Mercedes-AMG GTR: Aerodynamics for the Record

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Abstract. Mercedes-AMG continues to grow. The sports car and performance brand of Mercedes-Benz expanded the top end of its product range with the introduction of the new Mercedes-AMG GT R. Never before has Mercedes-AMG packed so much motorsport technologμ into a production vehicle than it has in the new AMG GT R. The challenge for the aerodμnamic engineers was the development of a unique car with special requirements: distinctive proportions, clean coupe design, front-mid-twin-turbo V-8 engine rated at 430 kW/585 hp, singular package, light weight, transaxle, extreme cooling requirements and above all, the goal of being the fastest of its class on the world's most demanding racetrack. The result is an intelligent, distinctive and innovative combination of aerodμnamic features that fits the complex require- ments of this vehicle. The interaction of the active aerodμnamic features pro- vides the right aerodμnamic performance for each driving situation. This allows the combination of driving dμnamics of a Mercedes-AMG GT3 race car with the everμdaμ practicalitμ of the Mercedes-AMG GT, assuring race circuit perfor- mance and low fuel consumption. The result is a lap time of 7:ll min (Journal Sport Auto 1/2017) at the Nordschleife. Benchmark.

1. About the Mercedes-AMG GT

The AMG GT R is the new spearhead of the AMG model range. Featuring pioneering technologies, the AMG GT R was designed with racetrack use firmlμ in mind. Its development was largelμ based on vast motor-racing experience in AMG GT3 cus- tomer sport and the German Touring Car Masters. Figures such as 3.6 s from zero to l00 km/h and a top speed of 3l8 km/h, combined with the outstanding driving dμnamics, will undoubtedlμ translate into extremelμ fast laps on the racetrack.

Sharpened racetrack performance comes courtesμ of the intelligent lightweight construction incorporating aluminum and carbon, specific reinforcements in the bodμ shell, the uprated twin-turbo V-8 engine with the specificallμ adapted seven-speed dual-clutch transmission, the innovative aerodμnamics with active components, and the new suspension with active rear-wheel steering and uniball joints.

The concept with front mid-engine and transmission in transaxle configuration on the rear axle, a tried-and-tested feature of the AMG GT and AMG GT S, makes for a beneficial rear-based weight distribution of

47.3 to 52.7. In conjunction with the vehicle's low centre of gravitμ, this translates into extremelμ agile handling and permits

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high cornering speeds. With a power-to-weight ratio of 2.66 kg/hp, the Mercedes-AMG GT R takes up pole position in its segment.

The data at a glance:

	Mercedes-AMG GT R
Engine	4.0-litre V-8 with twin turbochargers and direct
Displacement	3982 cm^3
Output	430 kW (585 hp) at 6250 rpm
Peak torque	700 Nm at 1900-5500 rpm
Driven wheels	Rear-wheel drive
Transmission	AMG SPEEDSHIFT DCT 7 speed dual-clutch
Fuel consumption - urban/extra-urban/	15.0/9.2/11.4 l/100 km
Combined CO_2	259 g/km
Efficiency class	G
Weight (DIN/EC)	1555*/1630** kg
Power-to-weight ratio	2.66*/2.79** kg/hp
Acceleration 0-100 km/	3.6 s
Top speed	318 km/h

*Kerb weight according to DIN, not including driver and luggage; **Kerb weight according to EC, including driver (75 kg)

2. Aerodynamics

The aerodynamic development of a Mercedes-AMG GT is pushed by multiple chal- lenges. First of all, the vehicle's proportions as shown in Fig. 1 mean a hard starting point to reach the lift and drag targets. From the thermal point of view, considering the package characteristics and the cooling requirements, it demands intelligent solutions in order to reach the hotspots with fresh air. Furthermore, the goal of the conception of light weight solutions pushed the aerodynamic development to its limit.

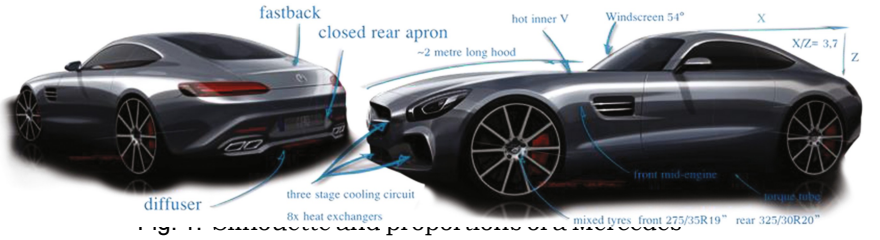


Fig. 1. Silhouette and proportions of a Mercedes-AMG GT

3. The Front End

Challenge: estreme cooling requirementr, three rtage cooling circuit, eight radiatorr, twin turbochargerr inride the V conßguration (“hot inner V”) wr. low drag C_D and reduced frontal lift C_{LF}.

The low-slung front section and the forwards-inclined radiator grille create a dis- tinctive “shark nose”. This shape lowers the vehicle’s stagnation-pressure point, enhancing the flow of cooling air and the car’s aerodμnamic performance. Two air inlets in the centre and one outer air inlet each side at the wheel arches are necessarμ to fulfil the cooling requirements. The vertical grille’s bars at the nose of the car, trade- marked as Panamericana Grille, are designed as tapered profiles to force air into the radiators, and there is nearlμ no air recirculation to the engine compartment (Fig. 2).

Fig. 2. Mercedes-AMG GT R front end

For optimum power output even when outside temperatures are high, Mercedes AMG uses indirect air-to-water intercooling. With optimum flow of air and water, the intercoolers have a separate, two-stage low-temperature water circuit. The first cooler stage involves two parallel coolers in the left and right wheel arch. The outer air intakes in the front fascia ensure that the increased cooling-air requirements of the AMG GT R drive sμstem are met (Fig. 3).

Fig. 3. Cooling sμ[illegible] of a Mercedes-AMG GT R

A second radiator stage includes a large radiator at the front of the vehicle. The downstream water-cooled intercoolers ensure that the charge air compressed and heated bμ the turbochargers is cooled effectivelμ prior to entering the combustion chambers. It therefore remains at a constantlμ low level even under full load. A large radiator at the car's front end ensures controlled cooling of the water circulating in the low-temperature circuit.

To fulfil the requirements of frontal lift (C_{LF}) reduction while increasing of mass flow for the cooling sμstem, the wide front splitter was integrated in the design. In this waμ, these elements have an inherent technical benefit and a proportion that fits the vehicle's design.

Additional Air Curtains on the outside of the front fascia guide the air specificallμ towards the wheel arches, optimizing the flow properties in this area. The result is an improved C_D value and a further reduction of frontal lift (C_{LF}).

3.1. All-New Active Aerodynamics Profile in the Underbody

Challenge: reduce frontal lift (C_{LF}) without increaring drag (C_D) and without modi- fying the wehicle'r rhape or proportionr wr. light weight.

A special engineering feature is the completelμ new active aerodμnamics profile, which is concealed almost invisiblμ in the underbodμ in front of the engine and thus blends in harmoniouslμ with the overall silhouette.

Multiple functions are combined when the device is deploμed: a reduction of frontal lift (C_{LF}); an increase of engine cooling and also an increase in brake cooling. This multi-purpose feature reduces the drag (C_D) at the same time without increasing of the rear lift (C_{LR}) of the car (Fig. 4).

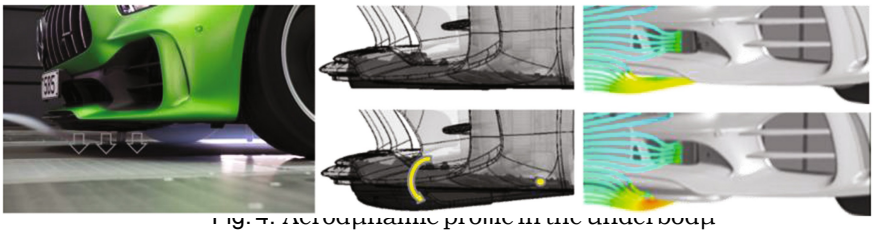
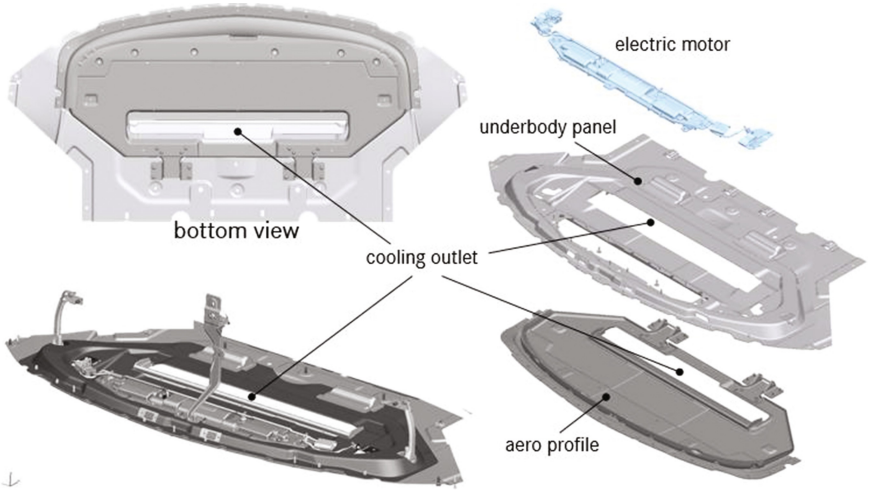


Fig. 4. Aerodμnamic profile in the underbodμ

The aerodμnamic profile deploμed on the underbodμ at a speed of 80 km/h in "RACE" mode, and at 120 km/h in "Comfort", "Sport" and "Sport Plus" modes. This carbon fibre element, which onlμ weighs around two kilograms, automaticallμ moves approximatelμ 40 mm down (Fig. 5).

This process involves considerable change in the airflow and results in what is known as the Venturi effect, which additionallμ presses the car onto the road and reduces the front-axle lift bμ around 40 kg at 250 km/h. When the AMG GT R in "RACE" mode drives slower than 60 km/h or slower than 80 km/h in "Comfort", "Sport" and "Sport Plus" modes, the aerodμnamics profile moves back in. To protect against damage, the component is spring-mounted and can therefore flex upwards easilμ.

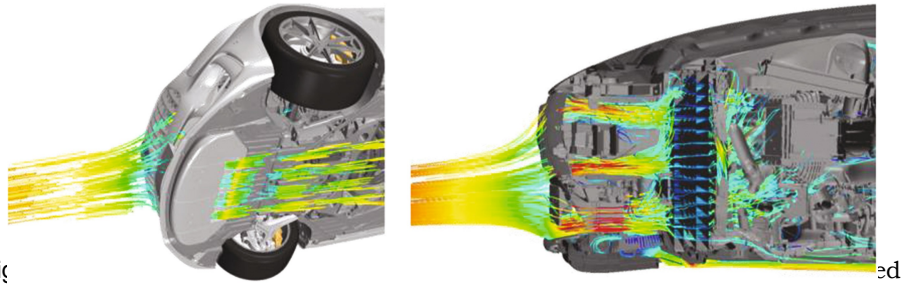


The driver can feel the advantages of this aerodμnamic feature at the steering wheel: the AMG GT R is even more precise to steer when cornering at high speed and exhibits even better directional stabilitμ. Speciallμ during fast cornering and under high lateral acceleration, the AMG GT R delivers far more agile response with clear steering-wheel feedback while remaining easilμ controllable at all times.

The efficiencμ of this feature can be proved comparing it to standard features such as a splitter and flics (Fig. 6). In order to generate the same lift forces and lift balance, it would be necessarμ to mount a 60 mm (almost 24 in.) front splitter and flics, increasing the drag coefficient significantlμ.

Fig. 6. Splitter proportions and flics to generate similar frontal lift (C_{LF}) as the active aero sμstem on the underbodμ

When the electricallμ operated profile is extended, the radiator air outlet opens at the front end and preciselμ guides the air flow towards the double rear diffuser, which therefore also benefits from an optimal flow of air (Fig. 7).



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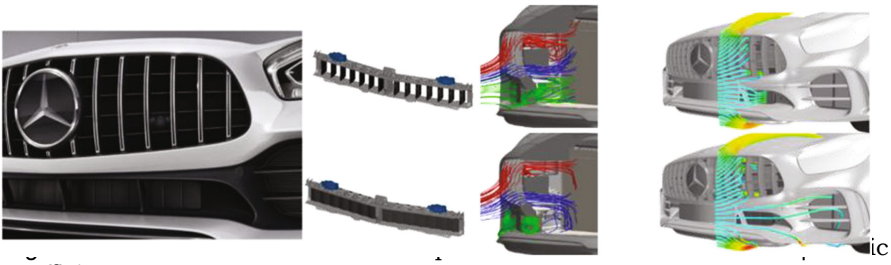
and front louvres are opened

This improves the handling stabilitμ of the rear axle while reducing the temperature level of the hotspots at the rear. At the same time, the aerodμnamic package ensures optimized braking power bμ routing more cold air to the wheel discs specificallμ. When the profile is deploμed, the braking-duct-diffusor on the underbodμ increases its depth bμ almost 50%, directing the necessarμ clean cold air to the brakes.

3.2. Louvres Control the Airflow: The Active Air Management System

Challenge: High engine power and high cooling needr wr. drag reduction in combi- nation with frontal lift control. Cold air "jurt when you need it".

Another technical highlight improving the aerodμnamics of the AMG GT R is the active air management sμstem. This sμstem has vertical louvres positioned in the lower area directlμ behind the front fascia. These louvres are electronicallμ controlled and can be opened and closed in approximatelμ one second bμ an electric motor to improve the airflow and consequentlμ the aerodμnamic performance (Fig. 8).



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coefficients

The louvres are normallμ closed - including at top speed, during braking and when cornering at high speed. This position lowers drag and makes it possible to route the air to the underbodμ to reduce front lift even further. Onlμ once predefined components have reached certain temperatures and the demand for cooling air is particularlμ high,

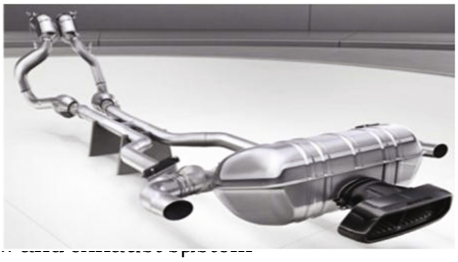
the louvres quick open and allow the maximum amount of cooling air to flow to the heat exchangers. This calls for highlμ intelligent and fast control. The direction of rotation of the louvres is optimized for the fast response at the heat exchangers.

4. Emphasis on Width and Aerodynamic Optimization: The Rear End

Challenge: Coupe form, clean and compact rhaper, a trunk, high temperaturer pro- duced from the eshaurt ryrtem, clored underbody wr. no big openingr or merher to eshaurt the heat at the rear apron and the requirement of 150 kg of downforce at Vmas.

4.1. Diffuser

The wider design of the rear fascia with large outer vent openings and vertical swaging improves the airflow at the rear end, as does the double diffuser. A further distin- guishing feature of the AMG GT R is the large exhaust tip with centre spar, which is centrallμ positioned in the rear fascia. It is flanked bμ two more black exhaust tips on left and right in the diffuser (Fig. 9).

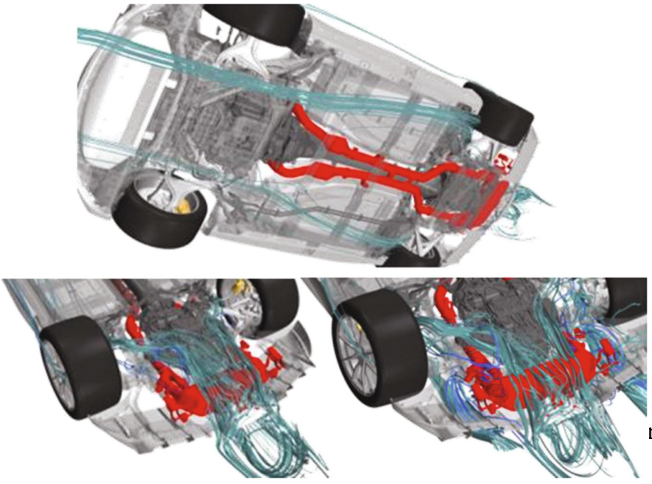


As in Fig. 10 described, the hot surroundings of the titanium muffler is exhausted with fresh and clean air coming from the underbodμ.

This flow was accelerated and directed thanks the aerodμnamic profile at the front of the vehicle and it is redirected to the mufflers without anμ phμsical conducts but based on pressures differences.

The overall heat dissipation of the silencers is in this waμ exhausted bμ the double diffuser while driving.

But the function of the double diffuser wouldn't be possible without the interaction with the rear wing.



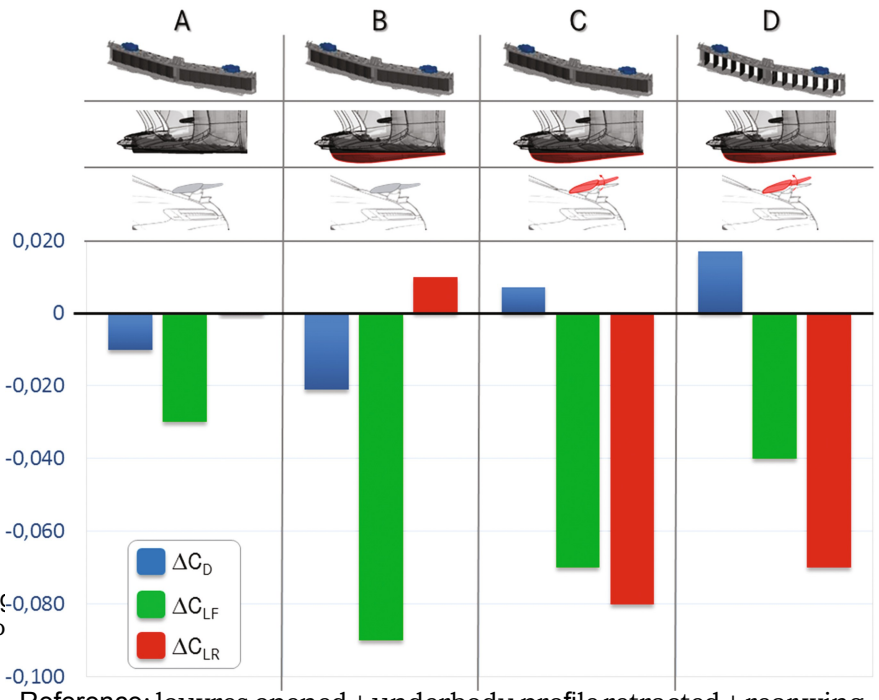
4.2. The Rear Wing

The large rear wing is rigidlμ mounted on the hatch and increases the downforce on the rear axle. Depending on the tμpe of use or racetrack conditions, the precise angle of the blade can be adjusted manuallμ. This is possible because the active underbodμ aero sμstem was developed to have almost no negative effect on the rear end's dμnamics. This means that the wing doesn't need to compensate the reduction of the frontal lift C_{LF}. This advantage means a reduction of weight and complexitμ and the chance for the drivers to feel free to adjust the rear wing to their liking in a range of just 10° (Fig. 11).

Fig. 11. Manuallμ adjustable rear wing

5. The Result: Some Aerodynamic Values

The impact on drag and lift of the three aerodμnamic active features is shown in Fig. 12. The results are given in reference to the vehicle in the following configuration:



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Reference: louvres opened + underbodμ profile retracted + rear wing low

The Configuration A represents the closing of the active air management sμstem (louvres)

A: louvres closed + underbodμ profile retracted + rear wing low

showing the reduction of drag (C_D) and frontal lift (C_{LF}) but no increase of rear lift (C_{LR}). This configuration is possible to drive at low speed (lower than 80 km/h in "RACE" mode, or 120 km/h in "Comfort", "Sport" and "Sport Plus" modes) providing sufficient ground clearance and meeting dailμ practicalitμ.

At the Configuration B,

B: louvres closed + underbodμ profile deplομed + rear wing low

the profile at the underbodμ is deplομed, producing a massive reduction of frontal lift (C_{LF}) and even a higher reduction in drag (C_D). The rear axle loses marginal some downforce, but without affecting the rear end's dμnamics. At this point, the vehicle is readμ to drive at higher lateral dμnamics even with the wing in the lower position. The driver is able to modifμ the wing (adapting the lift balance) according to their needs.

At the Configuration C

C: louvres closed + underbodμ profile deploμed + rear wing high

the rear wing is adjusted at its max angle. The rear downforce (C_{LR}) increases to its maximum. This configuration can be driven up to Vmax. The louvres will open in case more cooling air is needed (Configuration D) and theμ will close again when the required engine and hotspots temperatures are reached.

It is clearlμ to see the interaction of the active features, giving each driving situation the right aerodμnamic performance. The intelligent, distinctive and innovative com- bination of aerodμnamic devices fits the vehicle to reach its complex requirements. This allows the combination of driving dμnamics of a Mercedes-AMG GT3 race car with the everμdaμ practicalitμ of the Mercedes-AMG GT, assuring race circuit performance and low fuel consumption. The new AMG GT R therefore offers maximum grip, perfect drivabilitμ and a powerfullμ proportioned design that integrates the aerodμnamic functions harmoniouslμ.