Airflow measurement at Formula Student car

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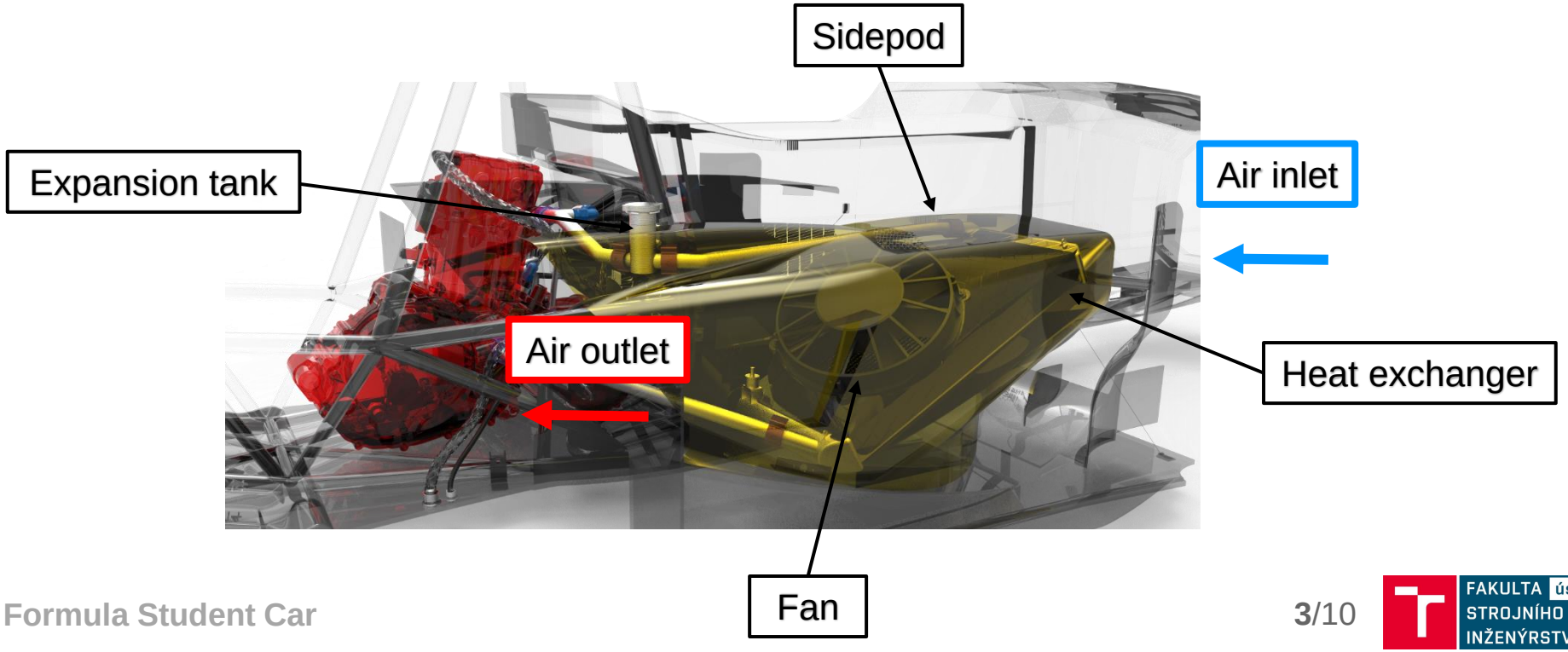
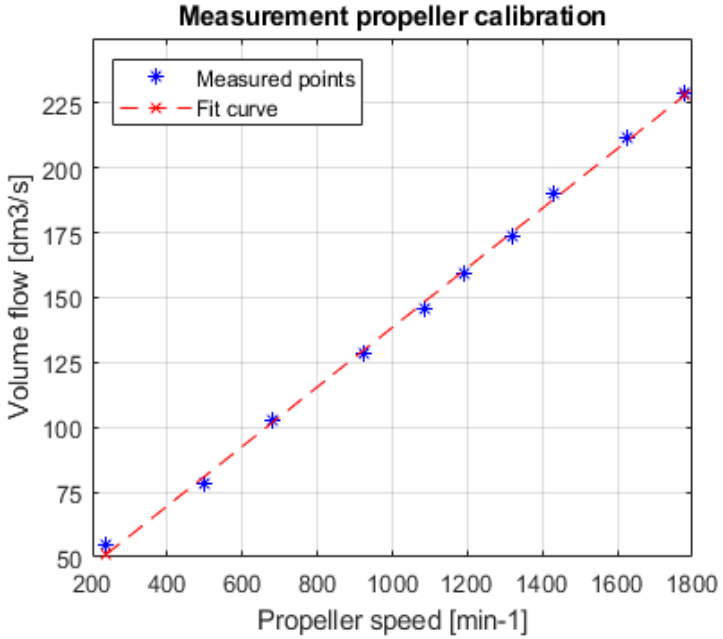
Problem overview and motivation

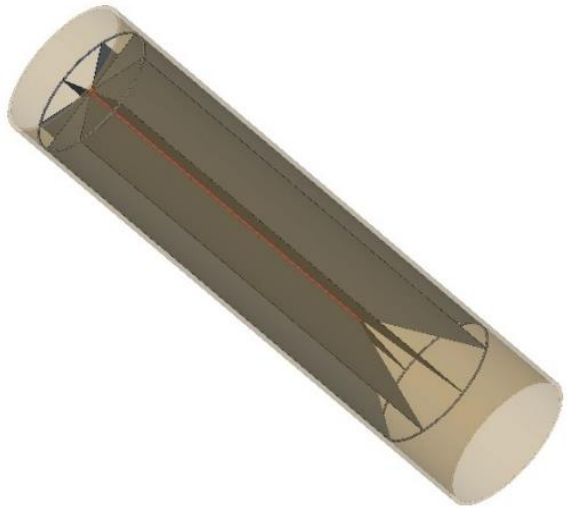
- Car overheated during endurance race in hot temperatures
- Engine durability and car performance has been compromised
- There is enough water flow thru heat exchanger (HX)
- Some strange phenomena must occur at cooling system
- Increasing cooling capacity help run engine with higher power thus reducing time at track



Methods

- Measurement propeller and flow straightener has been used
- Placed at fan outlet downstream of HX
- Calibration for propeller RPM to air flow has been measured
- Static pressure measurement at upstream and downstream of HX



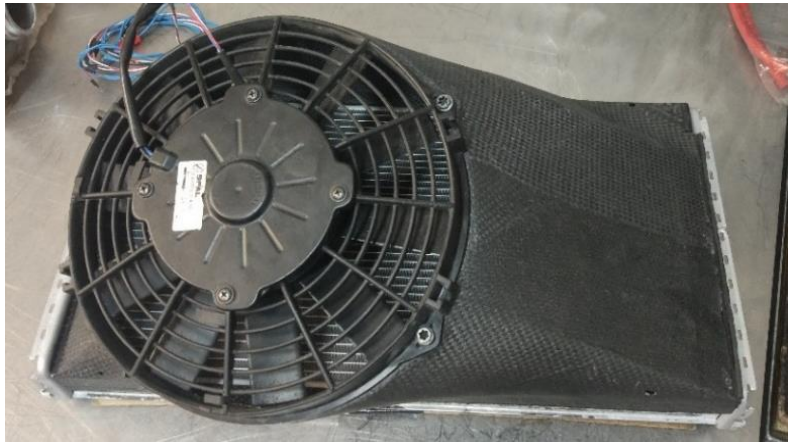


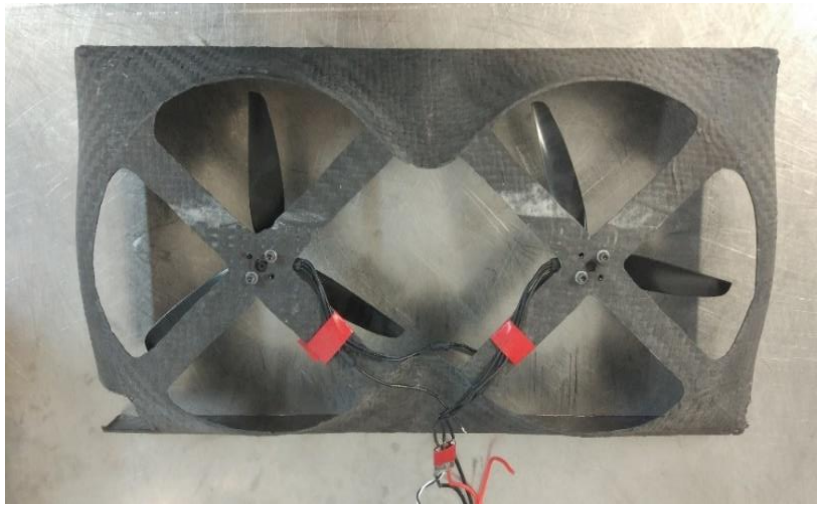
Methods

- Car has been placed in small wind tunnel without rolling floor or rotating wheels
- At fan outlet measuring section with propeller has been mounted
- Air speed was increased in 10 km/h increments from 20 km/h and zero speed was measured

Methods

- Two fans were used to compare different design of rotor and electrics engine
- One Spal fan with DC engine and thick blades were measured in ON and OFF state
- Two BLDC engines with aircraft blades were tested to compare with Spal fan
- Air guide upstream of HX channelled air from sidepod inlet onto HX
- Seal around HX forced air to travel only thru HX

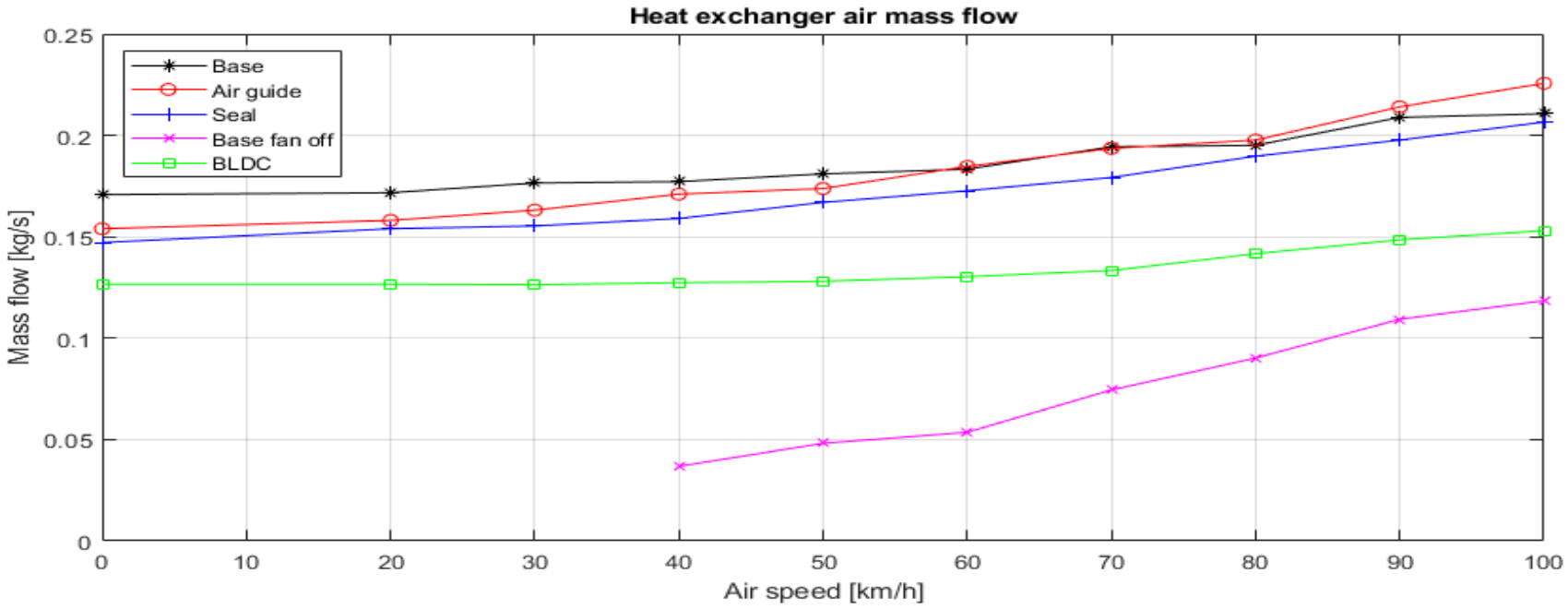




Case number	Fan	Heat exchanger surrounding
1	Spal ON	Base
2	Spal ON	Air guide upstream
3	Spal ON	Seal
4	Spal OFF	Base
5	BLDC	Air guide

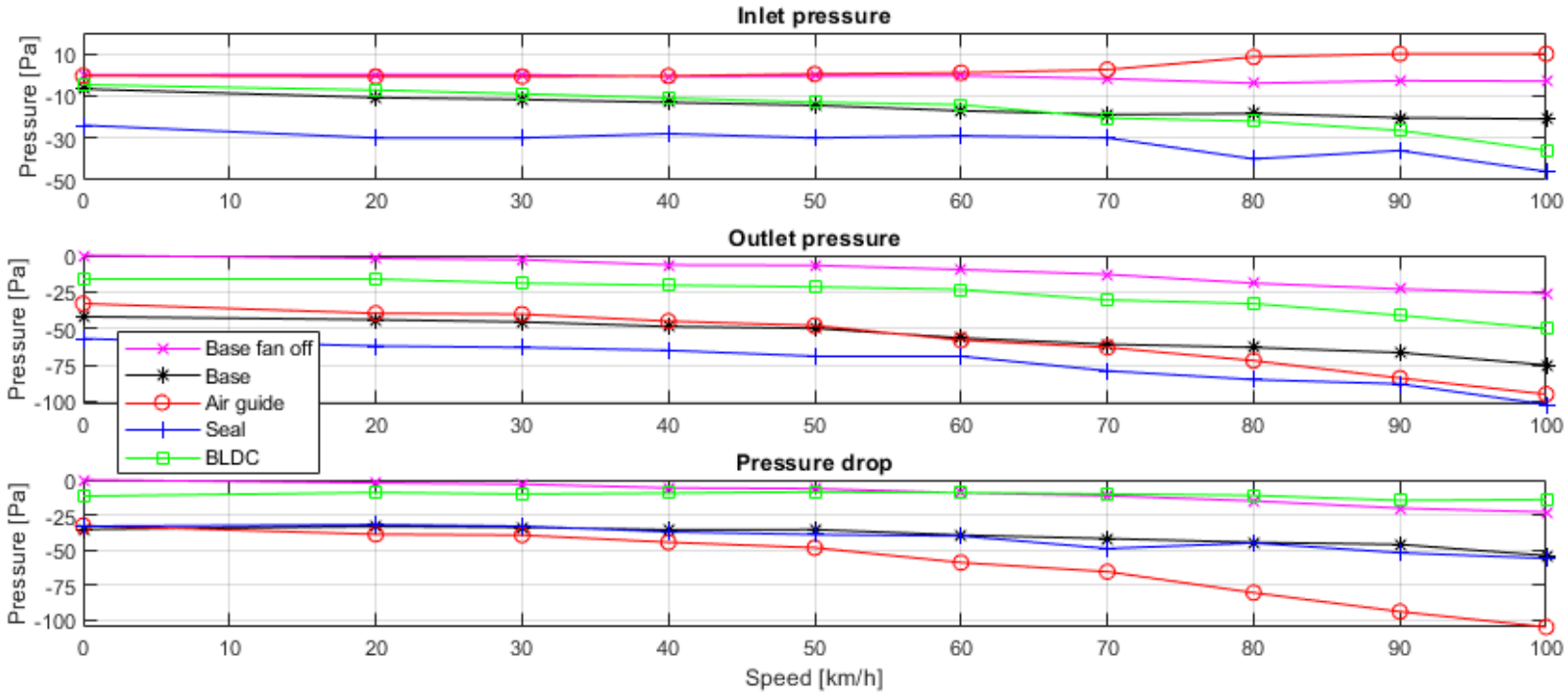
Results

- Base setup show highest air flow at lower and mid speed
- Seal case is constantly lower than base and air guide case
- Air guide gain only in high speed where utilized ram pressure from air speed against base setup
- BLDC fans are not able delivered enough mass flow against Spal fan
- Case with Spal OFF demonstrate how much fan contribute to whole speed range to air flow



Results

- Measured pressure show clear trend following mass flow measurement
- Air guide have highest pressure drop thru HX thus highest mass flow especially at high speed
- Seal case have lower inlet pressure due to allowing air passing only thru sidepod inlet and eliminating recirculation
- BLDC fans create only small under pressure at HX outlet and is not capable of pushing enough air as Spal fan



Conclusion

- From mass flow and pressure drop is possible to evaluate HX, fan and aerodynamics design
- Only integral values ale presented not flow distribution across HX
- Easy and fast measuring method, but demanding some space at fan outlet
- From measured values is clear that air guide is best suited for current car
- Air guide utilizing ram pressure and eliminates recirculation phenomena at air side thus increasing cooling capacity and increasing air flow at higher speeds
- Recirculation confirmed by other measurements at car while running by measuring inlet air temperature which was at low speed higher than ambient by 15 – 20 °C

Thank you for your attention

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