**Case Description:** This Benchmark corresponds to a performance analysis of the cooling system proposed by the client for the air intake cover of a car.

The following image shows the geometry and the injection system modeled and analyzed.

![Fig. 1 - Geometry of the piece and the injection system](image)

The injection system consists on a hot runner (in red) followed by a cold channel (in green).

After the optimization work, variations in dimensions of the piece after the injection process and its warpage will be verified to check the dimensional specified tolerances.
Development: Below is shown the finite element model for the original cooling system proposed by the client.

![Finite Element Model](image)

*Fig. 2 – Finite Element Model*

The blue arrows show the cooling inlets, water @ 25°C.
The results of the injection and thermal analysis carried out were the followings:

Fig. 3 – Temperature on the mold surface / ORIGINAL COOLING
Depending on the large temperature difference that could be seen in Fig. 3 between the upper and lower surfaces of the mold, above 30 °C, it was decided to perform an optimization of the original cooling system. The modifications were made in the bottom of the piece, in the male part of the mold, where was modeled a cooling system with baffles to increase the performance in that zone.
The results obtained with the new proposed cooling system were:

![Image of temperature distribution](image)

- $70.6^\circ C$
- $53.2^\circ C$
- $57.6^\circ C$
- $61.9^\circ C$
- $66.3^\circ C$
- $75^\circ C$
- $57.6^\circ C$
- $48.9^\circ C$

**Fig. 5 – New temperature distribution / COOLING SYSTEM PROPOSED**
It can be seen a significant improvement, bringing the temperature difference between the upper and lower surfaces at least 7°C in 96% of the surface of the piece, giving less distortion and residual stresses on completion of the process.

Finally, critical dimensions were measured in order to verify that the part meets the specifications in their design. Fig. 6 shows the starting point and the measurement direction of ovalization of the air inlet.

![Fig. 6 – Starting point and direction of the ovalization measurement](image)

The Fig. 7 shows the obtained results.
With the new cooling scheme the inlet ovalization presented significant improvements. Fig. 9 shows that the deformation of the lower seal of the part has the same tendency to deform, but in Fig. 11 can be seen that the amount of deformation is different, being lower in the cooling system proposed.
The new cooling system also improved the total deformation of the piece. Was measured the total displacement of the bottom edge, Fig. 10 shows the origin and direction of the measurement and Fig. 11 the results obtained.
Improvements of the new cooling system can be observed in the figure above. The new total deformation of the lower edge of the workpiece was improved by up to 0.2 mm, allowing a better quality seal with the remaining element of the assembly.
**Conclusions:** The original cooling system was analyzed noticing a deficiency in the heat extraction in the male side of the mold, which caused excessive distortion of the part due to uneven cooling of the surfaces of the mold.

Therefore a new design of the cooling system of the male side of the matrix was proposed, suggesting a baffles system to achieve more efficiency in the heat removal from the male side of the mold.

The results were:

- A difference less than 7°C between upper and lower surfaces of the piece was obtained.

- Controlled ovalization and improved air inlet diameter, allowing a higher quality seal with the air intake system.

- Less deformation of the lower seal, also achieving a superior seal with the remaining piece of the assembly.

- Cycle time reduction of 7 seconds, 14% of the original cycle time.

*Once again is demonstrated the power optimization of simulation methods applied allowing mold and process improvement, increasing productivity and improving the quality of products produced.*