Powerpack Thermal Simulation & Cooling air Requirements

By Kolio Kojouharov, General Manager, termoflow.com

SYN TRAC Infinite Possibilities.

The SYN TRAC is a completely new vehicle for different application areas, developed by SYN TRAC GmbH in Austria. The SYN TRAC is a more advanced and flexible vehicle than the market has been offered before. Its innovative coupling method allows for an automatic connection for hydraulics, pneumatics, electronics/CAN-bus, ground speed power take-off (PTO) and general operating concepts without leaving the vehicle.

The combination of the vehicle and the attachments form optimal synergies. The SYN TRAC engineers created a perfect working machine. They realized a wide range of possible configurations and flexible applications, for agriculture, transport infrastructure, municipal services, forestry, and special applications such as disaster control. Due to the automation of the coupling process, the operator does not have to enter the 'danger zone', they can remain in the vehicle cab, and so simultaneously save considerable time.

Being a completely new product, there were high expectations in terms of reliability, robustness for agricultural demands, costs and series-production readiness, being comparable to series automotive demands. This required enormous efforts from all participating disciplines. For this reason, the SYN TRAC engineers had to employ significant amount of digital prototyping and simulation from the very beginning. One major issue is the thermal management of the powerpack/powertrain and the heat balance of the engine compartment. Cooling airflow, fan performance and an appropriate cooler integration are strongly influenced by complex geometries and decreased available design space. The consideration of all these factors is crucial for the correct determination of the volume flow dependent pressure drop in the engine

> "With FloEFD, we were able to fulfill the challenge of short schedule and supported the high degree of digital prototyping."
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> **Kolio Kojouharov, General Manager, termoflow.com**

compartment (system impedance) and thus for the selection of a suitable fan. In this respect the team of SYN TRAC worked with Kolio Kojouharov from Termoflow.com, an experienced consultancy in powerpack/powertrain thermal management and state of the art CAE computational methods. Termoflow.com introduced CFD into the design process and worked on a simulation program in tight accordance with the SYN TRAC design team. In the course of this, a heat balance study and simulation of the cooling air of the engine bay for the two operating conditions at 0 km/h and 10 km/h ambient velocity were conducted to identify improvements.

The vehicle standstill condition (0 km/h) is always one of the most critical for thermal management because no ambient air for cooling is moved. Vehicle standstill and low speeds, with simultaneous full thermal load, are crucial for these areas of application (agricultural activities on fields, working at trees, municipal services on roads). In addition, due to the dusty air in the application areas, overpressure should be present in important engine regions and short circuits in the air flow distribution should be avoided wherever possible.

The following factors were identified:
- Velocity distribution of the cooling air in the machine;
- Pressure distribution of the cooling air in the machine;
- Temperature distribution of the cooling air in the machine;
- Pressure losses. Cooling air pressure drop vs. volume flow rate
- Cooling air inlet temperature; and
- Velocity distribution at cooler outlet.

Being aware of the challenge of dealing with a highly complex geometry within a short schedule, Termoflow.com used FloEFD™ with its efficient mesh generation capabilities and broad range of physical models, alongside their valuable experience with the tool in other projects.

One of the key benefits was the prediction of the system impedance, which helped find the optimal design point of the cooling system (Figure 1). Because of the dusty operating environment, the engine bay has to be capsuled as much as possible, though it needs to provide the required airflow for appropriate cooling across the entire engine operating range.

The CFD simulation was conducted for an ambient temperature of 45°C, the temperatures of the motor etc. were defined as boundary conditions.

One of the main tasks was the design of the coolers for charge air, cooling water and oil with a cooling capacity between 30 and 120 kW.

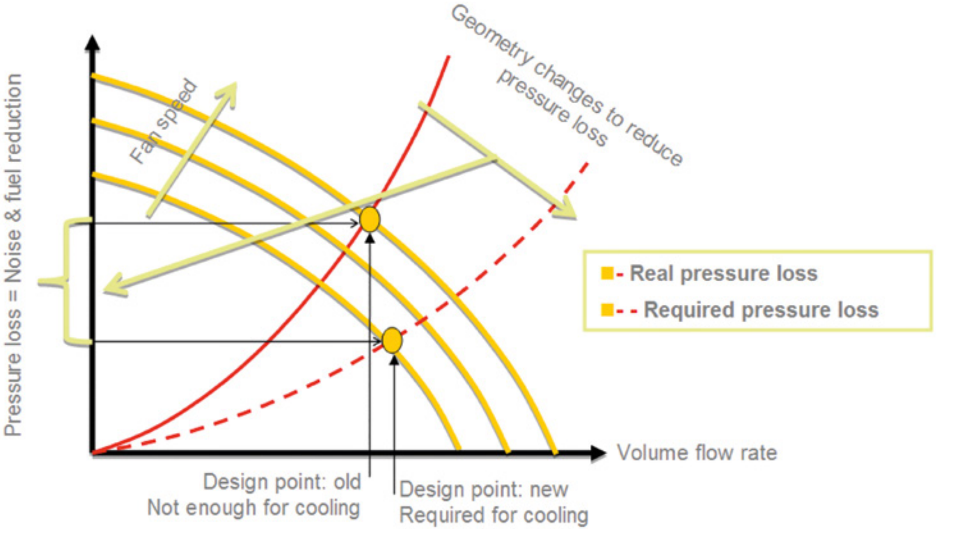

Figure 1. Cooling air vs. pressure loss

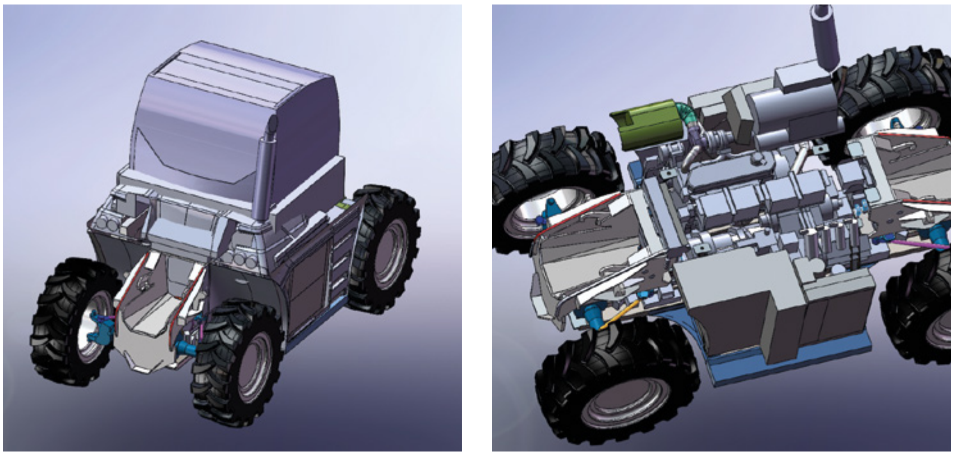

Figure 2a, b. CAD model of the SYN TRAC

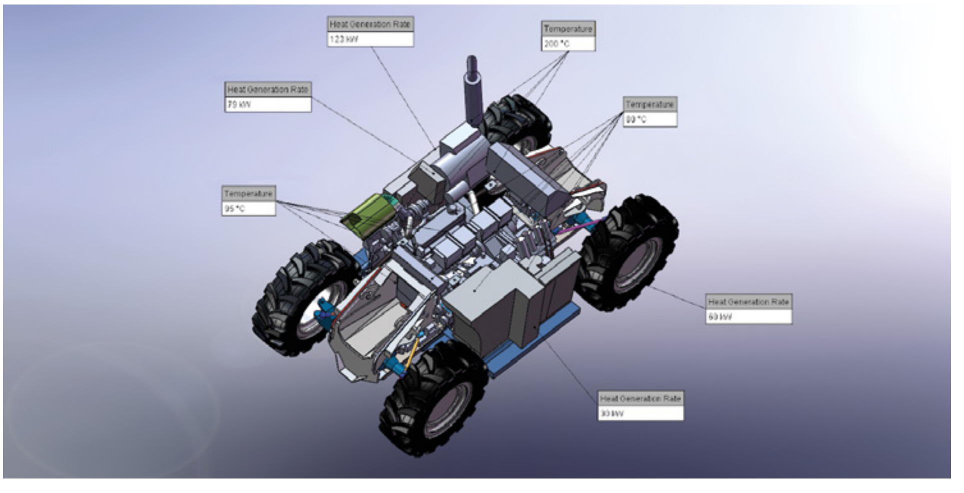

Figure 2. Boundary conditions

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The air intake and exhaust should be as free as possible. For reliable operation, it is very important to avoid an intake of air that is much hotter than the ambient air.

The engineers compared a large number of result output images and investigated the flow distributions and temperature fields, based on the two operating stages simulated in FloEFD.

In Figure 3, the flow field at the back view is shown for the ambient velocity of 10 km/h. When the vehicle comes to a standstill, the air is only moved by the fans. The different flow profile to the moving vehicle is clearly visible in the image.

With these findings, the pressure resistance curves (cooling air pressure drop depending on volume flow rate) for several operating conditions were generated. Based on this, the design specifications for the fans could be determined also taking into account the installation conditions and space requirements. Another aspect that the engineers considered at an early stage, was the drive power for the fans, which also influences the overall vehicle efficiency.

The SYN TRAC engineers in collaboration with Termoflow.com gained a deep understanding of the flow distribution and the temperature fields, even for areas that are not visible without simulations, and realized the unique SYN TRAC.

References

[1] https://www.syn-trac.at/

[2] https://www.termoflow.com/

[3] https://www.youtube.com/watch?v=NdxjbVBHcWU

[4] https://www.youtube.com/watch?v=YHtlb-X37dQ

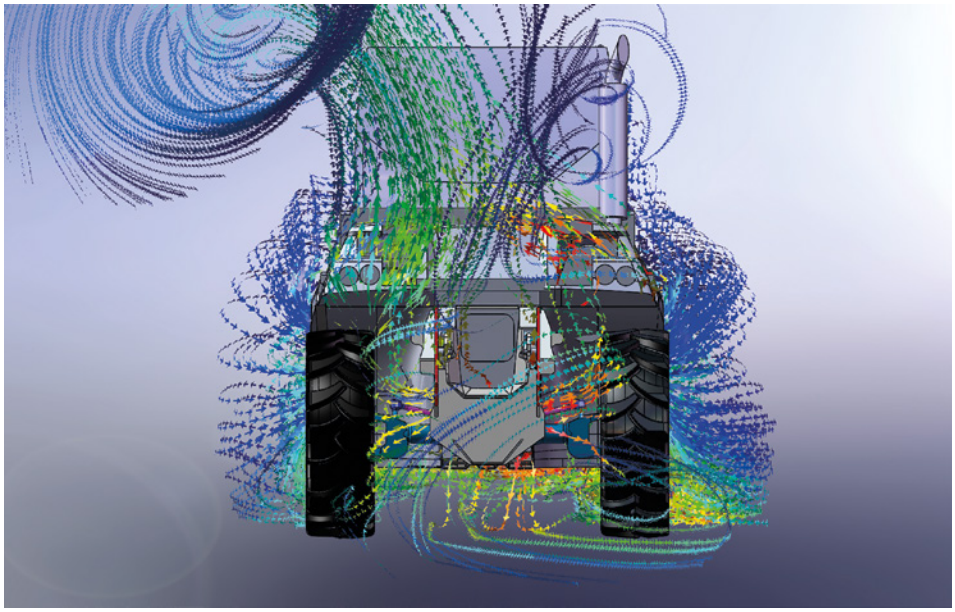

Figure 3. Flow field at the back view

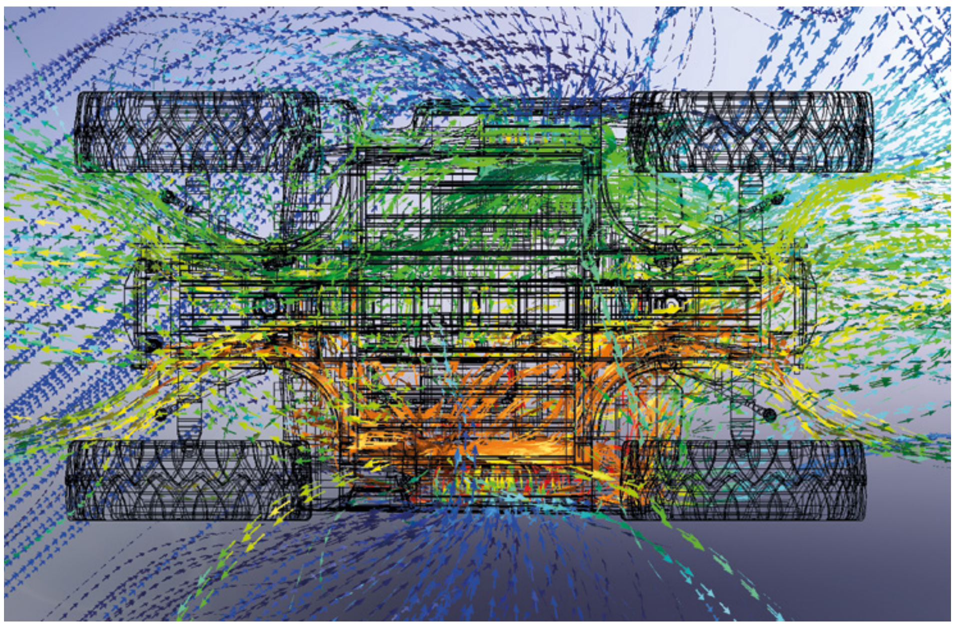

Figure 4. Cooling airflows into the undercarriage

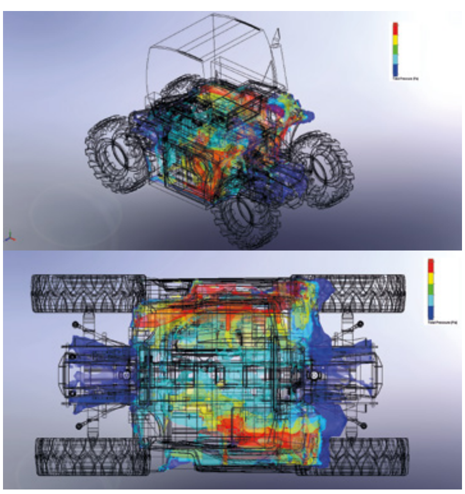

Figure 5 a, b. Analysis of the overpressure areas

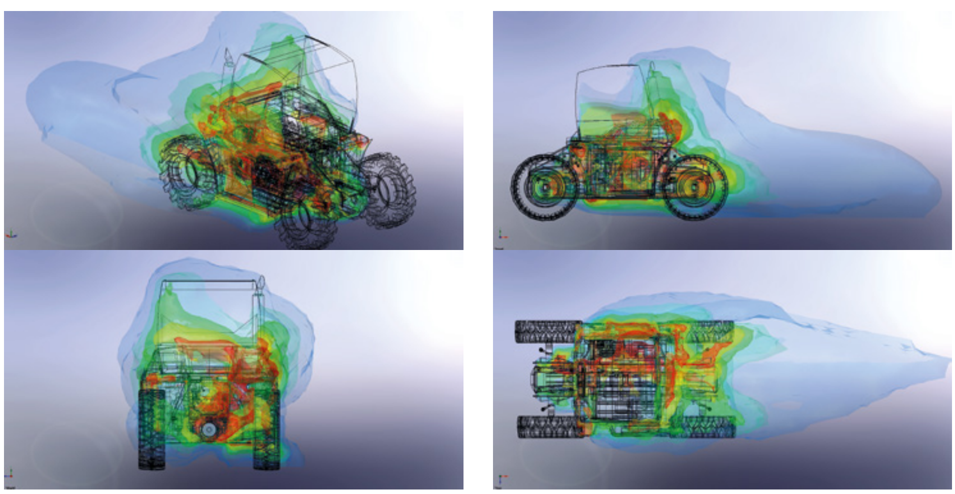

Figure 6 a - d. Analysis of the temperature distribution

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