

FRONT AXLE OF MERCEDES AMG GT. MODELLING IN AUTODESK INVENTOR

Abstract: This paper analyzes the front axle of the Mercedes AMG GT model, as so as the graphical representation of the axle and of the subassemblies of suspension system and steering system, using the AutoCAD and Autodesk Inventor software. The paper include the steps for made the 3D model of the front axle in order to highlight the advantages of suspension and steering system, the function of this systems and methods for manufacturing of these. The 3D model presents a suite of complex surfaces. This type of surfaces is often designed with non-analytical means. The main commands and options used in Autodesk Inventor software were presented and explained. All the component parts of the front axle were modelled and assembled according to their functional role. Finally, the models were rendered in order to have a realistic appearance.

Key words: Front axle, subassembly, 3D model, suspension system, steering system

1. INTRODUCTION

The front axle allows steering and make link between steering wheels and car body, by transmitting the pulling force to wheels, in order to overcome the resistance emerging at wheel's rolling [1]. During braking, the front axle transmits to car body the forces emerging between wheels and driveway [2]. Generally, a car may be categorized, depending to the front axle model. The front axles can be rigid, on scales (axle holding arm) or semi rigid. The rigid front axle, frequently used, is composed from a beam, on the end of which are joined, with pivots, two steering knuckles [3]. The beam, or axle 1, see Figure 1, has an "I" section. The mounting of springs on beam is made onto two support surfaces, 2, from the upper flange. In order to decrease the height of the center of mass of car, the beam has the central part lowered, in order to allow lowering the motor. The steering knuckles, 3, are joined with the beam using the pivots 4 and are used as axle for steering wheels [4].

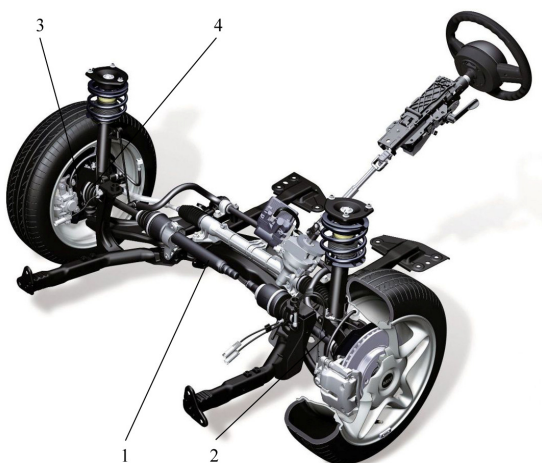


Fig. 1 Rigid front axle [4].

This paper analyze the front axle of the Mercedes AMG GT model, as so as the graphical representation of the axle and of the subassemblies of suspension system and steering system, using the AutoCAD and Autodesk Inventor software [5], [6].

The paper include the steps for made the 3D model of the front axle in order to highlight the advantages of suspension and steering system, the function of this systems and methods for manufacturing of these.

The 2016 model of Mercedes Benz brand, AMG GT, is a sport vehicle, designed to overtake the model Porche 911.

2. MERCEDES AMG GT MODEL PRESENTATION

The AMG GT model uses a central emplacement of the motor onto the front axle, with a power repartition of 60-40% on the front/back axle. The chassis and car body are made from aluminum alloys, and the tailgate trunk is made from steel. The hood is made from magnesium alloy. The car is made from light alloys, so the total weight of car is 1542 kg. The front wheel gauge is 1682 mm and the back wheel gauge is 1653 mm [7].

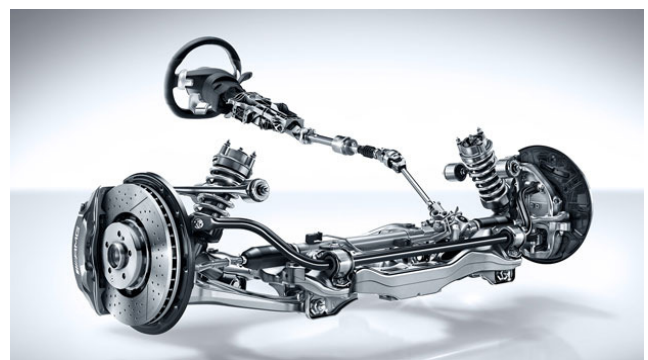


Fig. 2 Mercedes AMG GT front axle [5].

3. AMG GT. FRONT AXLE MODELING

3.1 Mainly parts of front axle

For the graphical modeling of the Mercedes AMG GT front axle, using the Autodesk Inventor was used as template the Figure 2. The modeling assumes to open two basic modules: the *Part* module, where is made the parts modeling and the *Assembly* module, where is made the assembling of axle ant the others elements.

As start point for modeling was used the 2D drawing of main parts of front axle, namely the rim and the tire. In the *Part* module, using the *Sketch* option, the crossing section of rim will be draw.

After this, using the *Revolve* command is obtained a 360° rotation around the axis of rim's sketch.

The rim's spokes will be drawing in the same way, Figure 3.

In Figure 5 it is presented the assembly of wheel with the composing elements of the braking system and holding elements.

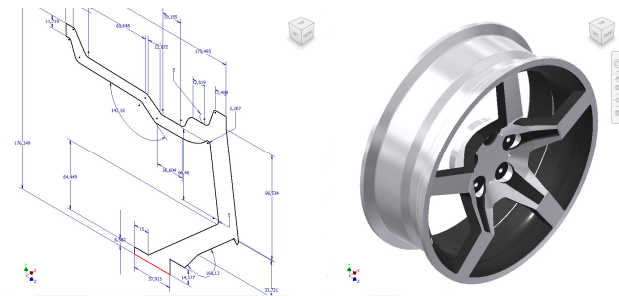


Fig 3. Rim's sketch before and after *Revolve* command.

Similarly, the tire's model was made.

In order to draw the profile onto the tire external surface, the curves were drawn using a plane tangent to the tire's edge, see Figure 4.

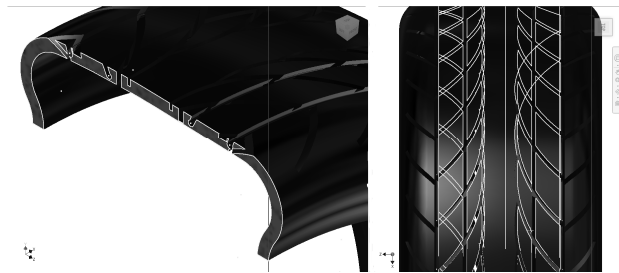


Fig. 4 The tire and rims sketch.

3.2 Braking system

The next main system is the braking system of the car. In the last years, the efforts for braking system development were focused to its role in the frame of the active safety of the vehicle.

The most convenient classification of the brakes is made based on the active elements [8].

In this case, the braking system is a jaws braking system.

The jaws action to a disc mounted on the wheel hub.

The caliper is one of the most important parts of the braking system, where the brake pads are mounted.

The brake pads have direct contact with the brake disk. For caliper modeling we start from the initial dimensioned sketch of this.

The 3D model was obtained using the *Extrude* command, Figure 6.

In the *Part* module was made the disk profile. Using the *Extrude* command, the 3D model of the brake disk was obtained, see Figure 7.



Fig. 5 Braking system elements: 1-rim; 2-tire; 3-caliper; 4-steering knuckle holder; 5-wheel hub; 6-brake disc.

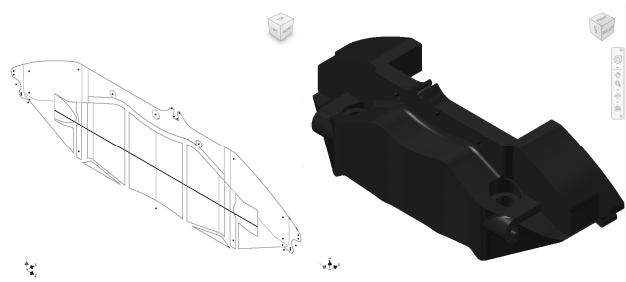


Fig. 6 Caliper.

In order to draw the ventilation holes, a plane was created on the disk half-part and, on the upper part of this, with extrusion with material removing, the ventilation holes were made.

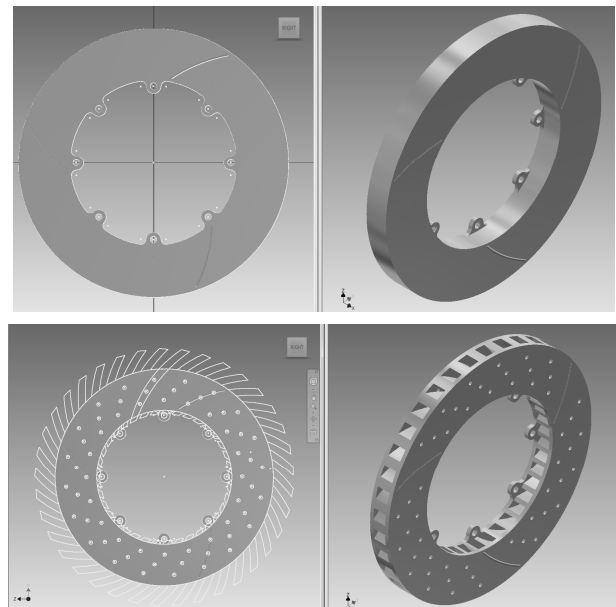


Fig. 7 Ventilated brake disc.

The steering knuckle holder is modeled and, in following, this will be assembled with the ventilated brake disc and the caliper.

The *Part* module is open and is made a skew in one of the working plane.

In this plane, the profile of steering knuckle holder is sketch using the *Line* command and establishing, in the same time the part dimensions. After this, the *Sketch* module will be closed and the 3D model of the steering knuckle will be obtained, see Figure 8.

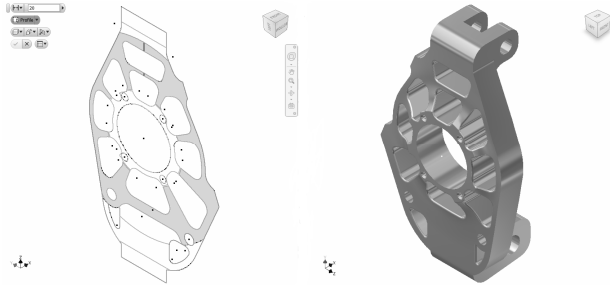


Fig. 8 Steering knuckle holder.

The same commands were used for hub modeling. The screw holes were made using the *Hole* command, Figure 9.

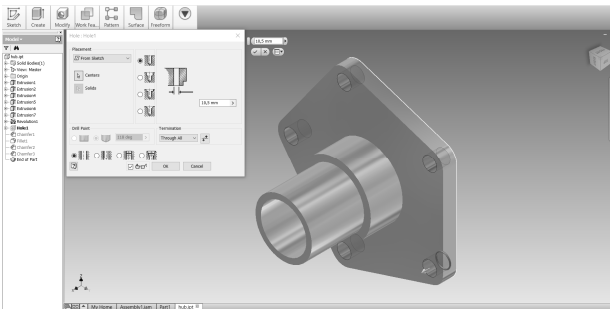


Fig. 9 3D Model of hub, holes made with command *Hole*.

In order to mount the braking subassembly, the import of previously modeled part will be necessary. A new *Assembly* module will be open and a new file will be created (*Create New File*) selecting the folder "Metric". After this, will be accessed the button *Standard(mm).iam* from the branch *Assembly – Assemble 2D and 3D components*.

After opening the assembly file, the components will be imported. Following this, is necessary to apply the constraints system needed for determining the 3D model, Figure 10.

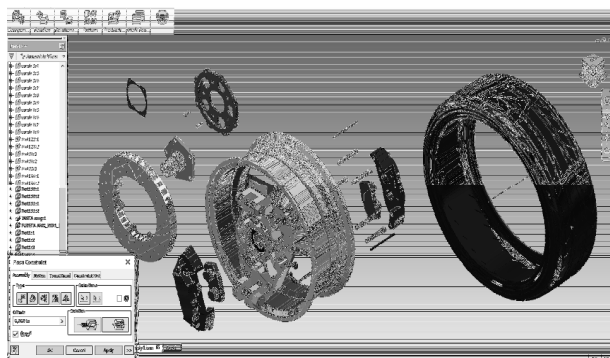


Fig. 10 Braking system subassembly.

By pressing the button *Place Constraint* from the *Assembly* module, with option *Insert*, which give access the constraints regarding the solid axis, the mounting of braking system onto wheel was made, see Figure 11.



Fig. 11 The wheel assembly with braking system.

3.3 Steering system

The steering system assure the vehicle's maneuverability, namely its capability to move following the commands give by driver, respectively to perform the desired turns and to maintain the straight direction when the turning it is not necessary.

The steering system is one of the main mechanisms of the car and has a major role to the driving safety, especially in conditions of increasing in number and speed of vehicles [9]. The AMG GT model is equipped with the traditional electronic servo-assisted steering system.

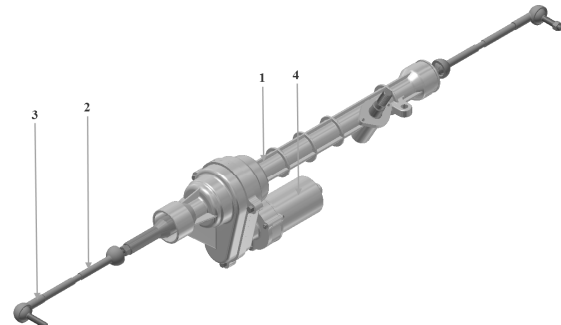


Fig. 12 Electronic servo-assisted steering system:
1-steering box; 2- steering connection rods;
3-bar end; 4-electric motor.

The main component of the steering system is the steering column. By means of the levers of steering knuckles, this leads the vehicle steering system.

For modeling we start from the main sketch, dimensioned with commands *Line* and *Dimension*, Figure 13.

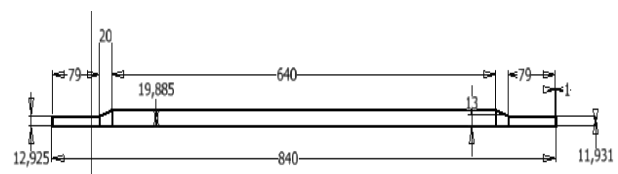


Fig. 13 Steps for draw the main sketch of steering column.

After using the *Revolve*, *Extrude* and *Rectangular Pattern* commands, the steering column teeth profile was obtained, Figure 14.

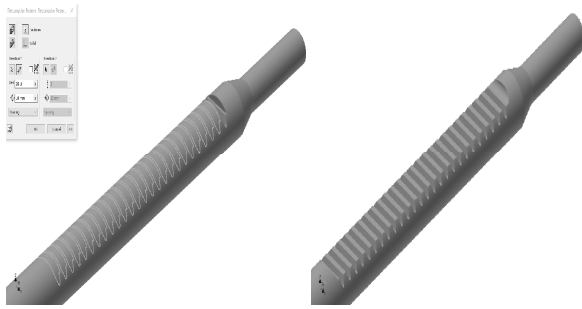


Fig. 14 Steering column –3D model.

The steering box casing has the role to hold the steering column and for retention and distribution of steering fluid. The casing modeling consists in drawing and dimensioning of the main sketch, using the *Line* and *Dimension* commands. After this, it is made the 3D modeling. Were used the *Revolve*, *Extrude* and *Hole* commands for holes generation and *Fillet* and *Chamfer* commands for dress-up the edges, see Figure 15.

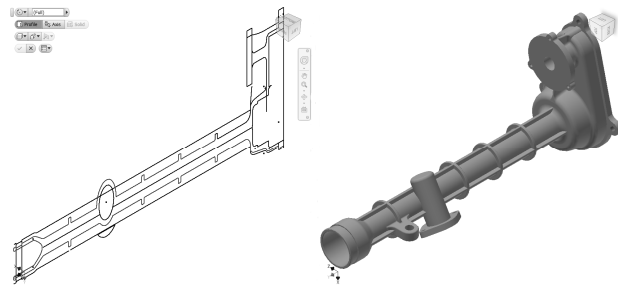


Fig. 15 3D model of steering box casing.

The steering connecting rods is part of vehicle's steering system and link the steering box with the bar swivel head [10]. The connecting rod is sketch in the XZ plane of reference system and is constrained from dimensional point of view. This part is cylindrical and, for this, the *Revolve* command is used, see Figure 16.

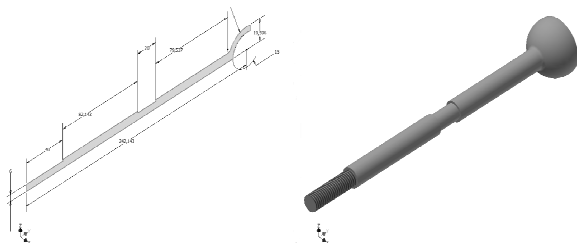


Fig. 16 The 3D sketch and model of steering connection rods.

In order to assembly the steering connection rods with the bar end it was the *Assembly* module, importing the component elements, namely the connection rods and bar end.

For assembling, the *Constraint Tangent* command was used for joining the bar end with the connecting rods and, for constraint the bar end with the connection rods was used the *Constraint Insert* command, selecting the axis, Figure 17.

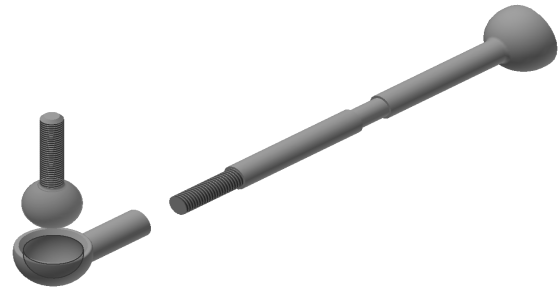


Fig. 17 The assembling of steering connection rods with bar end.

The 3D model of steering box is obtained by importing the components parts for assembling, Figure 18.

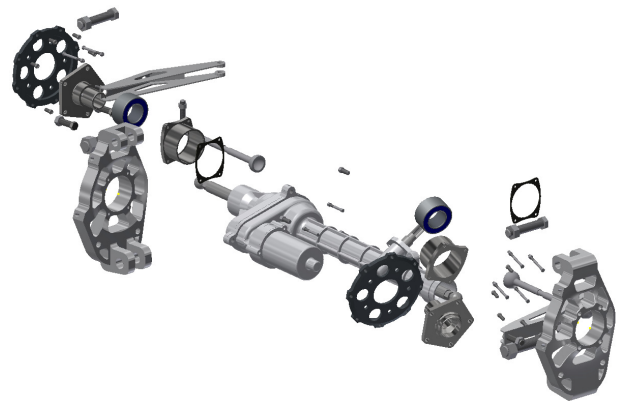


Fig. 18 Import of steering box components.

In order to assembly the entire steering system, the *Constraint Tangent*, *Insert*, *Mate* and *Angle* commands will be used, see Figure 19.

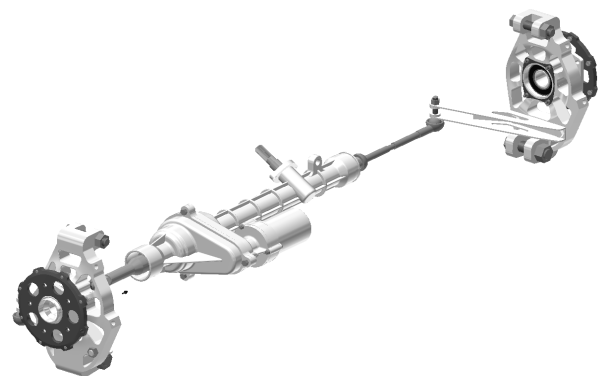


Fig. 19 3D model of the steering system.

Considering the importance of the steering system, is crucial for this to accomplish important requirements as: the wheels' position not be affected by oscillations transmitted to suspension system by the road unevenness; to not transmit shock from wheels to steering wheel and to allow turning without effort.

3.4 The suspension system

The suspension system is a mechanism which made link between the wheels and the car body. It transmits the weight of vehicle to road and, at the same time, insulates the vehicle to the forces transmitted from road, increasing the comfort and the maneuverability [11].

The main elements of suspension are: spring; bush; shock absorber and joins. The Mercedes AMG GT model use a suspension system with racing destination of type double wishbone, used for both axle. The arms and spindle are made from forged aluminum, maximizing the rigidity and hardness and minimizing the weight in order to increase the maneuverability. The upper and lower arms are parallel and each back suspension is mounted in an inferior point of spindle, in order to minimize the response time and the vibrations. The final result consists in a balanced maneuverability even in limit situations [12]. The spring supports the vehicle weight, maintaining the correct position on road.

The *Part*, *Sketch* module will be selected in order to drawing the arc in the YZ plane. For arc representation, the helix with given diameter and height will be defined.

After the dimensional constraint of the spring sketch, the *Coil* command will be selected and a helix around the axis will be generated, with given pitch and start point, see Figure 20.

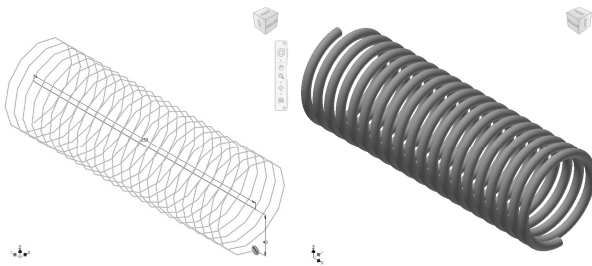


Fig. 20 Spring sketch and 3D model.

The shock absorber has as main role, the car body and wheels vibrations decreasing, maintaining, at the same time, a close contact between wheel and road. The shock absorber controls the spring movement. By this control the wheels are maintained in contact with the road, assure the car body stability and increase the comfort. In order to model the shock absorber, it was necessary to use the *Part* module. Here, its rods are drawn using the *Sketch* option. Taking in consideration the cylindrical forms of the rods, only half of profile will be drawing and constrained. This half-profile will be rotated with 360° for obtaining the rods 3D model, see Figure 21.

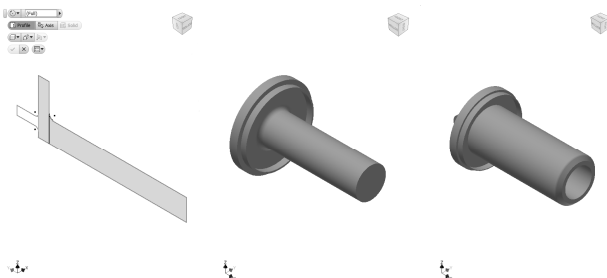


Fig. 21 Rods sketch and 3D model.

The suspension system of AMG GT model is composed from two tilts in form of “A” letter. The advantage of this system is that the two tilts have parallel motions, allowing to wheel to be always perpendicular to road. For tilts modeling, the sketch will be draw and dimensioned according to the blue prints. The *Part* module is accessed for 3D construction of the tilts, using the *Extrude*, *Hole* and *Fillet* commands, Figure 22.

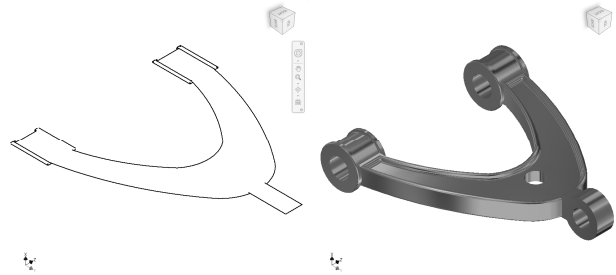


Fig. 22 Tilt – 3D model.

The lower tilt was made in a similar way; the only difference is the dimension. After modeling the component parts, these will be imported in order to assembly the suspension system. We will focus to correct positioning of the suspension rods and tilts, Figure 23.



Fig. 23 Components import and positioning.

It will consider the coaxially constraints of holes from the tilts with the joints from the steering knuckle holders. After the constraints, the screws and nuts are imported. Finally, the 9.65° inclination between the front suspension axis and the wheel's assembly plane will be established. From here, the 3D model will results correct, see Figure 24.

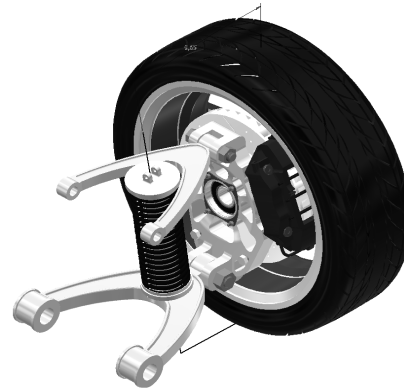


Fig. 24 Establishing of the inclination angle between the front suspension and the wheel plane.

In the end, all the axle components will be imported, considering the starting template for modeling and the geometrical and dimensional constraints.

The *Assembly* module will be open and, using the *Place component* command, each part will be imported and assembled.

In order to has a realistic appearance of the model, a *Render* (real scan) of the axle was made, as is presented in Figure 25.

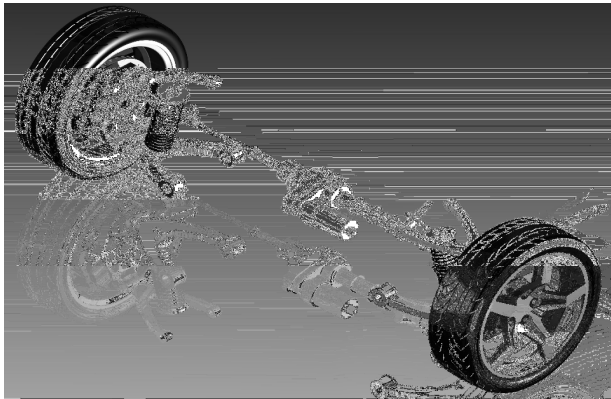


Fig. 25 The Mercedes AMG GT axle model – render.

4. CONCLUSIONS

The independent suspension is characteristic for cars with tilt axle. At vehicles with independent suspension, the planetary gear does not turn inside the shaft but free. The tilt axle is composed by smaller parts that a rigid axle which is a single body.

The most modern car are equipped with tilt axle and independent suspension in order to increase the performance and safety.

The suspension system technical condition is very important for driver and passengers comfort, as so as for the reliability and maintainability of the others parts and subsystems included and dependent from suspension system.

In conclusion, the double wishbone system has better performance regarding others suspension types but it comes to market with a high cost.

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Authors:

Student Eduard – Narcis COROLENCU, Department of Thermal Systems & Environmental Engineering, “Dunărea de Jos” University of Galați, România, E-mail: eduard.corolencu@gmail.com, tel.0040741694201.

Assoc. Prof., PhD. Virgil Gabriel TEODOR, Depart. of Manufacturing Engineering, “Dunărea de Jos” University of Galați, România, E-mail: Virgil.Teodor@ugal.ro, tel.0040745253196.