Transient phenomena effect on energy consumption

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2002 SAE AUTOMOTIVE
ALTERNATE REFRIGERANT
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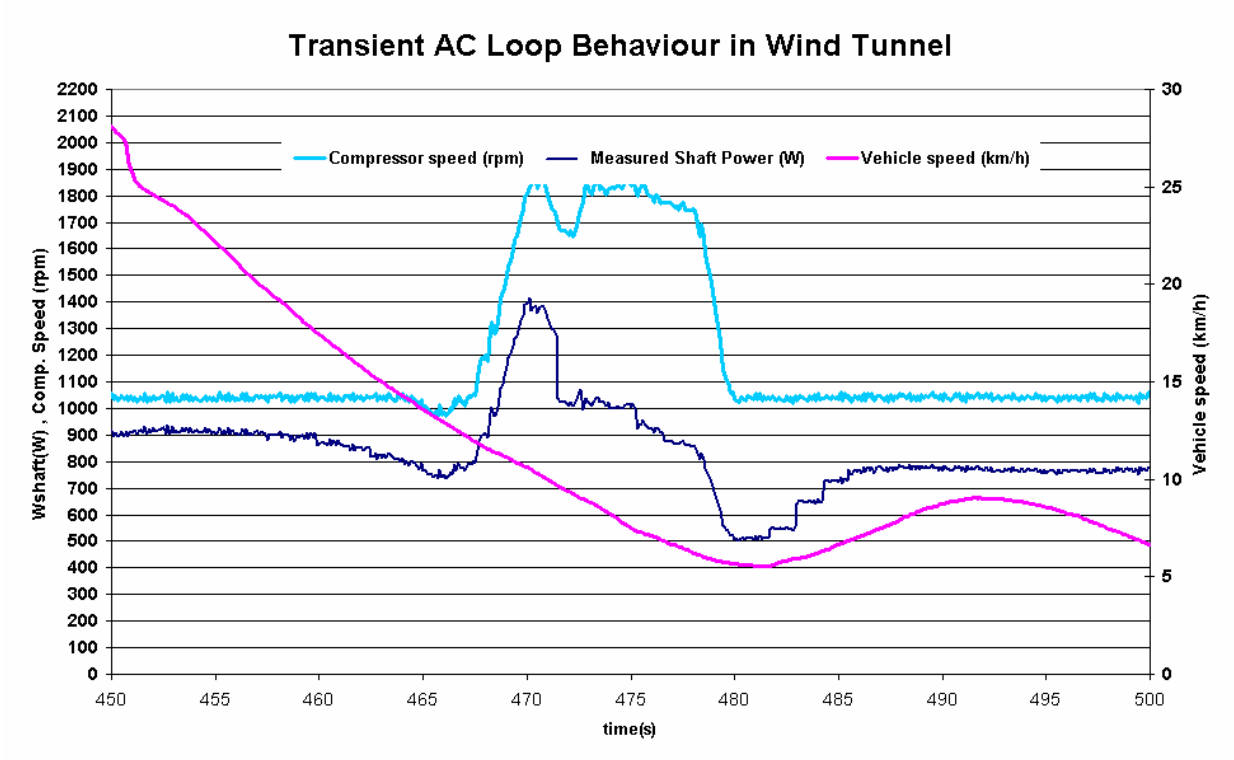
Valeo
CLIMATE CONTROL

Environmental background

- More attention paid to fuel consumption used for comfort and safety
- Significant Difference between Energy consumption and Fuel consumption
- Different method of measurements
  - At the test bench (stabilized or dynamic)
  - In the Wind tunnel (stabilized or dynamic)

Transient phenomena background

- How much time the system needs to be in realistic stabilized and optimized conditions



Approach for European conditions

- Matrix of tests for test bench

Based on:

- NEDC cycle
- European climate conditions

Testing points are selected:

- to cover the operating map
- to have reference values

Point name	Evapo. Air mass flow kg/h	Evapo. Air Temp °C	Evapo.Air humidity %	Condenser Air mass flow kg/h	Condenser Air Temp. °C	Comp. Speed rpm
IH35	439	25	40	1338	35	1000
MH35	439	25	40	1967	35	2200
HH35	439	25	40	3386	35	2971
IL35	440	25	40	1299	45	999
ML35	439	25	40	1731	35	1598
HL35	439	25	40	2833	35	2498
IH30	316	30	40	1369	30	1598
MH30	316	30	40	2014	30	2200
HH30	316	30	40	3463	30	2998
IL30	316	30	40	1330	41	999
ML30	316	30	40	1771	29	1598
HL30	316	30	40	2901	31	2499
IH25	218	25	55	1393	26	1598
MH25	218	25	55	2047	26	2198
HH25	218	25	55	3521	26	2999
IL25	218	25	55	1352	35	999
ML25	218	25	55	1803	26	1598
HL25	218	25	55	2951	26	2499
IH20	218	20	70	1418	20	1598
MH20	217	20	70	2085	21	2200
HH20	218	20	70	3524	21	2999
IL20	218	20	70	1377	30	999
ML20	218	20	70	1836	20	1598

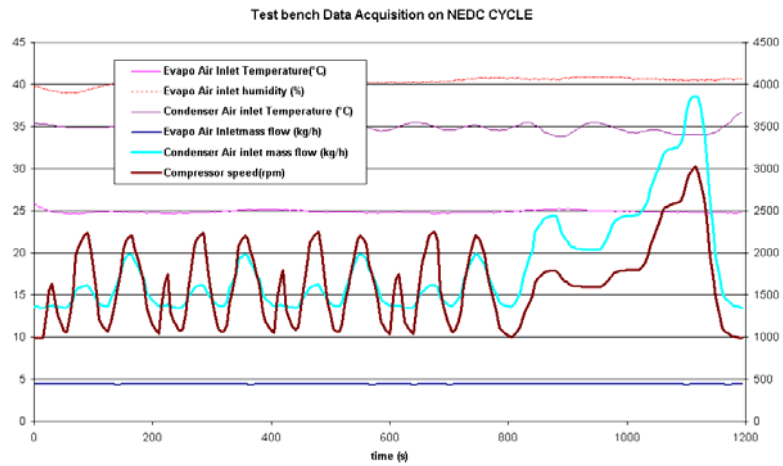
Test bench tests

- Type of test benches

- 2 independent air flow tunnels
- 1 compressor stand (variable speed)
- Simulation of NEDC cycle possible
- Full data recording system

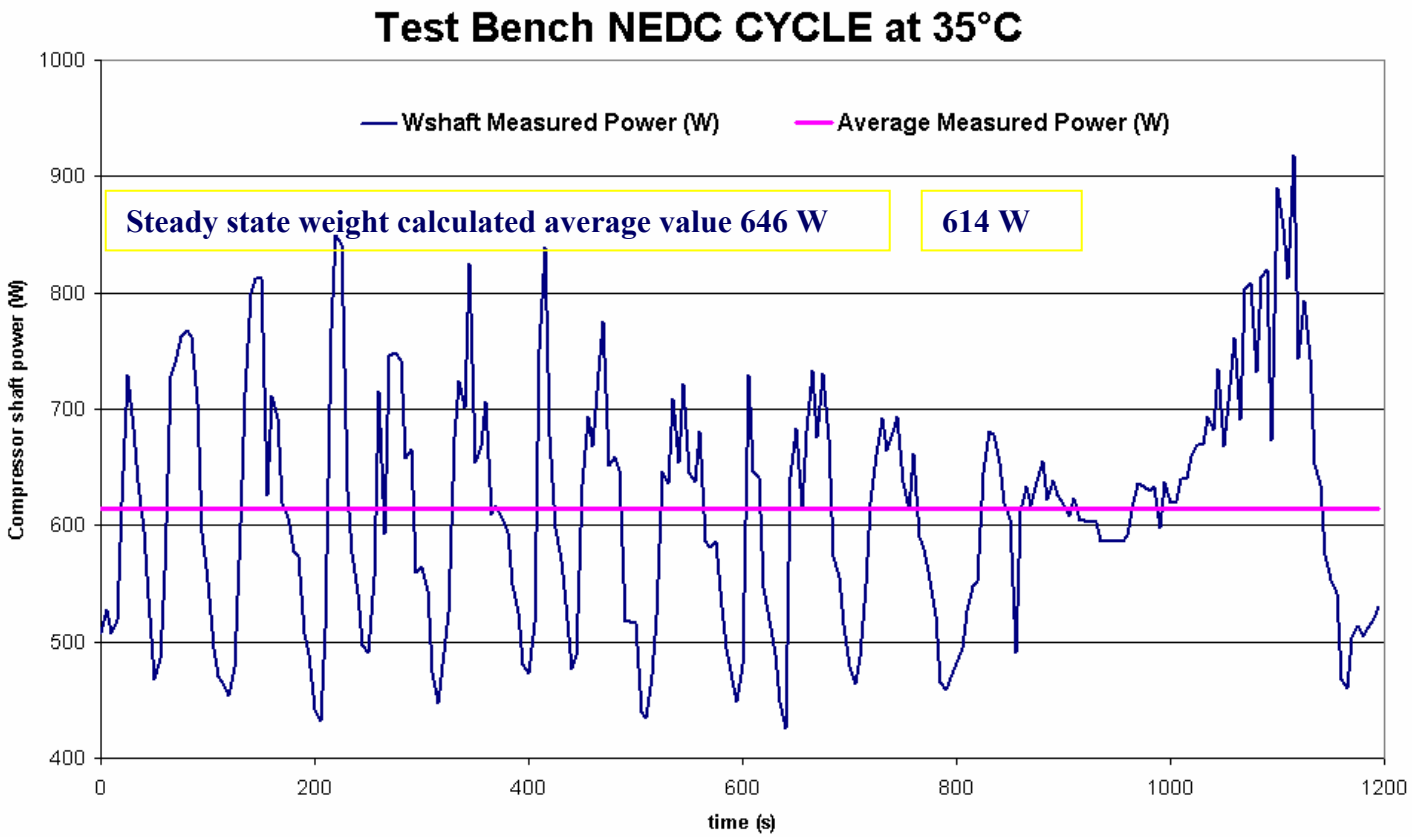
- Type of tests

Measures	IH35	MH35	HH35	IL35	ML35	HL35
Evaporator Air Mass flow (kg/h)	439	439	439	440	439	439
Evaporator Air inlet (°C)	25	25	25	25	25	25
Evaporator Air Inlet Humidity (%)	40	40	40	40	40	40
Condenser Air mass flow (kg/h)	1338	1967	3386	1299	1731	2833
Condenser Air inlet Temperature(°c)	35	35	35	45	35	35
Compressor Speed (rpm)	1000	2200	2971	999	1598	2498
Evaporator Outlet Air Temperature (°C)	12,7	12,6	12,4	10,4	12,3	12,8
134a Refrigerant mass flow (kg/h)	40,0	40,5	42,2	56,3	41,9	41,8
Compressor model shaft power (W)	632,0	741,2	897,7	828,7	637,2	796,5
Compressor suction pressure (bar)	3,8	3,8	3,8	3,7	3,9	3,9
Compressor discharge pressure(bar)	10,7	10,4	10,3	14,7	10,6	10,3
Compressor suction Temperature (°C)	15,9	16,0	15,8	13,2	14,1	14,7
Compressor discharge temperature(°C)	4,7	4,7	4,6	4,4	4,7	4,7



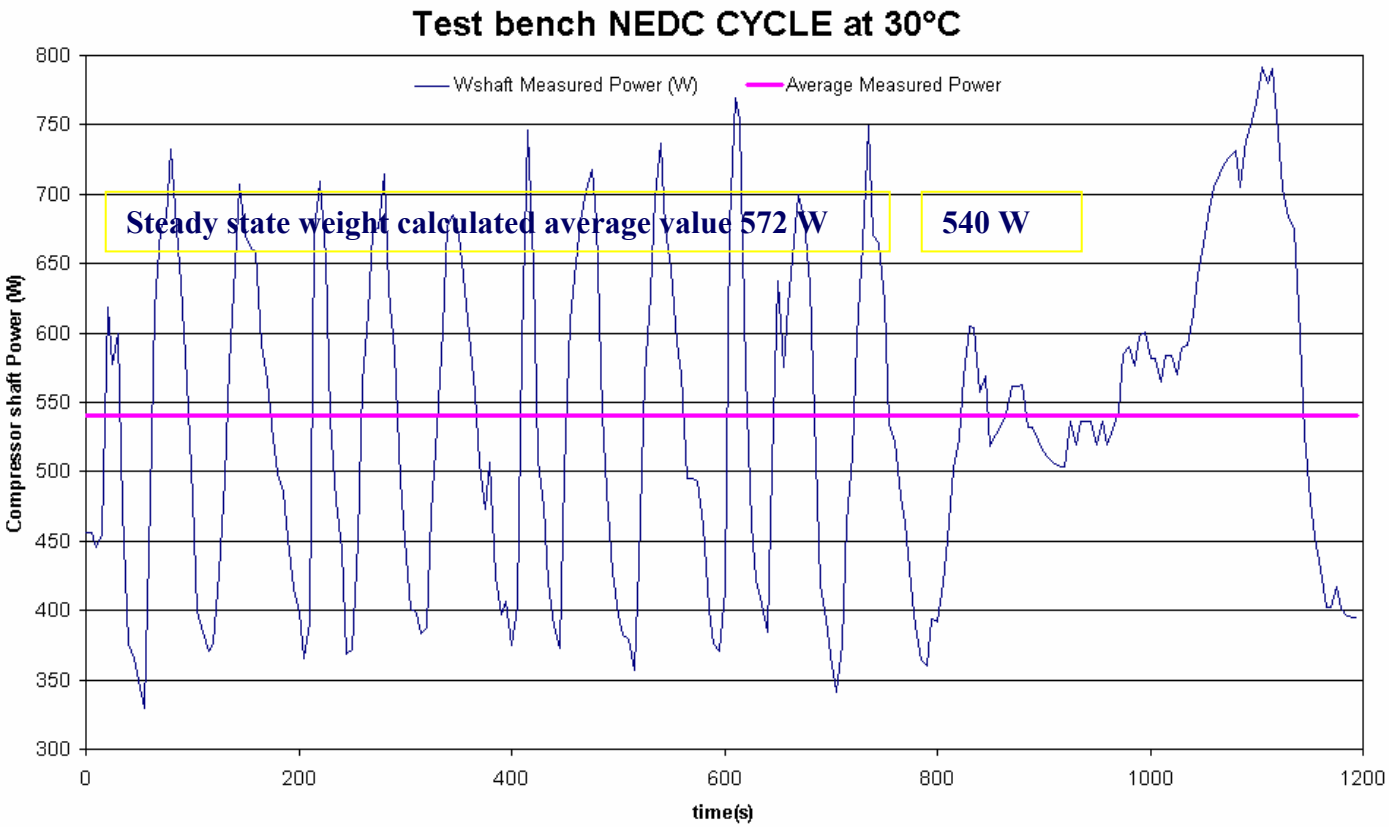
Test bench results

- NEDC cycle results at 35°C



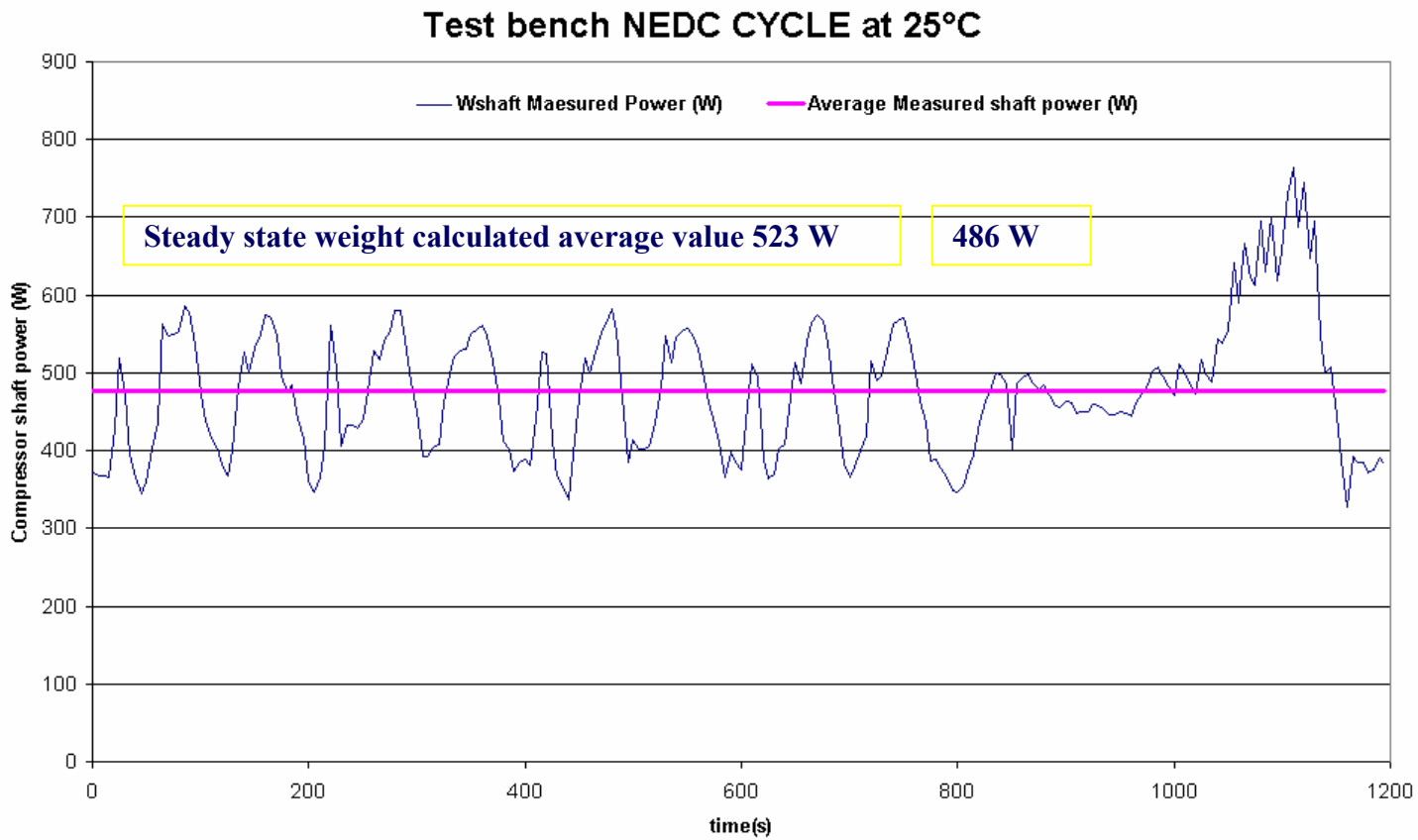
Test bench results

- NEDC cycle results at 30°C



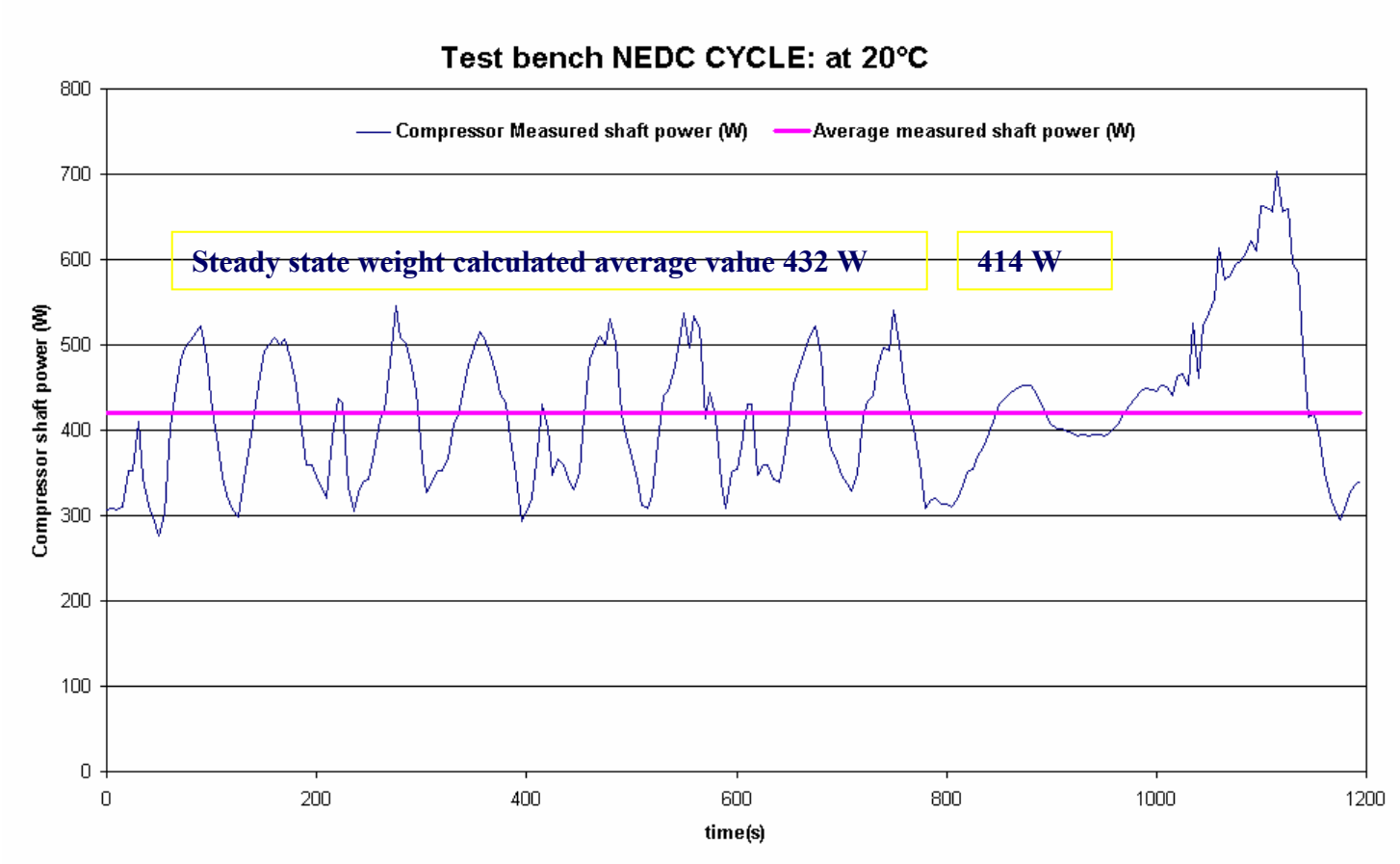
Test bench results

- NEDC cycle results at 25°C



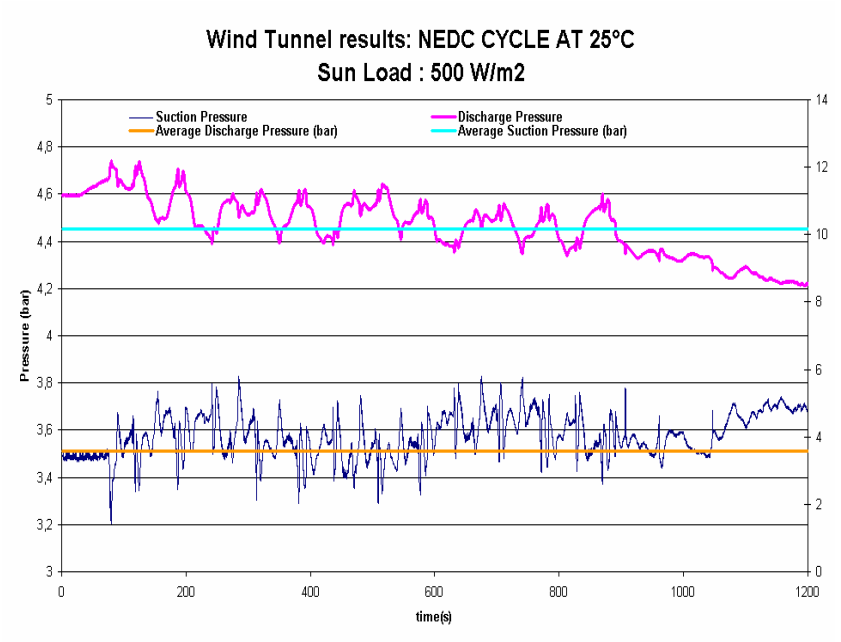
Test bench results

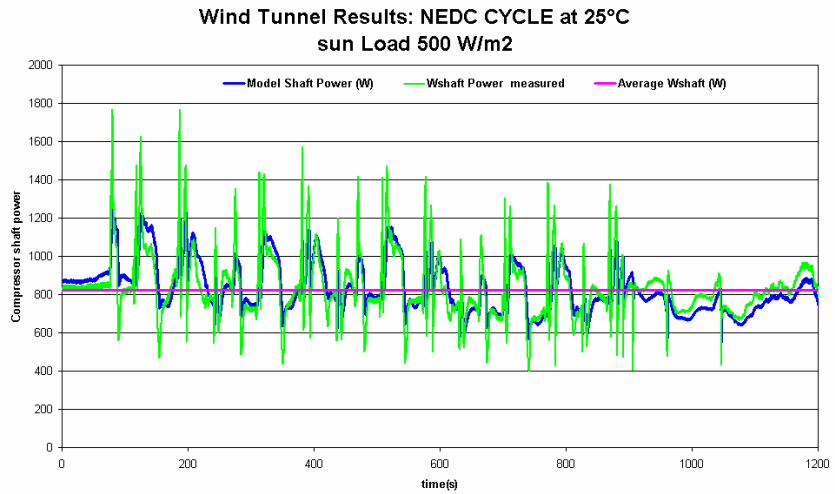
- NEDC cycle results at 20°C

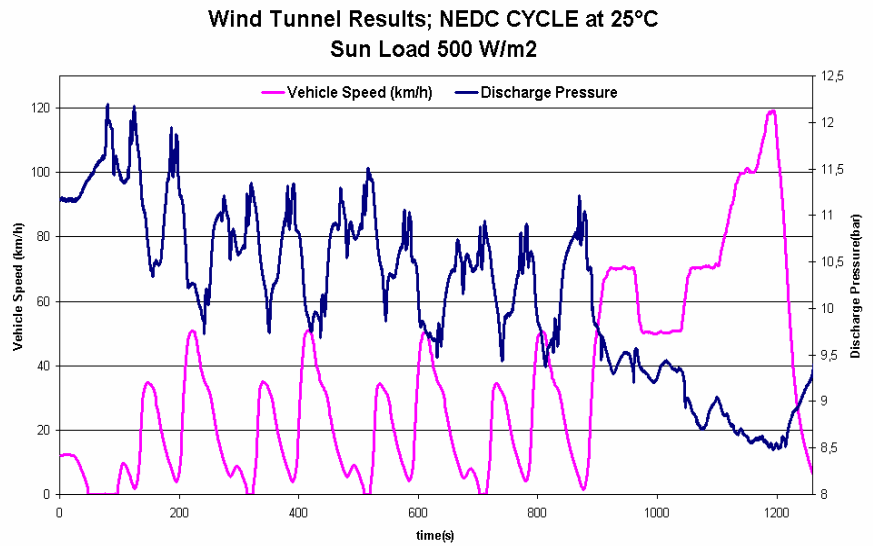


Climatic Wind Tunnel results

- Transient result

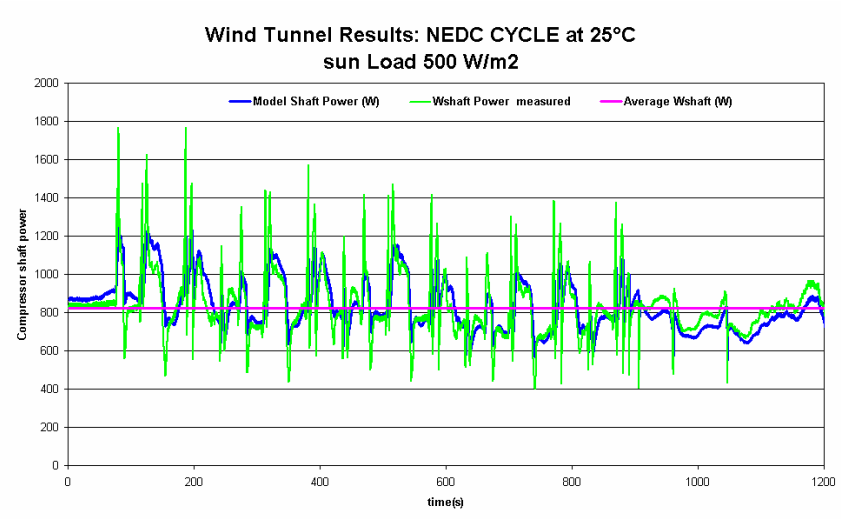


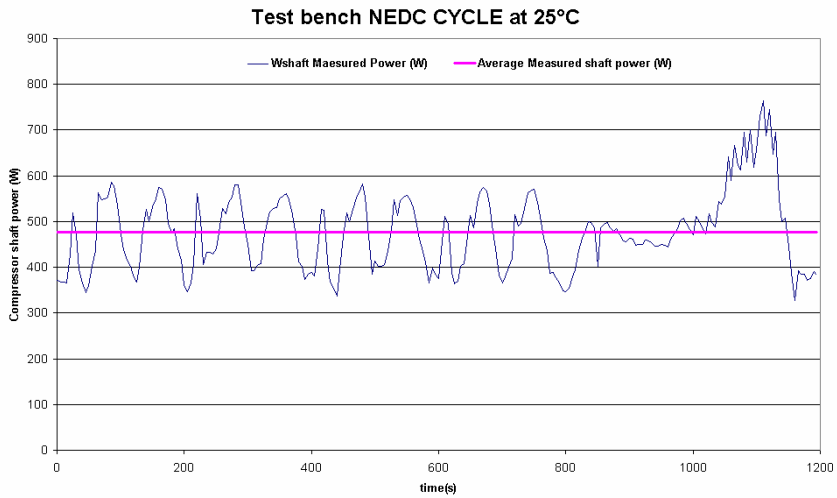


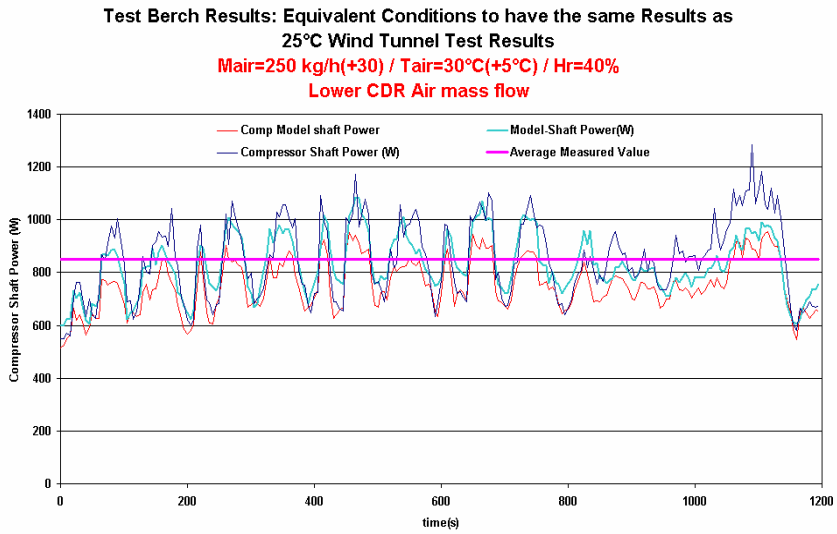


Results understanding

- Coherence between bench and CW Tunnel

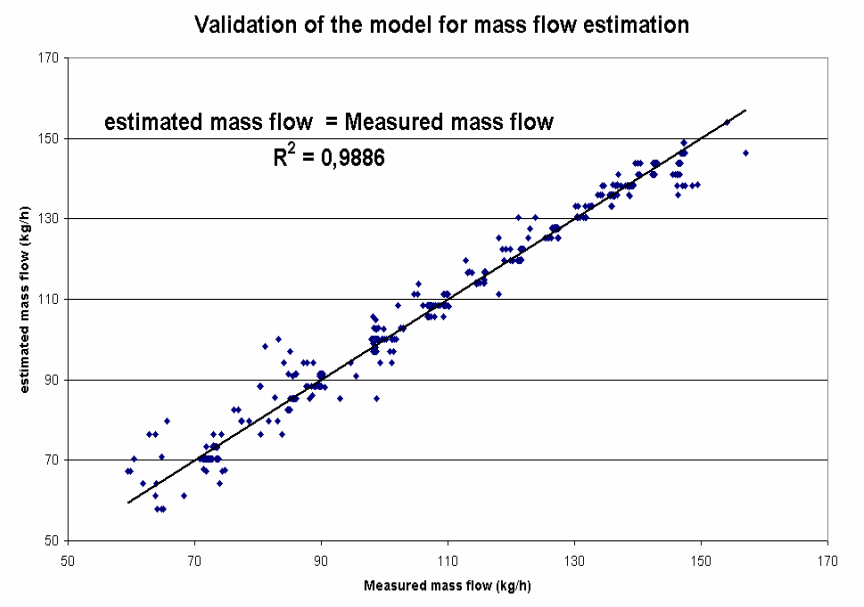


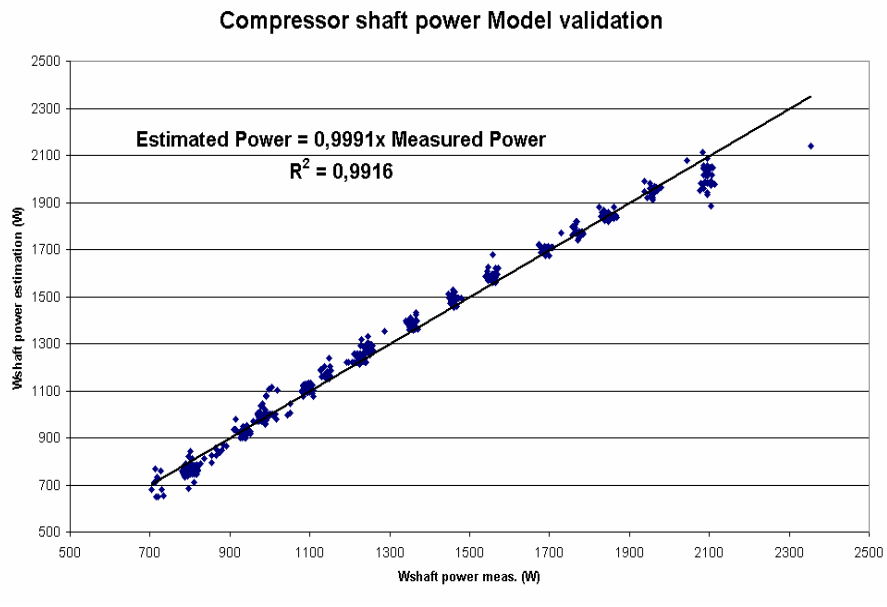




Model use to check data coherence

- Compressor & Refrigerant Mass flow Model





Models are used to:

- check coherence of data recording
- to have good analysis of dynamic situation

Conclusion

- If the A/C system is well controlled with short time response
  - no big effect of transient on energy consumption

- Behind energy consumption, fuel consumption remained strongly influenced by to engine type and management (including dialog with A/C system control)

Next steps

- Check on R134a systems based on summer test results
- Check on R744 systems with special attention to the system reactivity
- Find a criteria and reference tests to decide when the system is well controlled enough