Development Of Water-Cooled Exhaust Turbo Chargers

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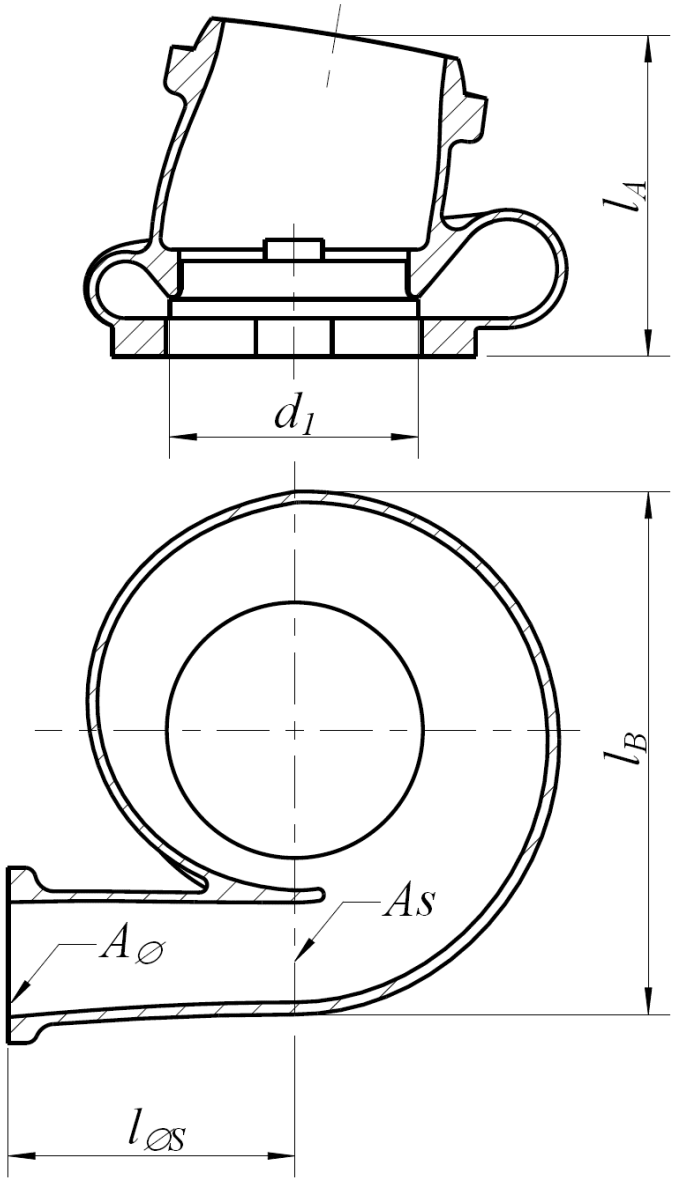
initial stat and goal

- initial stat
  - exhaust-gas turbocharger (TC) is balanced with the engine
  - the geometry of flow is well designed (diffuser, scroll, turbine wheel und bypass valve)
- goal
  - design of the water jacked
  - design the flow to prevent formation of vapor gas layers (Leidenfrost effect)

- initial model

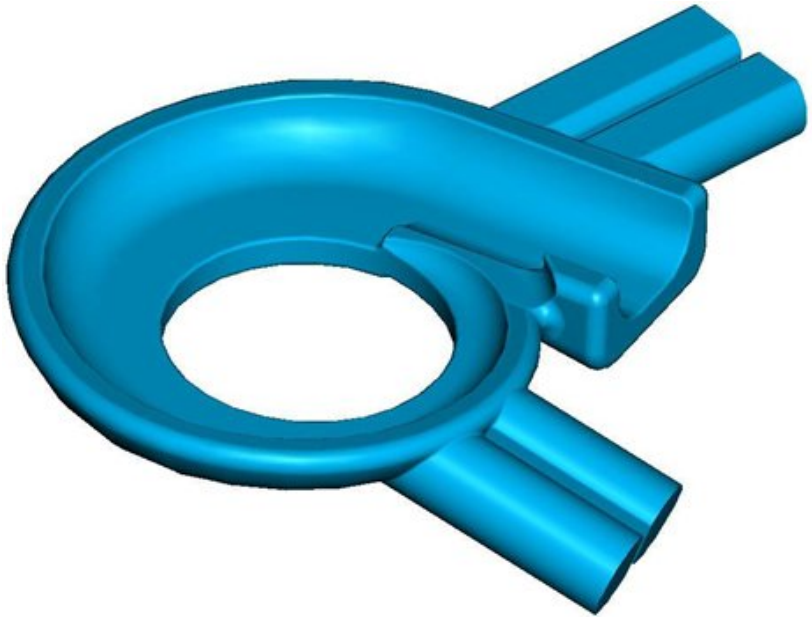
parameter	quantity
sectional area at diffuser intake ($A_{\varnothing}$)	1120 mm²
turbine wheel diameter (d_1)	65 mm
size of scroll housing (l_B)	140 mm
distance flange bearing case – flange exhaust gas outlet (l_A)	90 mm
sectional area at scroll intake (As)	934 mm²
length diffuser ($l_{\varnothing S}$)	75 mm

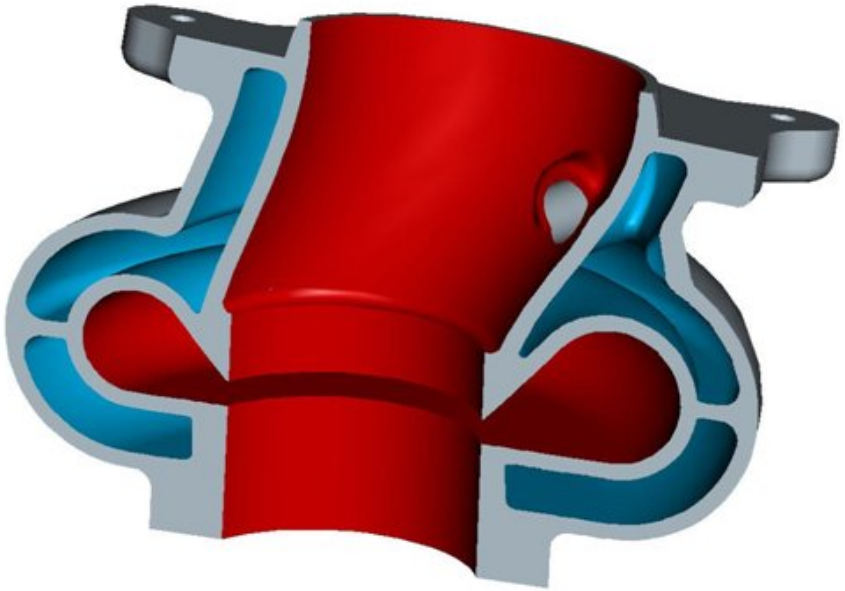
Table 1: dimensions of the turbine housing



two possibilities:

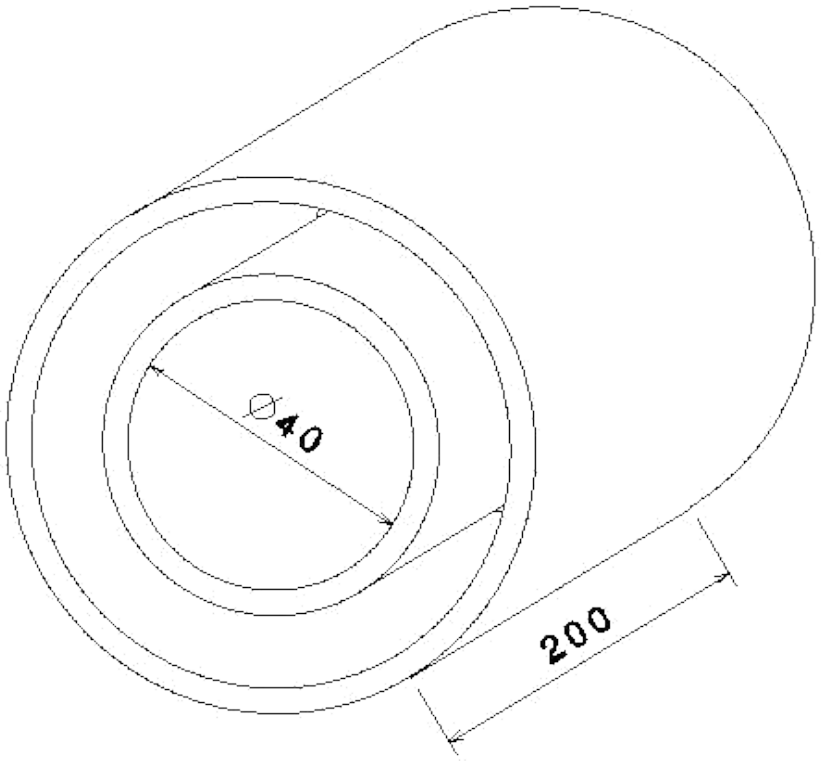
- The water jacket core has an opening large enough that the volute core passes through.
- The water jacket core is made of parts that the volute core can placed between the jacket core parts.





- same surface
- same volume
- same wall thickness
- same flow velocity

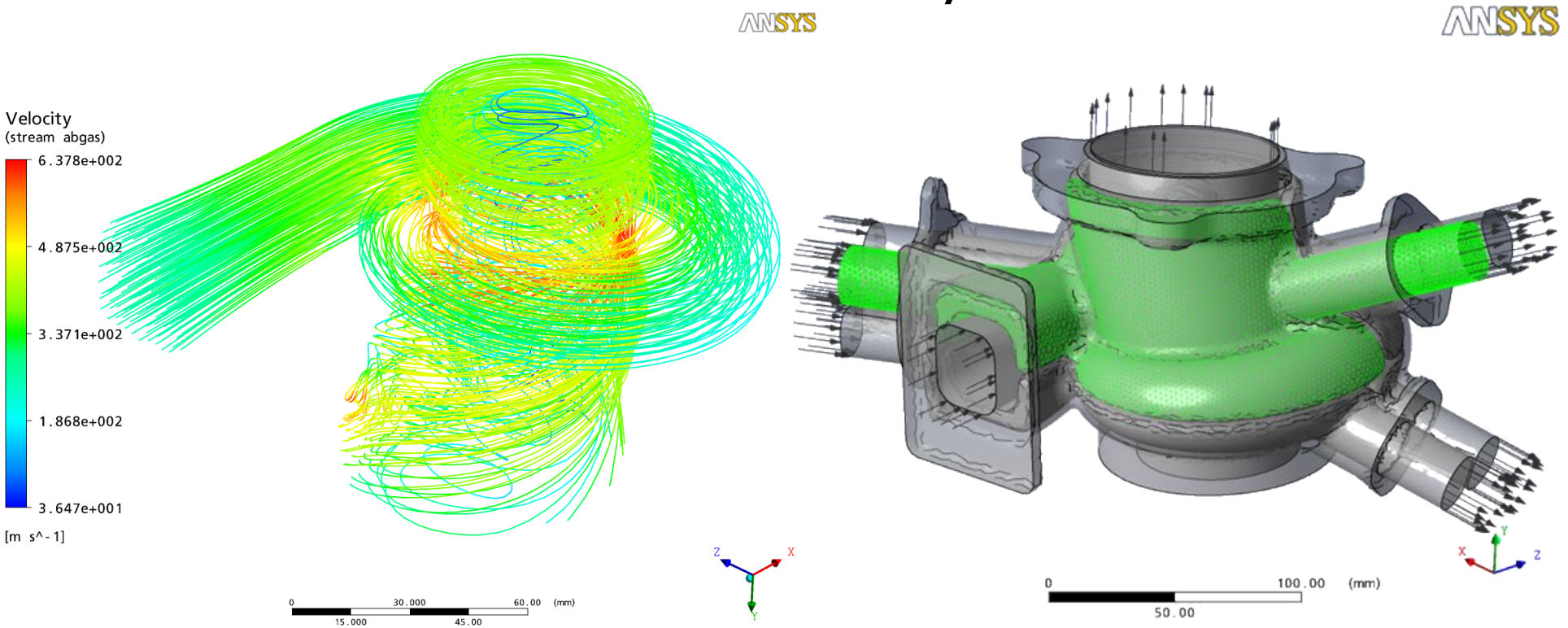
as 3D design



turbine housing wall temperature	exhaust site	coolant site
steel	167 °C	142 °C
aluminum	146 °C	143 °C

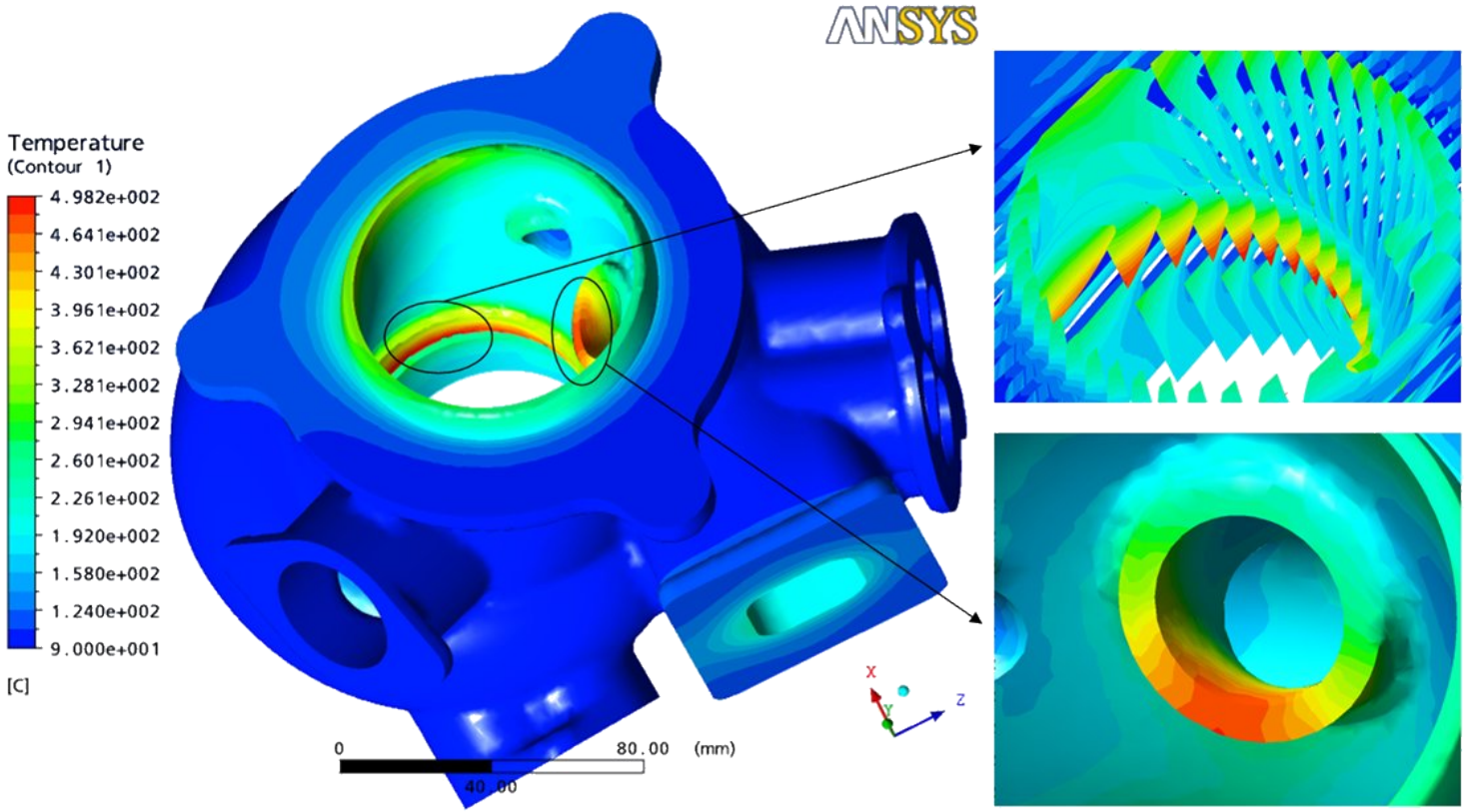
- character of fluid = f(temperature)
- temperature = f(flow)
- flow = f(character of fluid)

=> transient calculation necessary



optimization of the water jacket

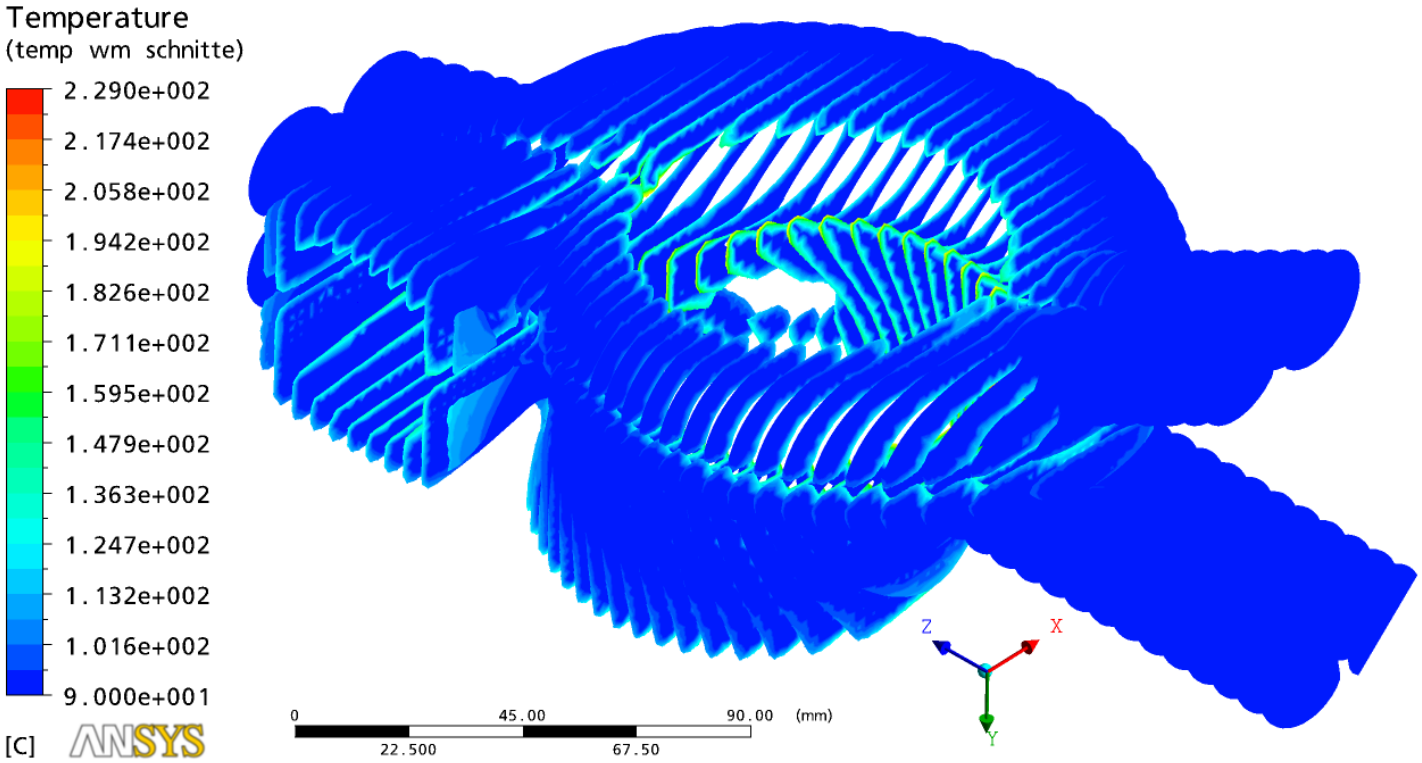
- first step: water jacket with uniform thickness



- hot spots
  - high exhaust gas flow velocity
  - double sided exposure by hot exhaust gas

optimization of the water jacket

- customize the thickness of the water jacket to uniformize the flow velocity
- eliminate all deepenings with low flow velocity
- direct the coolant flow round the bypass flap shaft to prevent turbulences



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comparison of turbine housings made of aluminum und ductile iron

- water cooled aluminum turbine housing
  - only slightly heavier than the common air cooled ductile iron turbine housing
  - essentially lower manufacturing costs compared to a water cooled ductile iron turbine housing

	air cooled TH	ductile iron TH	aluminum TH
part weight (incl. H_2O)	1,64 kg	6,368 kg	2,183 kg
max. part temperature	1040 °C	578 °C	320 °C
mean part temperature	1000 °C	250 °C	180 °C
water jacket surface temperature	-	150 °C	140 °C

summary and prospects

The importance of water-cooled exhaust turbo chargers will rapidly increase in the next few years. The reasons are:

- Turbo chargers are one of the key components for reducing fuel consumption.
- The water cooling enables considerable higher exhaust gas temperatures. Thus provides higher efficiency.
- The water cooling makes exhaust turbo chargers suitable in indoor premises, important for mini cogeneration units for family homes and apartment buildings and important for shipbuilding.

The paper presents the development of a water-cooled exhaust turbo chargers including thermal and CFD-simulation. The alternatives iron and aluminum turbo charger are compared.