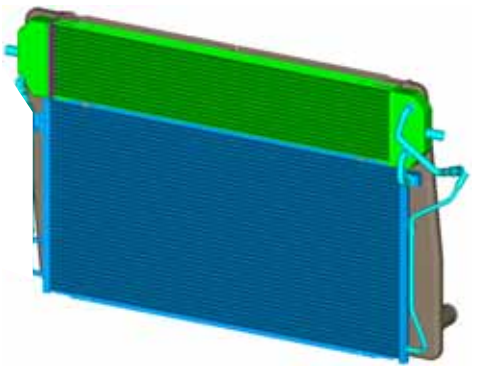
SLIM

■ Single Layer Integrated cooling Module ■



Nov. 2010
Calsonic Kansei Corp.

content

1)Market needs

2)What's SLIM？

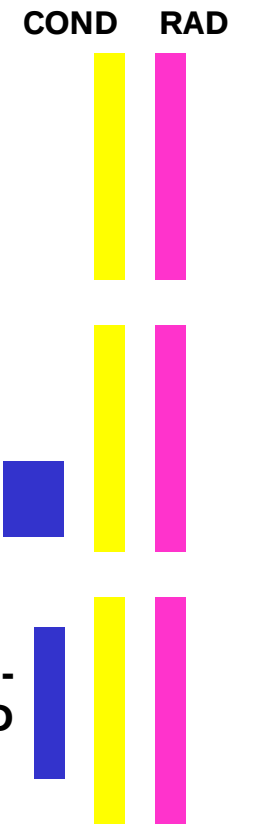
3)SLIM's two features

4)Test result

5)Conclusion

Requirement for New Power Sources

Power sources	Heat exchangers		Additional heat exchangers	
	Radiator	AC condenser	CAC (Charge air cooler)	Motor / Inverter cooling Radiator
Natural aspiration Petrol engine	☆	☆		
Turbo Petrol engine "Downsizing turbo"	☆	☆	☆	
Clean Diesel engine	☆	☆	☆	
Hybrid vehicle	☆	☆	(☆)	☆



Larger size

◆New Power source vehicle requires Additional Heat Exchangers

Influence of Additional heat exchanger

Additional heat exchanger

Reduction of air flow
which flows through heat exchangers in the front end of cooling system

Performance declines in these areas:

- **Engine cooling**
- **Air conditioning**
- **Turbo charging**
- **Inverter cooling**

Heat exchangers become larger

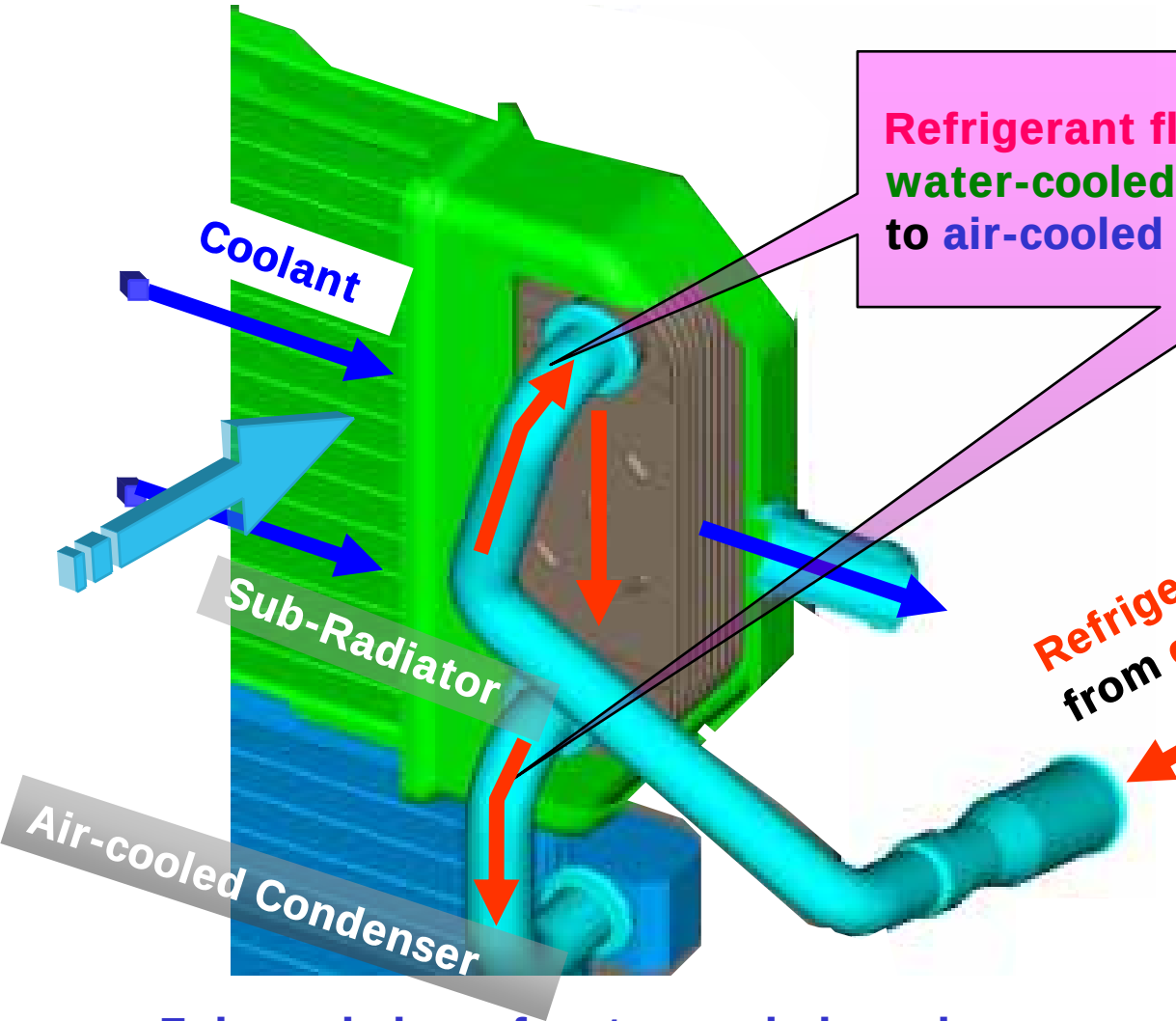
- **Power of Motor fan increases more**
- **Compressor power increases by rise of pressure of condenser**

◆New Power source vehicles bring additional factors of Additional Fuel Consumption

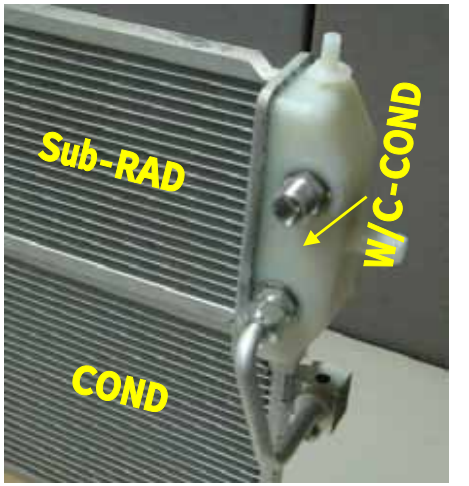
SLIM technology

What is SLIM ?

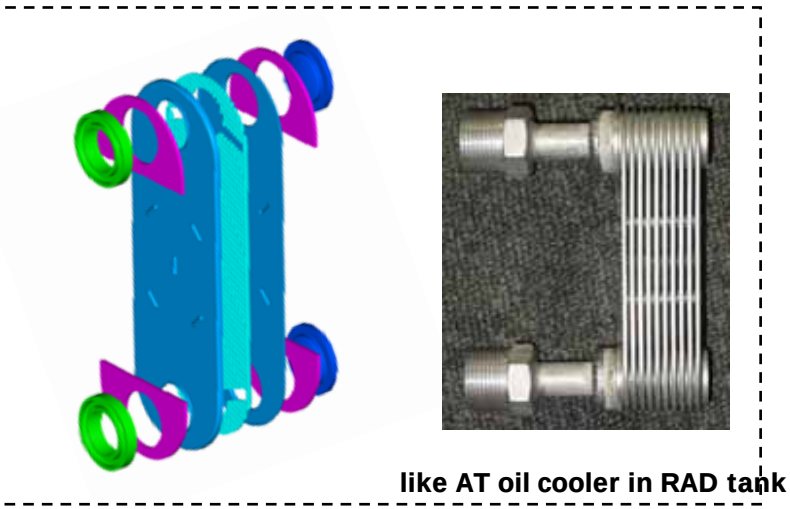
Structure of Water-Cooled Condenser



Refrigerant flows from water-cooled condenser to air-cooled condenser



Refrigerant from compressor

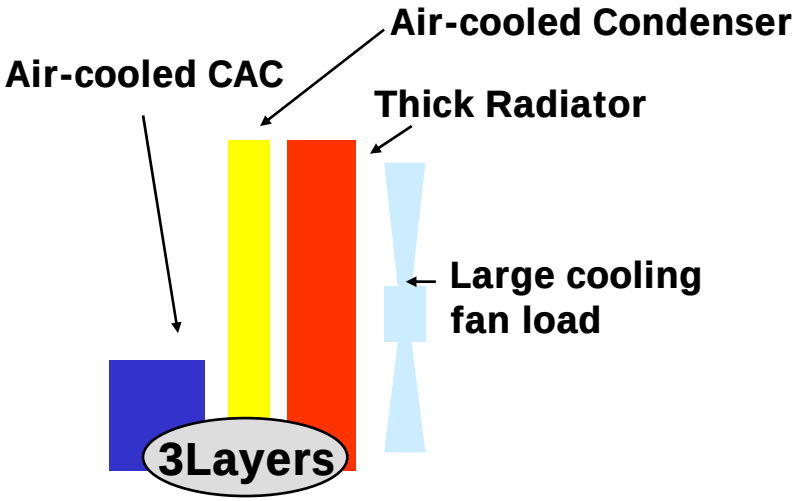


like AT oil cooler in RAD tank

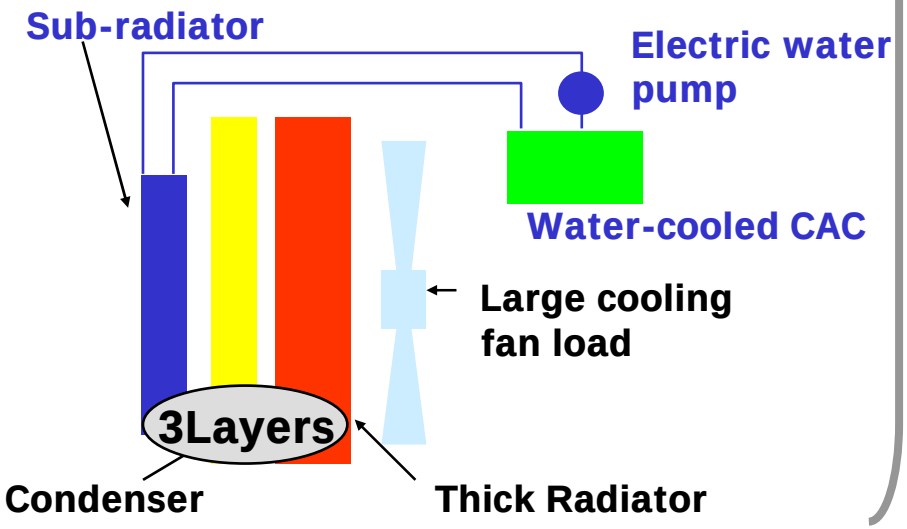
Enlarged view of water-cooled condenser

What is SLIM (for turbo) ?

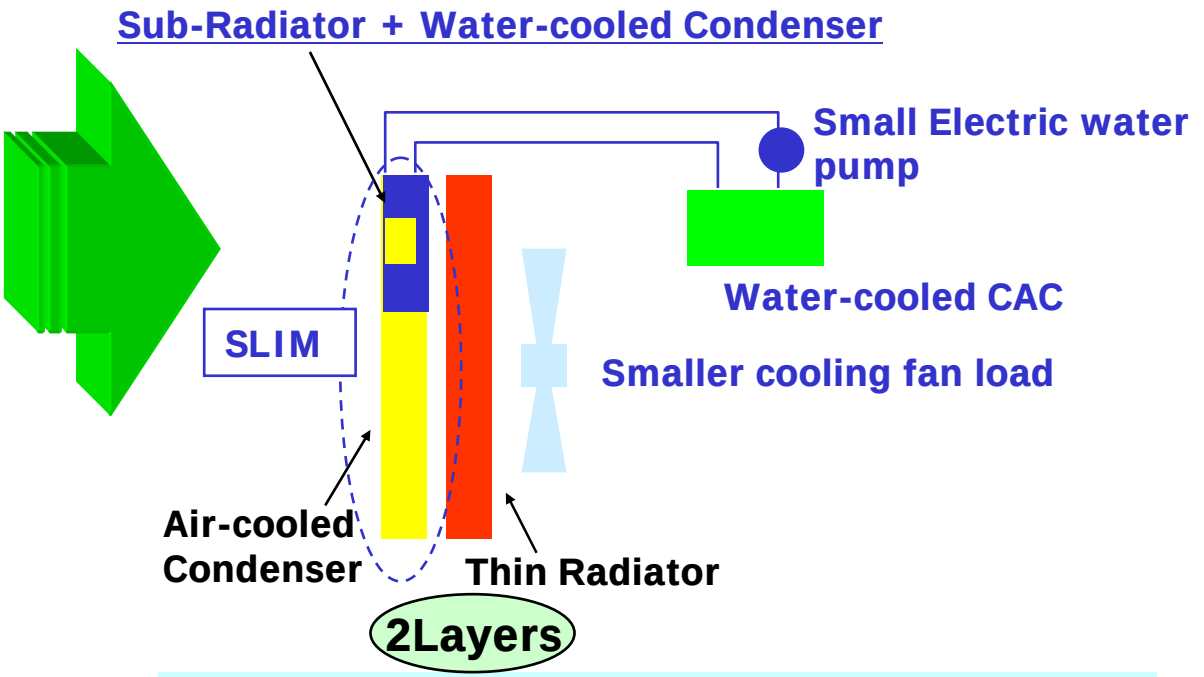
■ Current Air-cooled CAC



■ Ordinary Water-cooled CAC



■ SLIM



Merits:

- ✓ AC compressor pressure reduced
- ✓ Cooling fan power reduced
- ✓ Engine Cooling Module downsized

➔ **Fuel consumption is improved**

Two Features

1.

- **One sub-radiator function is changeable automatically**

  And choose the best heat transfer coefficient in each relation

➔Can reduce air pressure drop（3 layer ECM to 2 layer ECM）

➔Can reduce motor fan power and space and weight

2.

- **Heat storage effect of water cooled condenser and CAC**

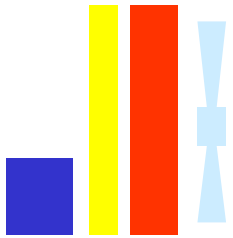
➔ Can prevent AC pressure Up and CAC outlet temp Up

➔ Can reduce AC compressor power and improve engine response

Both can improve fuel consumption

Feature One : Image of Downsizing

One air cooled CAC



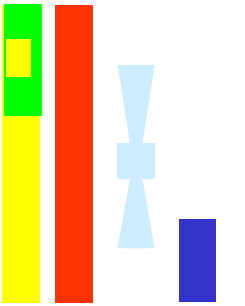
Small

Load of CAC

Large at hi-speed

fusion

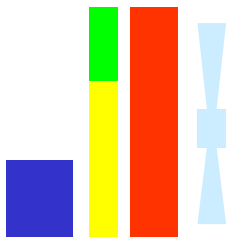
SLIM



water cooled CAC

Total only One sub-radiator

One sub-radiator



Small

Load of water cooled condenser

Large at low-speed

Small

Sub-Radiator performance

Load of water cooled condenser

Small

Load of CAC

Large at hi-speed

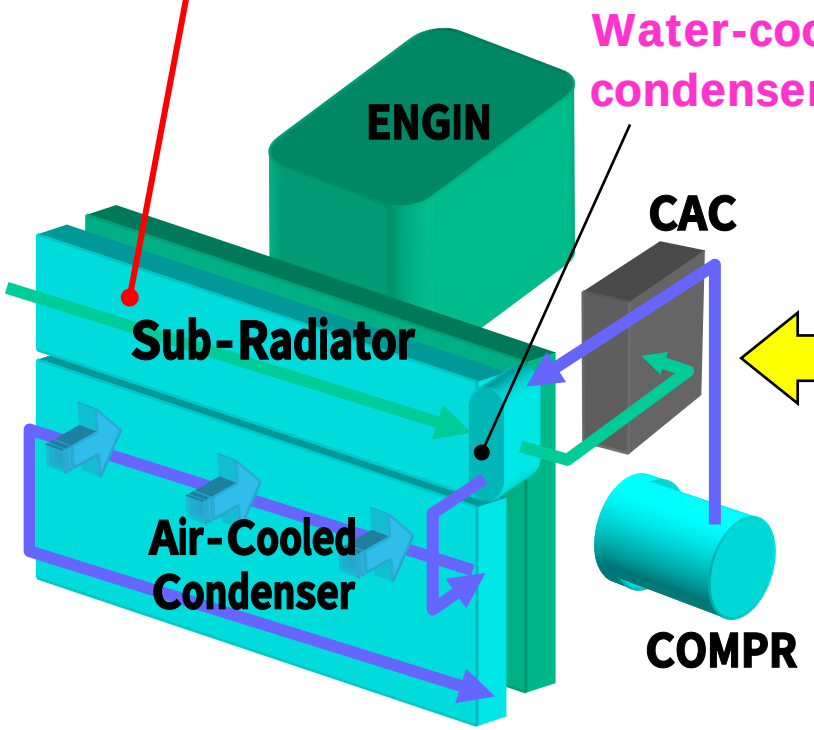
Large at low-speed

- One sub-radiator function is changeable automatically
- No valve & no actuator

Mutual Use of Sub-Radiator

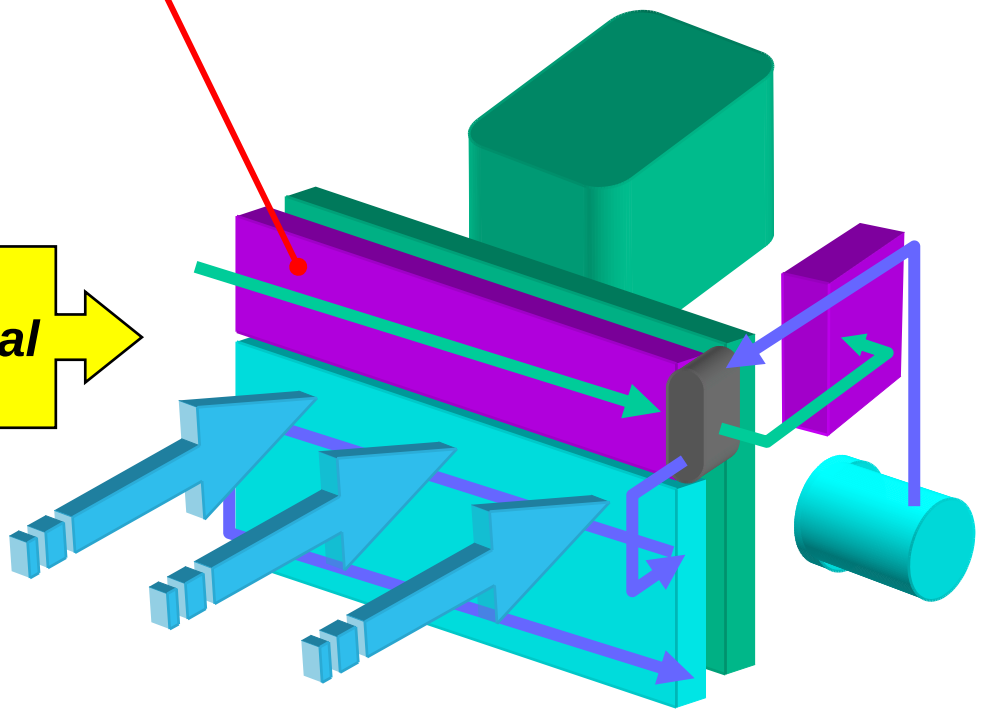
Idling

Sub RAD
: mainly for Water-cooled condenser



Hill-climbing

Sub-RAD : mainly for CAC

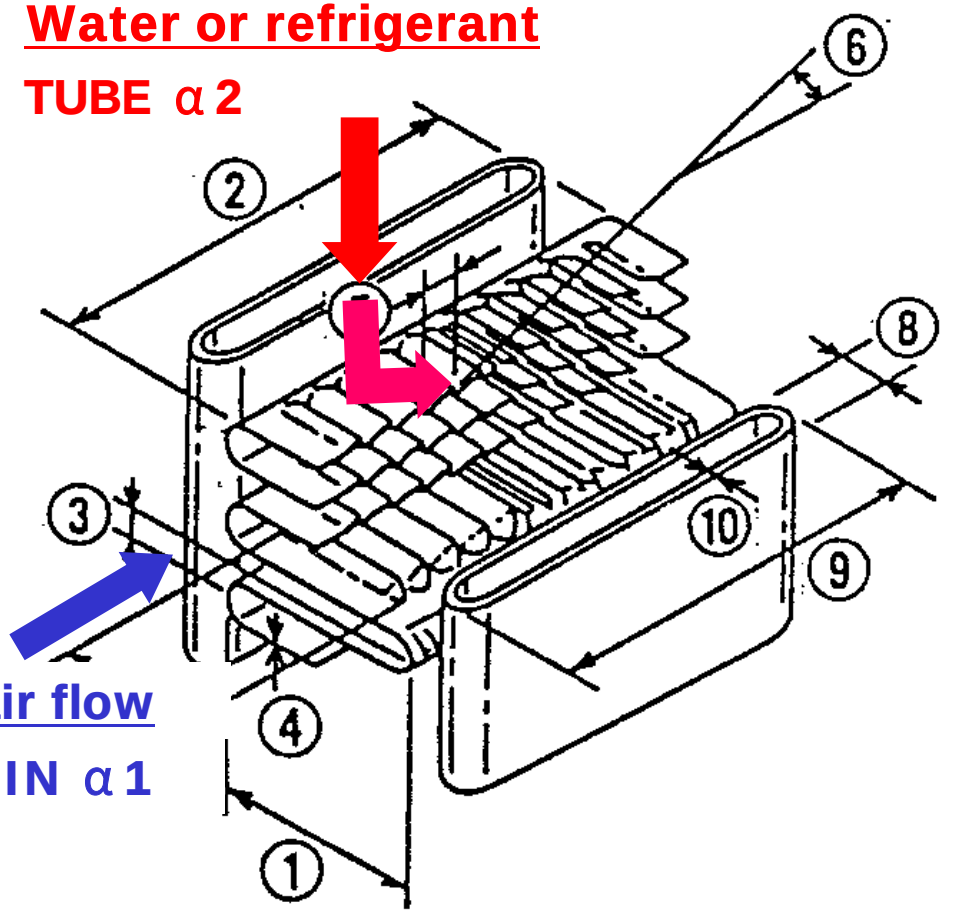


Not an Additional Device

Why use both water and air-cooled condenser ?

Water or refrigerant

TUBE α2



air flow

FIN α1

PARAMETERS	
1	FIN HEIGHT
2	FIN DEPTH
3	FIN PITCH
4	FIN MATERIAL THICKNESS
5	LOUVRE PITCH
6	LOUVRE ANGLE
7	LOUVRE CUT LENGTH
8	TUBE HEIGHT
9	TUBE DEPTH
10	TUBE MATERIAL THICKNESS

Heat transfer capacity:

$$Q = K \times A \times \Delta T$$

where

$1/K = 1/(\alpha 1) + 1/(\alpha 2)$ (outline)

α：Heat transfer coefficient

A：Area of heat dissipation

ΔT：Temperature difference

= Water temp. – Air flow temp.

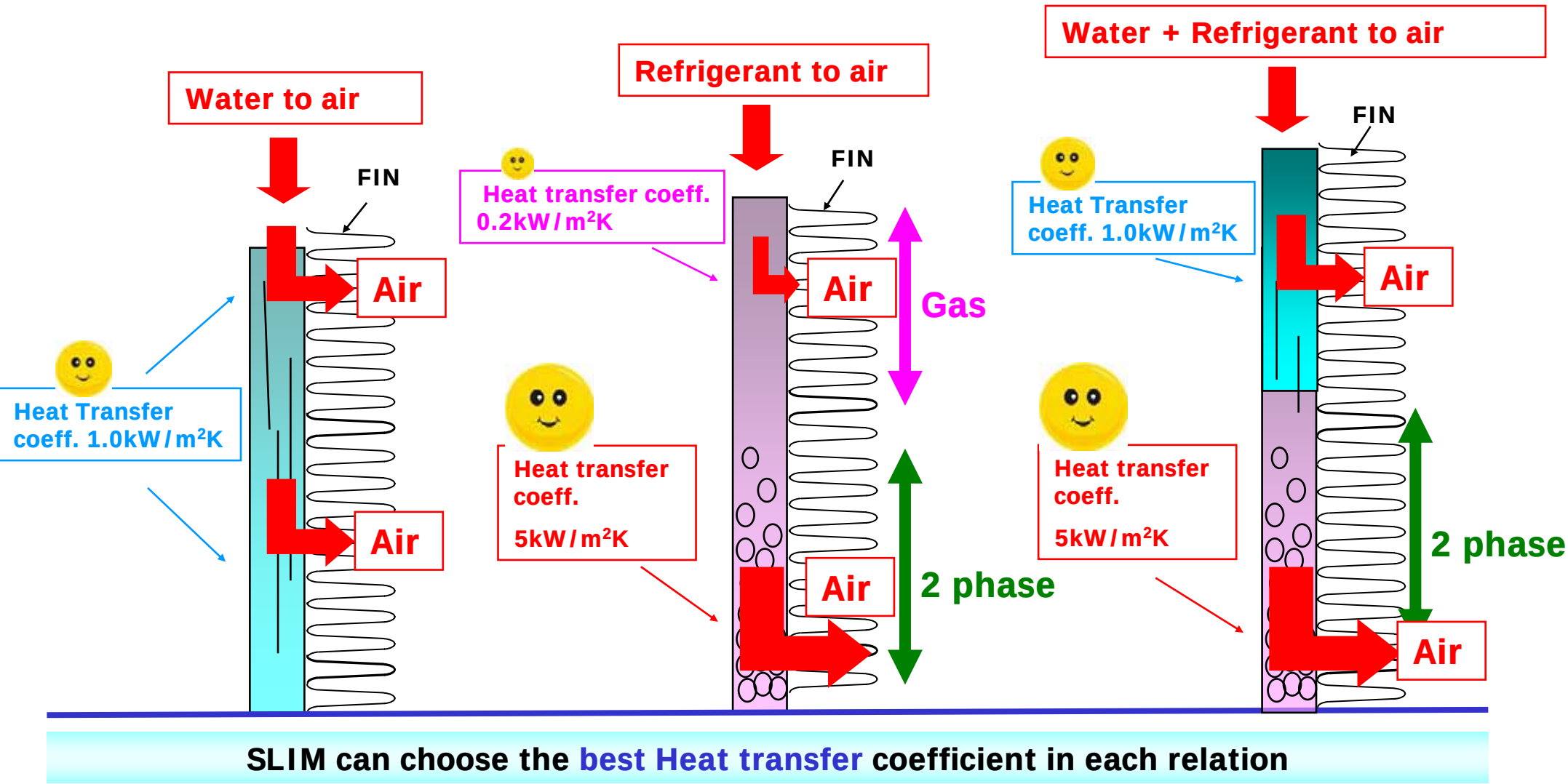
Heat transfer coefficient is important for heat transfer capacity of heat exchanger

Comparison of Heat Transfer Coefficient

Full water cooled condenser

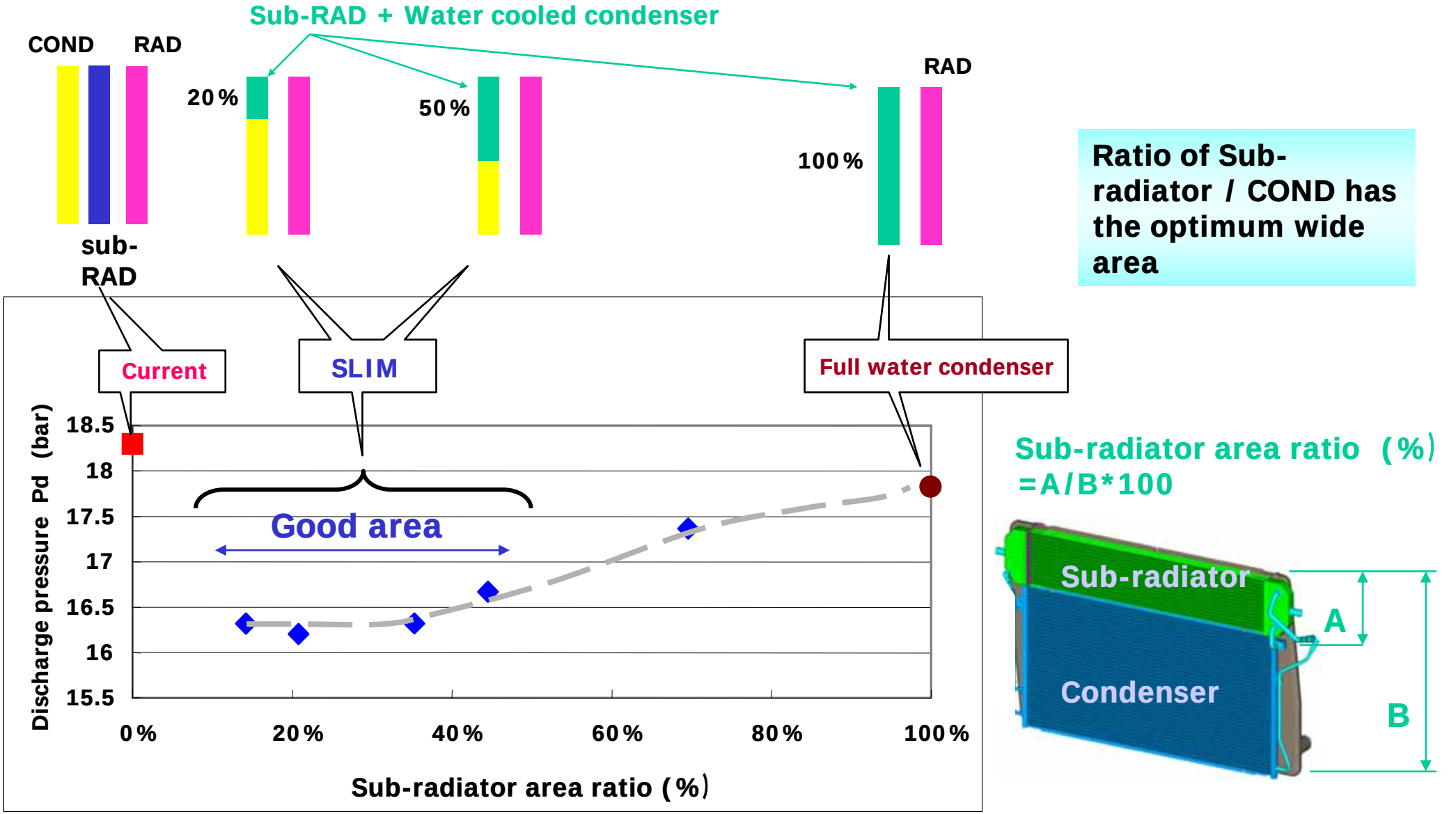
Current condenser

SLIM



SLIM can choose the best Heat transfer coefficient in each relation

Optimum Ratio of Sub-RAD/COND



Ratio of Sub-radiator / COND has the optimum wide area

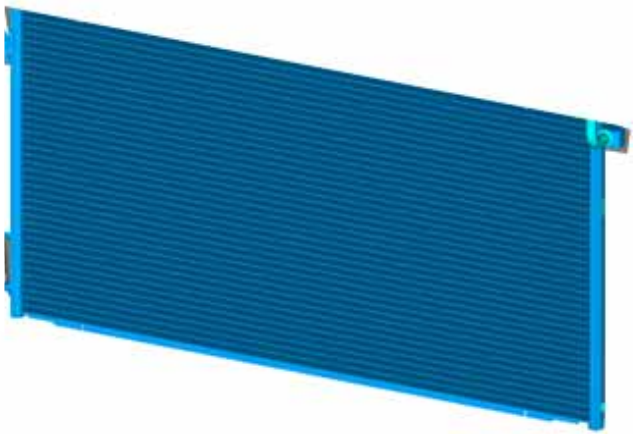
Sub-radiator area ratio (%)
=A/B*100

(Pd at 40degC, 40km/h, AC ON, and constant motor fan power by calculation)

Features two : thermal storage of water

Current

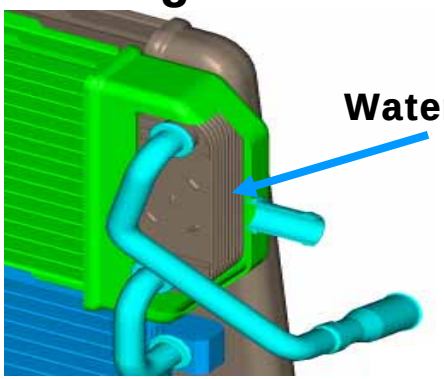
- Specific heat of air is small

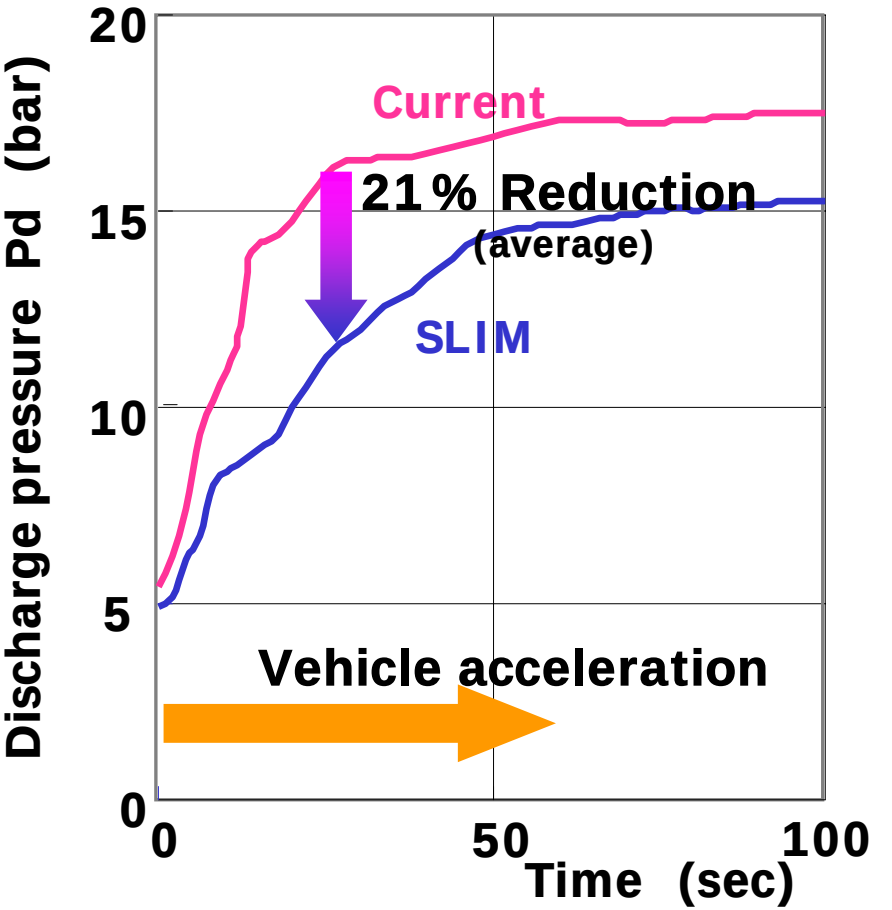


SLIM

- Specific heat of water is large

So Refrigerant can be cooled more



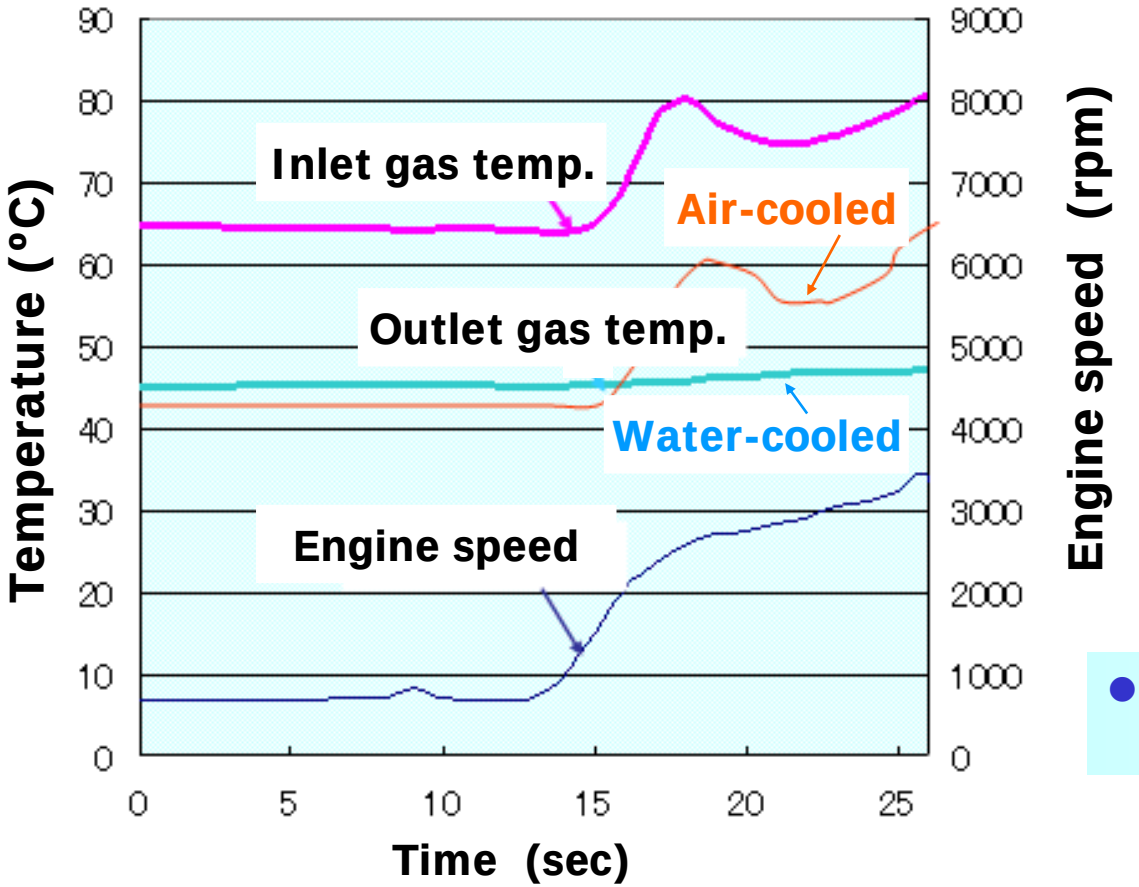


- Fuel consumption is improved by the effect of the water storage.

Effect of water-cooled CAC

Heat storage effect

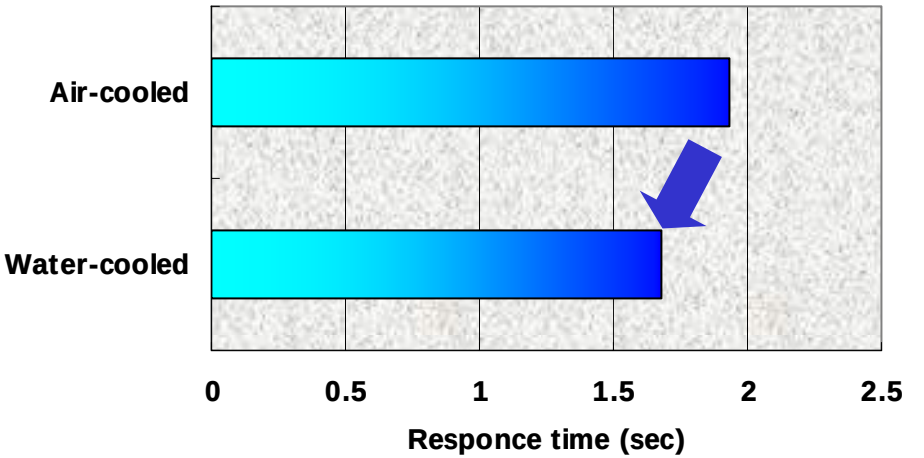
CAC outlet gas temp. is not increased at the time of acceleration .



Reduction of inhalation resistance

By reduction of inhalation resistance,

Engine response becomes good



Time until some suction pressure

1.4L petrol engine with Turbo-charger

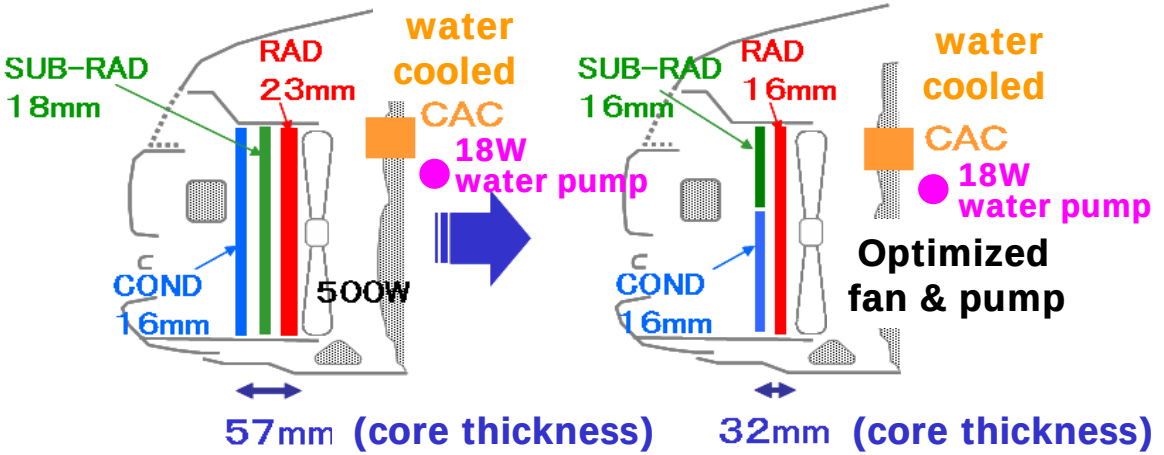
- **Fuel consumption is improved by low CAC outlet gas temp and good response.**

Results of car tests using SLIM

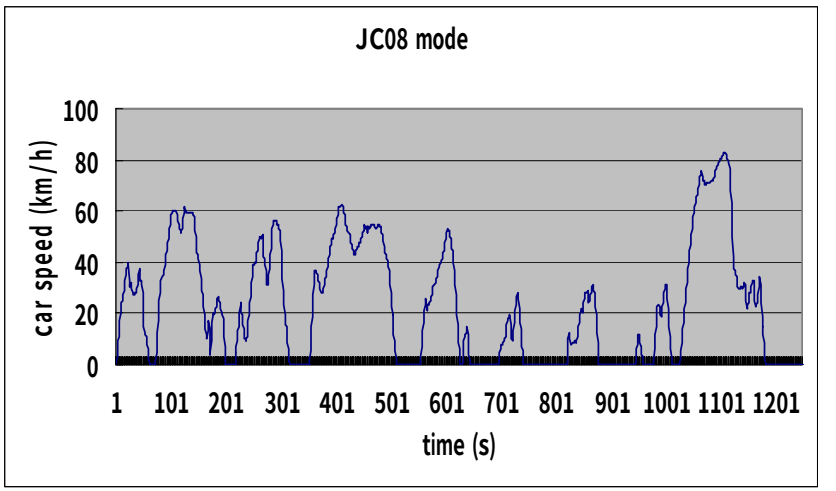
Performance of Vehicle which installed SLIM

Experiment vehicle --- VW Golf TSI Trend line (1.4L Petrol engine Turbo)

	Result
ECM thickness , weight	40 % reduced
Fuel consumption	4% improved (JC08, AC on)
・A/C pressure ・Cooling Fan Power	Equal to 150 Watt reduced



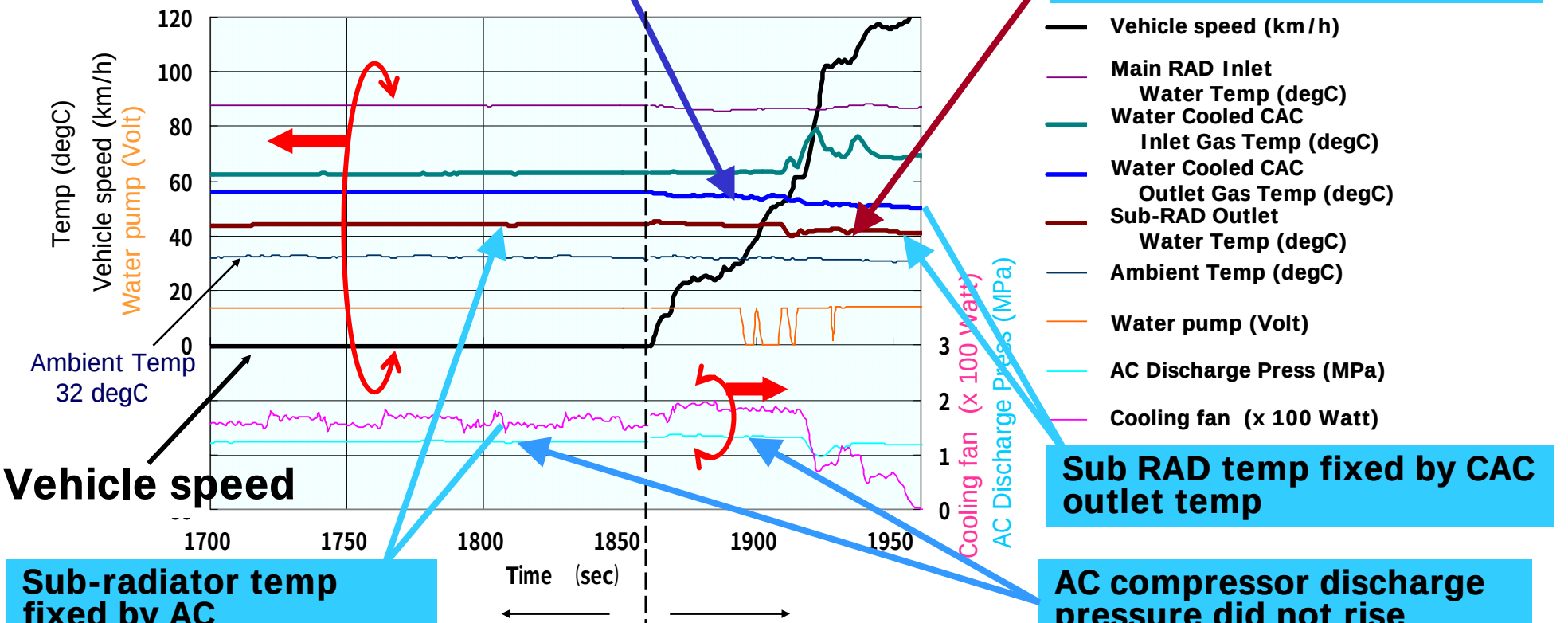
Driving mode:
JC08 (Japanese regulation)
+ 35degC in ambient
+ A/C ON



The acceleration result from idling

Water cooled CAC outlet temperature does not go up at acceleration

Sub-radiator temp does not go up



Sub RAD temp fixed by CAC outlet temp

Sub-radiator temp fixed by AC

AC compressor discharge pressure did not rise

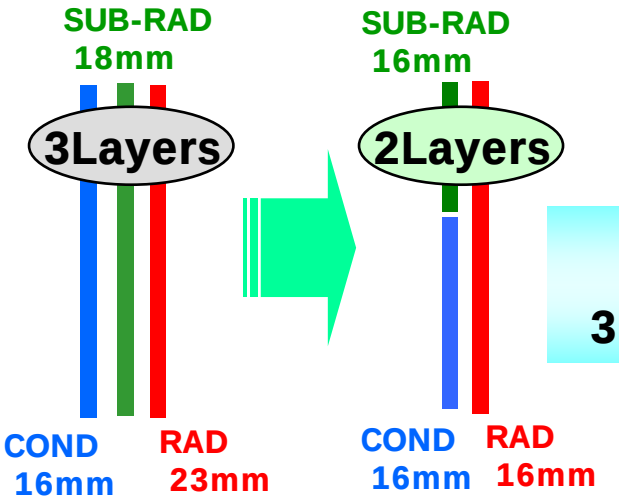
Sub-radiator cools condenser

Sub-radiator cools water-cooled CAC

No Additional Device Needed

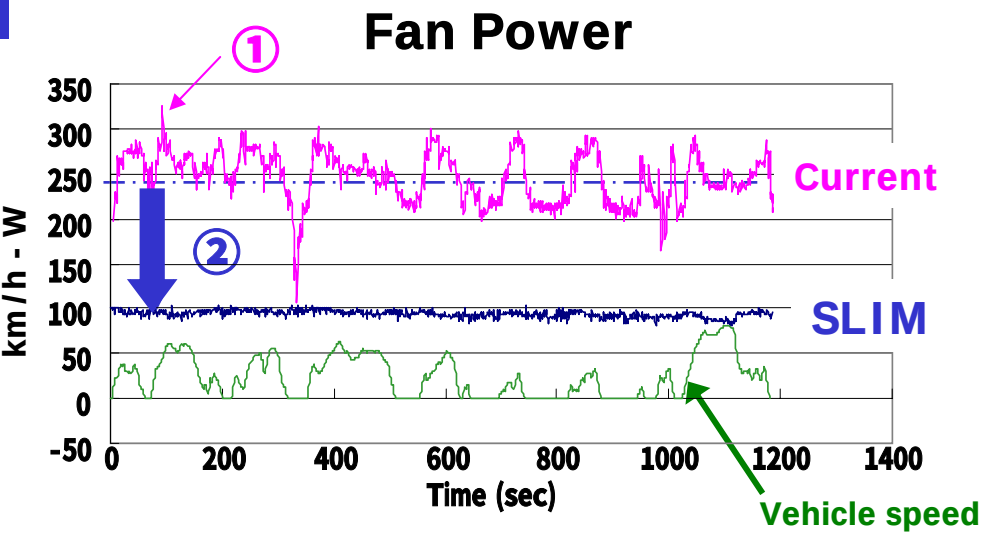
Analysis of Effect to Fuel Consumption

(1) Reduction of air pressure drop



Fan power:

30~40% reduced



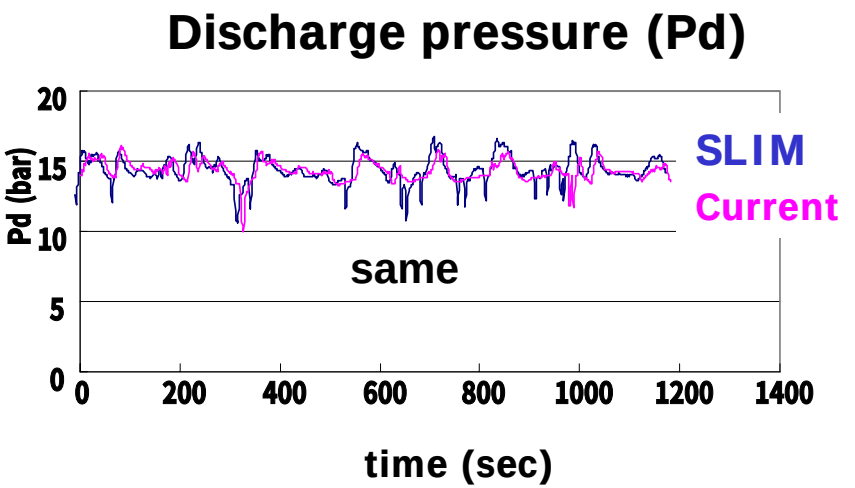
・at the same air temperature of AC outlet

(2) Thermal storage effect of water

・Current = For preventing Pd rise, Cooling fan power increases at the time of acceleration ①

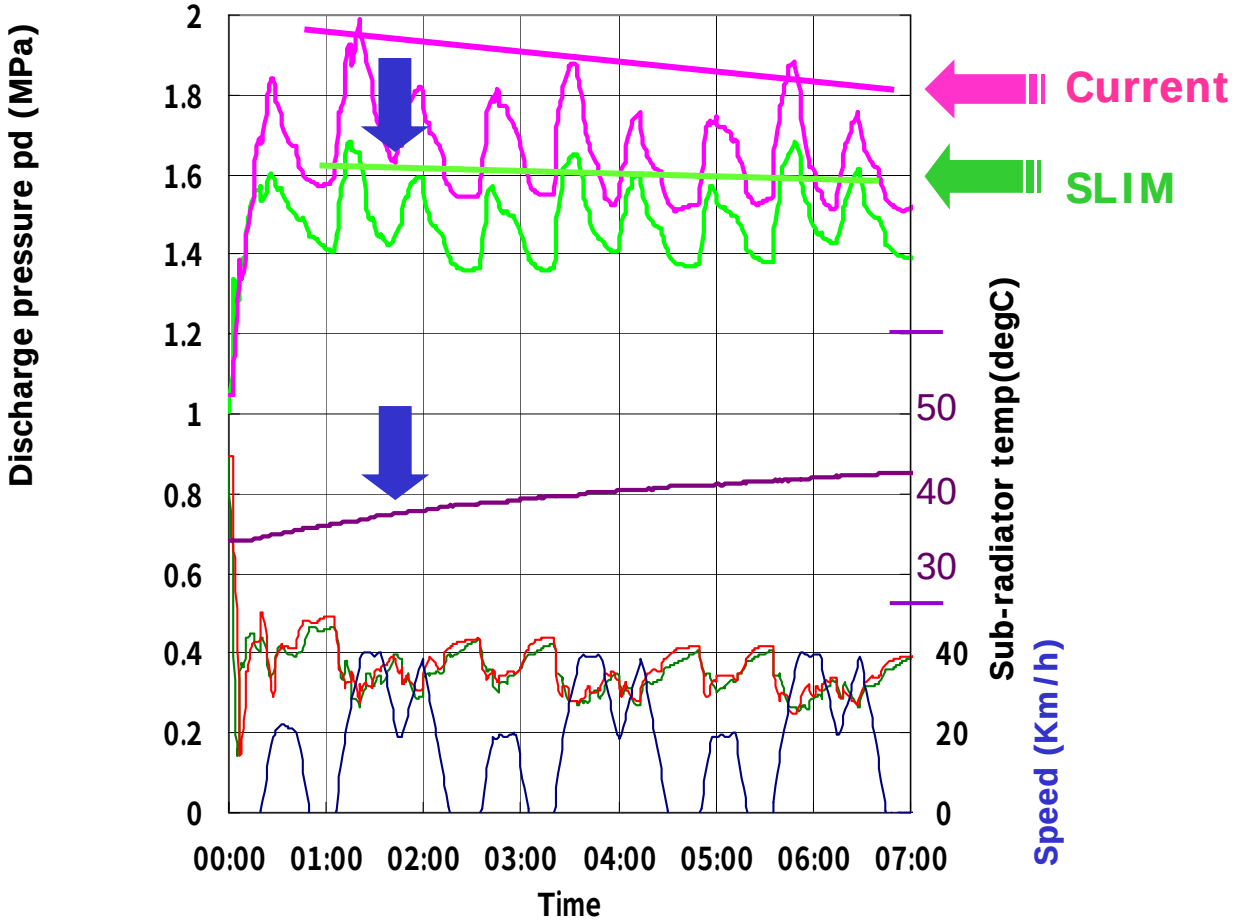
・SLIM =Even if reduces and constants fan power ,why is it Pd dose not go up ? ②

Explain on the following page



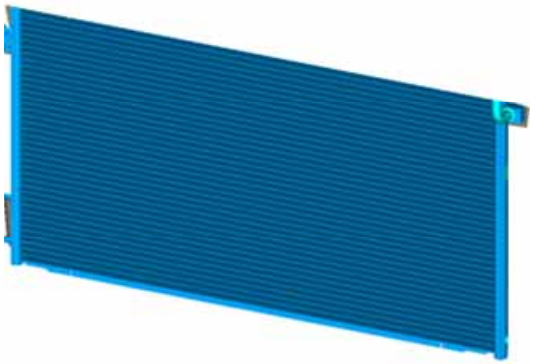
Thermal Storage Effect by Water

Pd comparison at constant fan power (JC08 AC ON)



Current

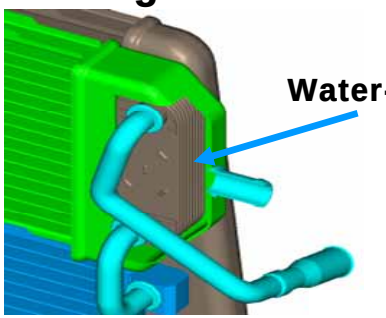
- Specific heat of air is small



SLIM

- Specific heat of water is large

So Refrigerant can be cooled more



When fan power is constant, Current is Pd UP, but SLIM is made low Pd

Application of SLIM

SLIM technology will be applied to the following new power sources.

- **HV --- Hybrid vehicle**
- **Super charging petrol engine**
- **Diesel**
- **EV --- Electric vehicle**
- **Plug-in HV**
- **Diesel HV**

Conclusion

By using SLIM technology to new power source vehicles, the following merits will be occur:

- **Compact space of front end**
- **Improved fuel consumption --- 2~5%**

Thank you so much of your attention.