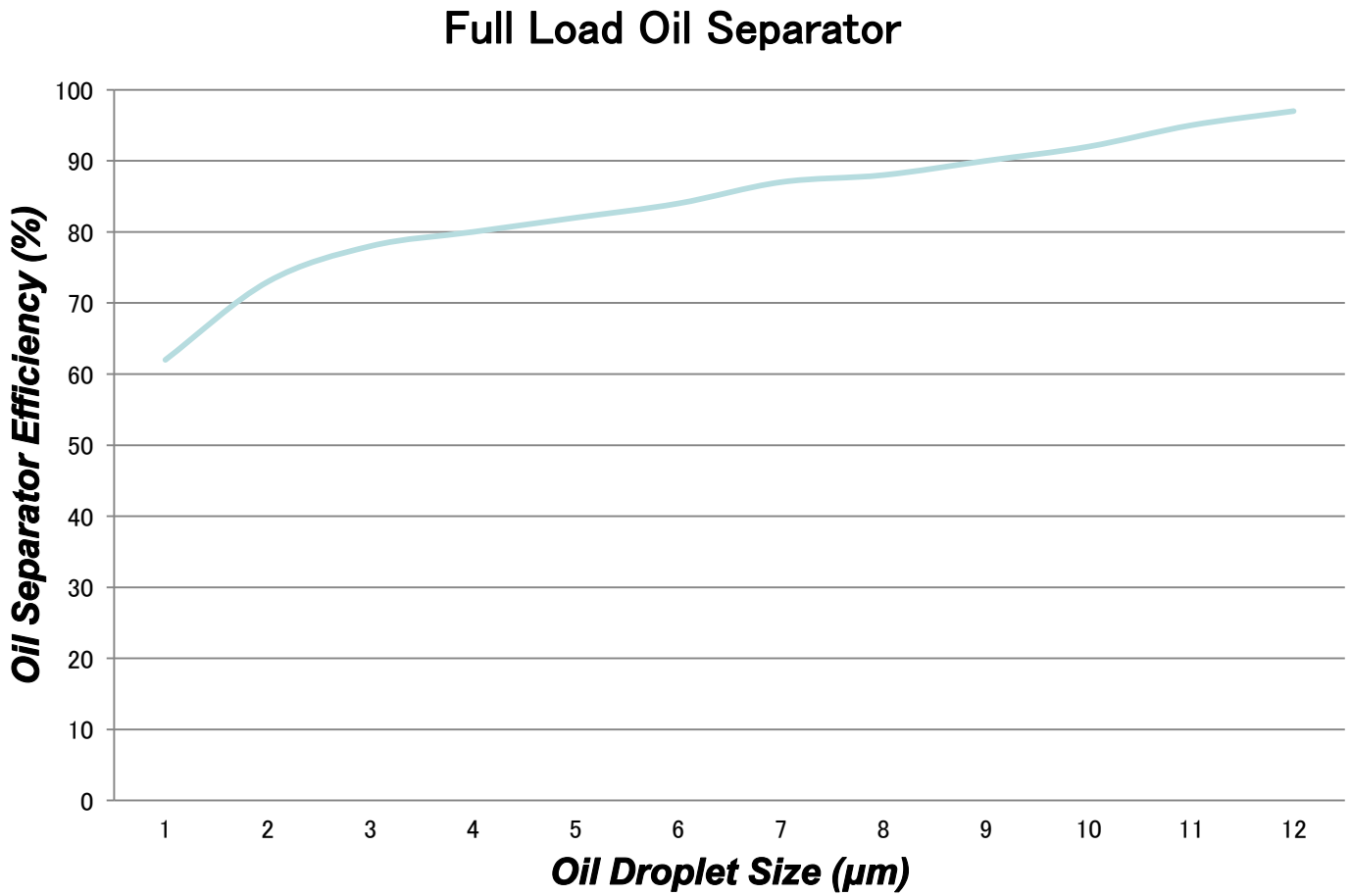


Droplet diameter：12μm

E= Oil Separator efficiency = 98%

Case @80l/min AIR FLOW RATE

CFD结果



The oil separator efficiency will be higher along with more air flow rate.

CFD结果

Oil consumption calculation as below:

- **Full load at 65l/min :**

  The weighted average is

  86.23%= ((0.5%*72%+5%*87%+0.3%*97.2%)/5.8%)

Oil consumption would be:

3.6g/h*(1-86.23%)=0.4956g/h<0.7g/h(customer requirement)

- **Full load at 80l/min :**

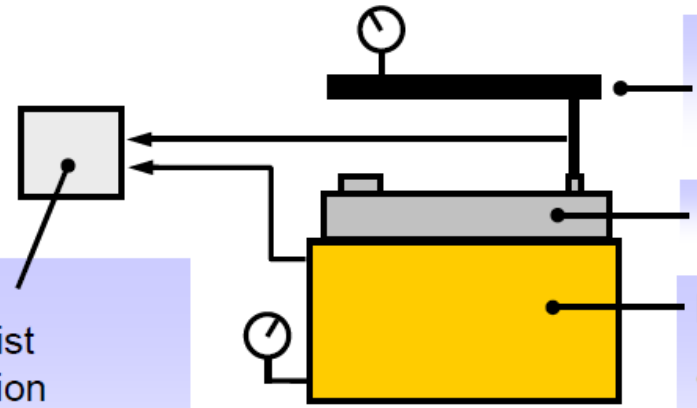
  The weighted average is

  88.51%=(0.5%*78%+5%*89%+0.3%*98%)/5.8%

  Oil consumption would be:

  3.6g/h*(1-88.51%)= 0.4133g/h <0.7g/h (customer requirement)

油气分离器测试



Air intake manifold dummy:
- Maintaining defined pressure

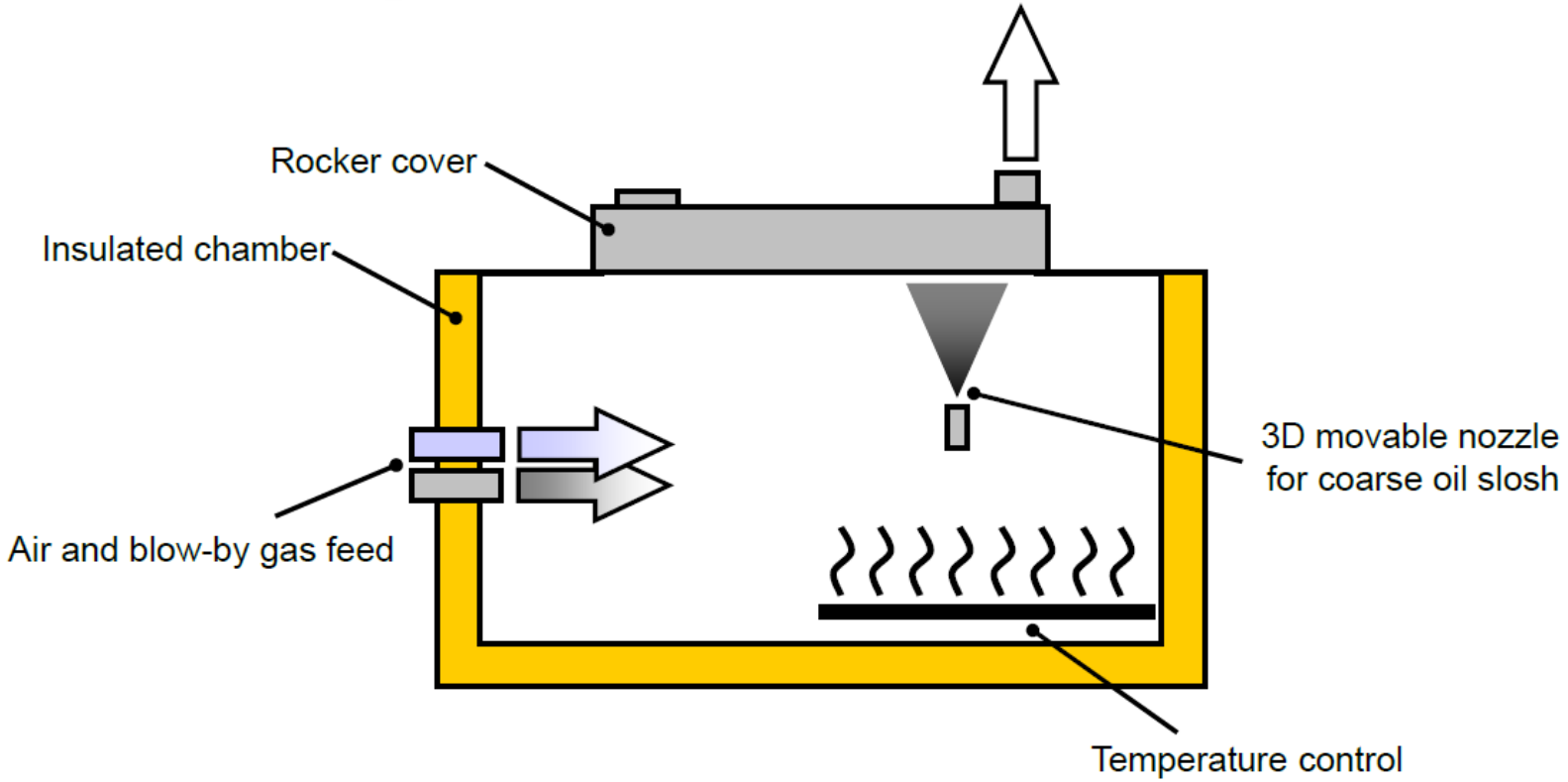
Separator unit under test

Engine dummy:
- Generation of blow-by gas with defined composition, temperature and mass flow
- Generation of sloshed oil

Aerosol measurement:
- Classification of oil mist
- Evaluation of separation efficiencies

Classification with:
- Fibrous web filter
- Multi-stage cascade impactor
- Laser spectrometer

油气分离器测试

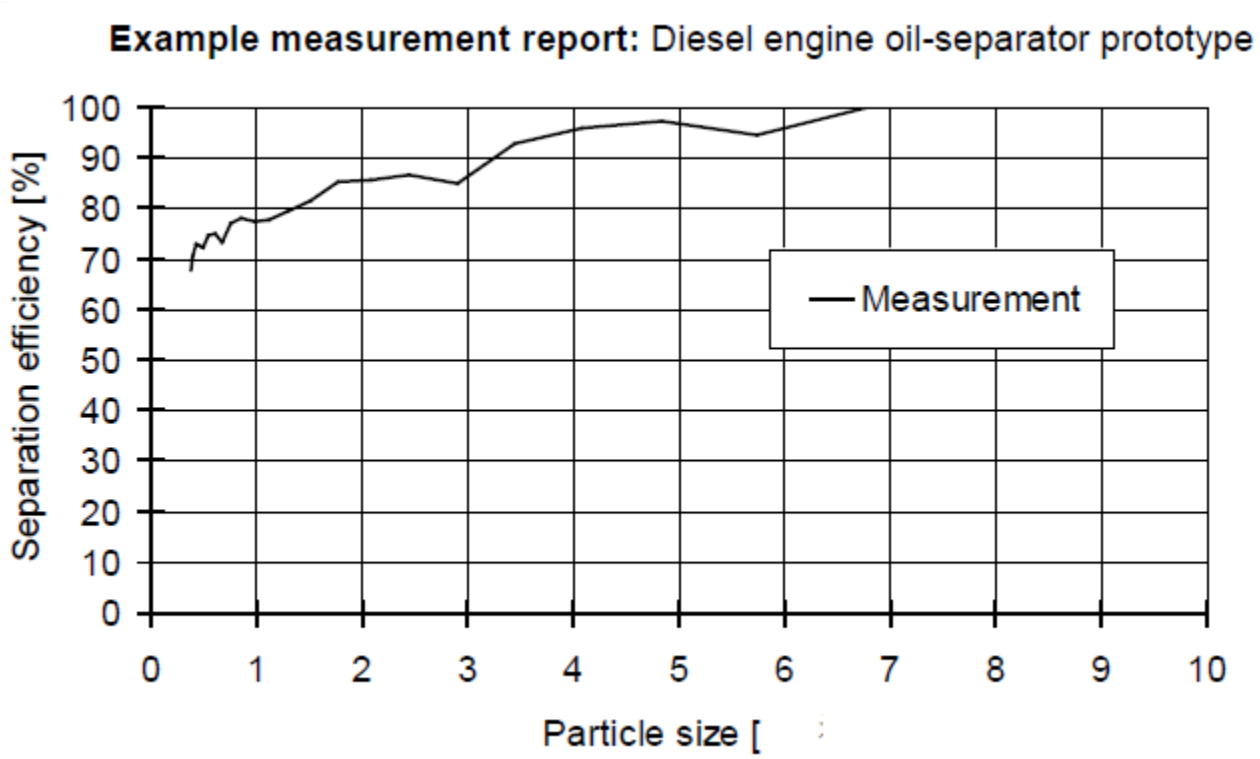


油气分离器测试

Specifications:

Gas volume flow:	0 – 170 l/min (Vol. at 1 bar, 23°C)
Particle size (oil drops):	0,3 µm – 10 µm
Pressure:	0,1 – 1,0 bar (abs)
Temperature range:	23°C – 100°C

油气分离器测试



感谢聆听！