Design and Durability Test of the Main Assemblies of Active Anti-roll bar

Nguyen Anh Ngoc, Tran Phuc Hoa, Vu Hai Quan, Nguyen Minh Tien, and Kieu Huu Bang

Abstract The anti-roll bar has the effect of increasing the stable motion of the vehicle. It has the role of receiving, transmitting force and torque between the wheel and the chassis, reducing the vibration frequency of the car, ensuring the smoothness and stick on the road of the vehicle. Therefore, this paper conducts research on "*design and durability test of the main assemblies of active anti-roll bar*". The active anti-roll bar uses MR fluid, the design of the magnetic brake assembly replaces two rubber bearings on the conventional anti-roll bar, this is also the position to increase the torque for the bar. The article conducts research and simulation with different materials, in different working modes to evaluate the durability of the bar, and gives the most suitable results for the design, ensuring the durability detail. At the same time, evaluate and give suitable materials for the MR brake assembly.

Keywords Durability test · Design and simulation anti-roll bar · Active anti-roll bar · MR brake · MR fluid

1 Introduction

The suspension system on modern vehicles must ensure two basic criteria: smoothness to the driver and firmness when the vehicle is in motion (such as when turning around or braking sharply). To meet the above two basic requirements, one of the methods is to use an active anti-roll bar. The body vehicle tilt angle ψ has a great influence on the stability of the motion. To improve the lateral stability of the car, solutions can be applied such as: changing the size of the passive anti-roll bar, using control

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B. T. Long et al. (eds.), *Proceedings of the 3rd Annual International Conference on Material, Machines and Methods for Sustainable Development (MMMS2022)*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-3-031-31824-5_46

systems such as suspension, steering and brake system… But in the above research cases, the smoothness and safety of movement and vice versa are not guaranteed. In order to satisfy both of the above criteria in accordance with the characteristics of the road and the stability and structure of the vehicle, the research team this time designed a passive anti-roll bar using MR fluid. With this passive anti-roll bar, in addition to the torsional values of the normal passive rod, it can be changed to increase the torque value for the rod to match the vehicle's stability with the road profile [1].

The research will approach the active anti-roll bar from the design, then evaluate and test the durability, select the right material for the active anti-roll bar and the component assemblies to serve the purpose of long-term use, avoiding damage that affects the movement as well as endangers the occupants of the vehicle.

2 Design Active Anti-roll bar

Bar design: In the active anti-roll bar model using MR magnetic oil with the design of the MRF magnetic brake assembly so that there is not much change in the rod structure and chassis structure on the vehicle to optimize, the research team has The design of the MRF brake assembly is the point to replace the two rubber bearings on the conventional anti-roll bar (passive bar) and at the same time, it is also the point to increase the torque for the rod [2]. The parameters selected in the study include size and shape according to the actual car model. After referencing documents, the research team has designed 01 stabilizer bar model created on Solidworks software with the standards and parameters shown in Table 1 (Table 2).

The research team selected 3 types of spring steel materials used to manufacture tweezers, springs, … for testing, which are AISI 1065, SAE 5160, SAE 9262 with the following characteristics [3] (Table 3).

Table 1 Steel parameters and values

Parameter	Value
Length	1100 mm
Type of section	Hollow section
Bearing position	440 mm
Swing arm length	150 mm
Inner-outer diameter	15–Ø20

Table 2 Characteristics of steel grade AISI 1018

Parameter	Value
Gradual recovery module (Pa), E	2.05e11
Poison's ratio	0.29
Density (kg/m^3), ρ	7870
Tensile strength (MPA), Sy	370

Table 3 Characteristics of steel grades

Characteristic	AISI 1065	SAE 5160	SAE 9262
Elastic modulus (MPa)	207	207	207
Poisson's ratio	0.3	0.3	0.3
Tensile strength (MPa)	280	1487	455
Max tensile strength (MPa)	420	1584	923

MR Brake design and assembly: MR brake assembly is designed to replace and install in place of two rubber bearing assemblies being used on current vehicles. The design requirement is that the magnetic oil brake assembly has the same shape and size as the rubber bearing assembly. The purpose of placing in the position of the bearing helps to keep the chassis design unchanged from the original size. With the design close to the position of the swingarm, it also helps to make the most of the generated torque to make the vehicle's stabilization time faster [4] (Figs. 1 and 2).

In order to come up with the optimal design in terms of the number of poles and the length of the brake, the authors have simulated and tested the design with different sizes and different numbers of poles on Ansoft Maxwell software and selected the 4-pole magnetic design. After selecting the number of poles, we continue to run the test of lengths of 45 mm, 50 mm, 60 mm, 70 mm, 80 mm respectively to evaluate the change in torque when the length size changes. The author chooses AISI 1018 magnetic steel as shown in Table 4 to evaluate and test two important main details, rotor and stator. The rotor is a very important detail in the MRF brake assembly, which is considered a core part (bone part) to assemble other details on it such as wire wrapping, magnetic shield, bolt holes (Fig. 3).

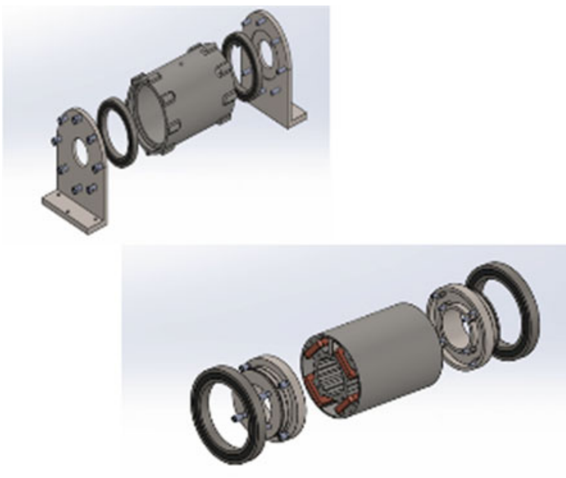

Fig. 1 MR brake assembly

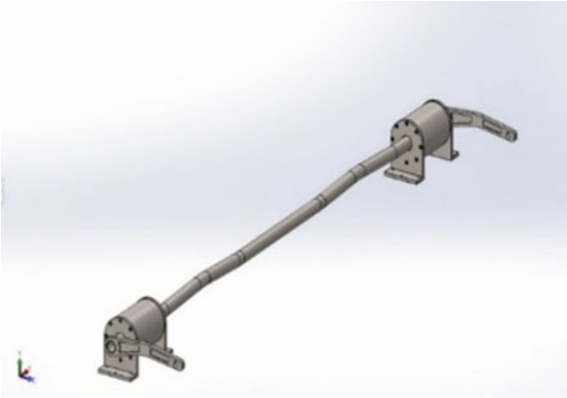

Fig. 2 The brake assembly is installed on the anti-roll bar

Table 4 Nodes and elements of details after meshing

Steel marks	AISI 1065	SAE 5160	SAE 9262
Maximum stress (MPa)	420	1584	923

The material chosen for the shield is aluminum because aluminum is a non-magnetic material, has high corrosion resistance and is easy to process and manufacture. The detail assembly cover is responsible for keeping the force and sealing with the internal components to form the MRF brake assembly. In order to ensure long-term use conditions, the material used for the detailed lid is stainless steel. And are fastened together with bolts. In the MRF brake assembly, the stator is an external fixed element that is hung on the iron cylinder through the brackets on both sides (Figs. 4 and 5).

The two ends of the stator have been designed to install oil-shielded ball bearings, to avoid the leakage of MR oil during use, and moreover, it also limits the swing angle of the rod to help the MRF brake assembly operate in the most stable way [5]. After the MRF brake assembly is fully assembled and sealed, the MR magnetic oil is poured into the MRF brake assembly through the threaded hole in the stator body.

3 Simulation

Link Settings: The stabilizer bar works based on the support of the ball bearing, so the condition of face-to-face contact is set, swing conditions for the swing arm. Then, setup bar boundary condition, rotor boundary conditions, stator boundary condition (Fig. 6).

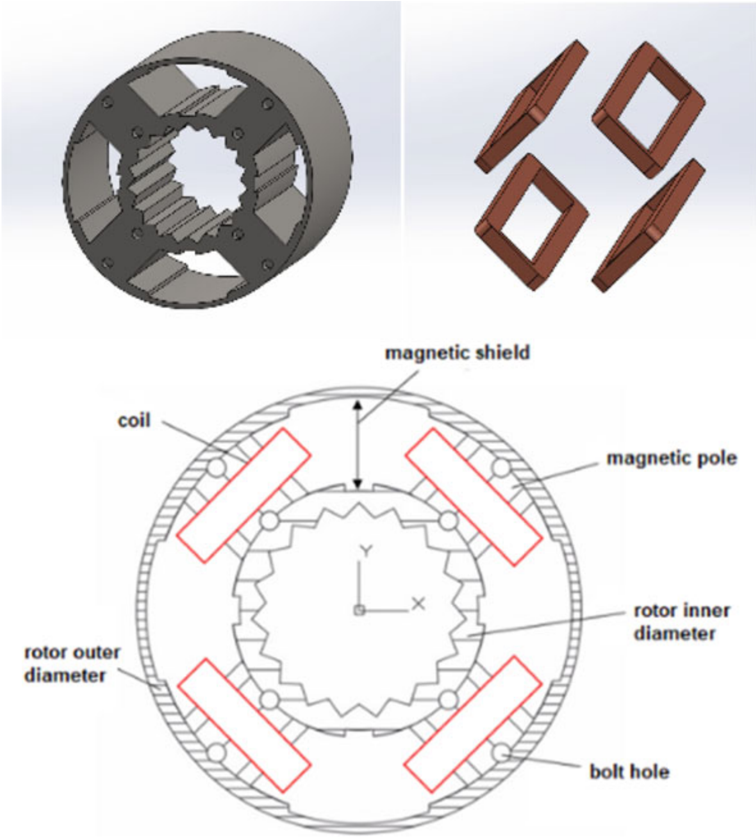

Fig. 3 Definition of parameters and rotor—winding

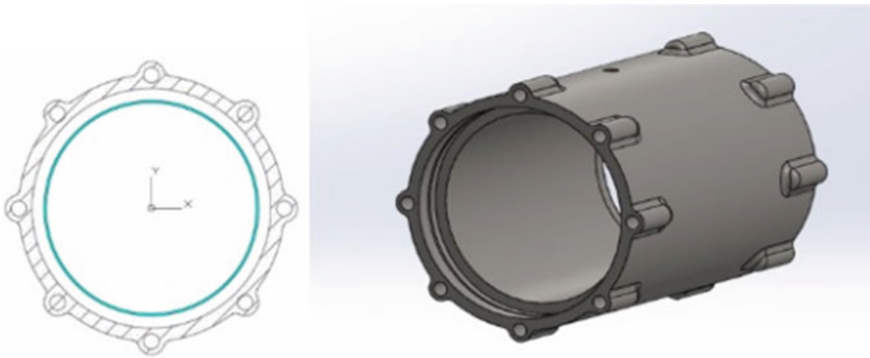

Fig. 4 Stator design model

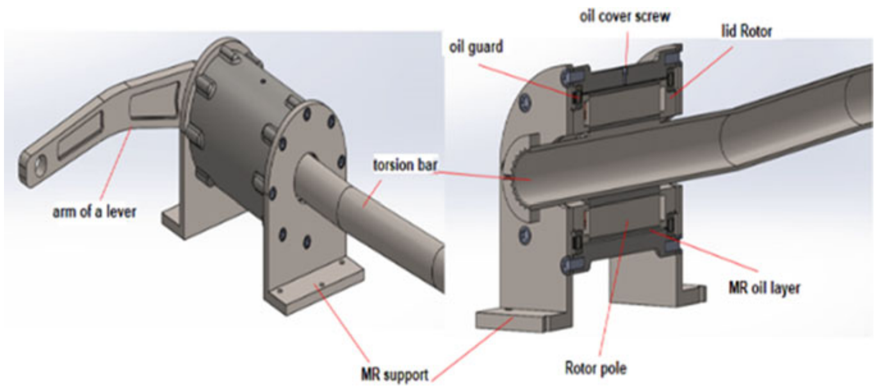

Fig. 5 Assembly model

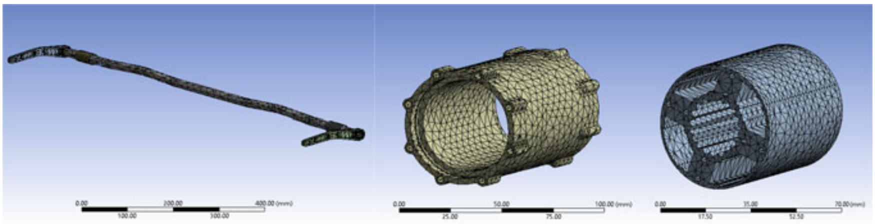

Fig. 6 Meshing the stator-rotor simulation model

4 Results and Discussion

Result: We run with each material in turn with the inner and outer diameters of (Ø14–Ø20), (Ø15–Ø20) (Fig. 7).

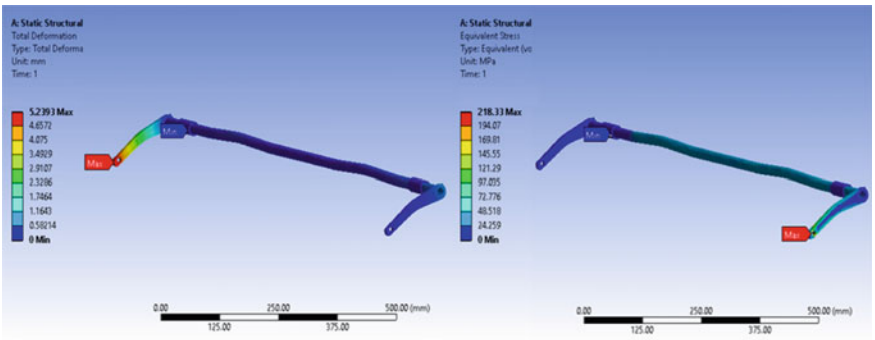

Fig. 7 Displacement and stress of steel grade SAE 5160

When changing rotation angle increases, the stress also increases gradually and reaches the maximum value for diameter 14 is 1423.1 MPa, for diameter 15 is 1337.5 MPa. The bar is durable enough, not destroyed even when reaching the largest rotation angle.

In Fig. 8, when the rotation angle increases, the stress also increases gradually and reaches the maximum value for diameter 14 is 1419.4 MPa, for diameter 15 is 1334.1 MPa. The bar can only be rotated to 40 rotations angle, check with 60 rotations angle, the maximum stress on the bar exceeds the allowable stress.

In Fig. 9, as the rotation angle increases, the stress also increases gradually and reaches the maximum value of 1432 MPa for diameter 14, 1345.8 MPa for diameter 15. The bar can only be rotated to a rotation angle of 80, check with a rotation angle of 100, the maximum stress on the bar exceeds the allowable stress (Figs. 10, 11 and 12).

Stress on Rotor and Stator is very small (<1 MPa), displacement on Rotor and Stator is very small (<1 mm). Rotor and Stator is durable enough under operating conditions.

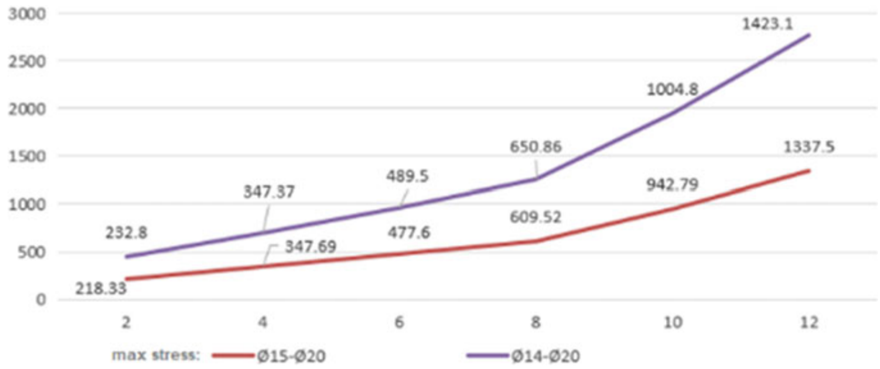

Fig. 8 Comparing the effect of diameter with steel SAE 5160 with each rotation angle

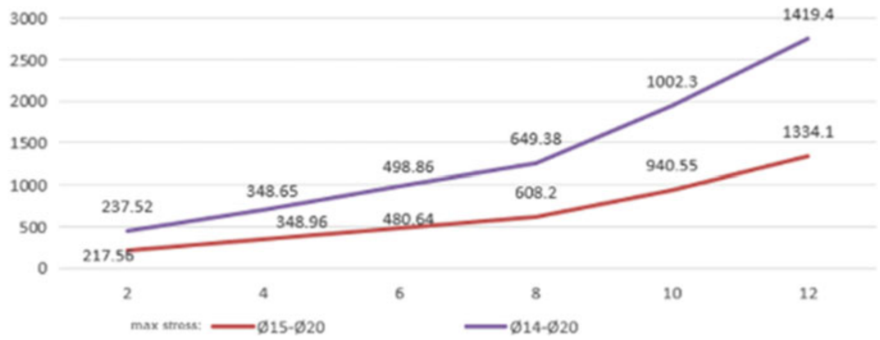

Fig. 9 Comparing the effect of diameter with steel AISI 1065 with each rotation angle

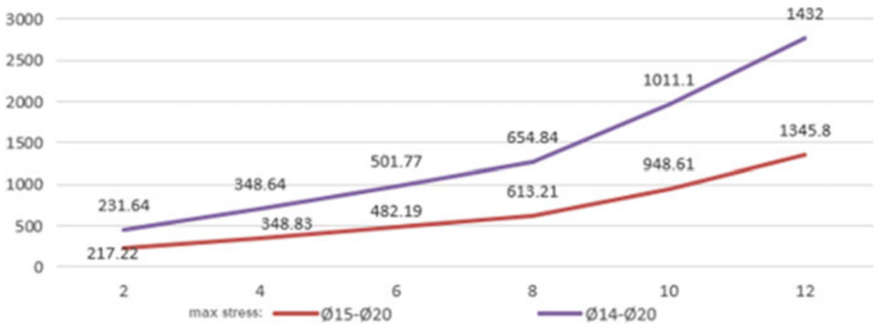

Fig. 10 Graph comparing the effect of diameter with steel SAE 9262 with each rotation angle

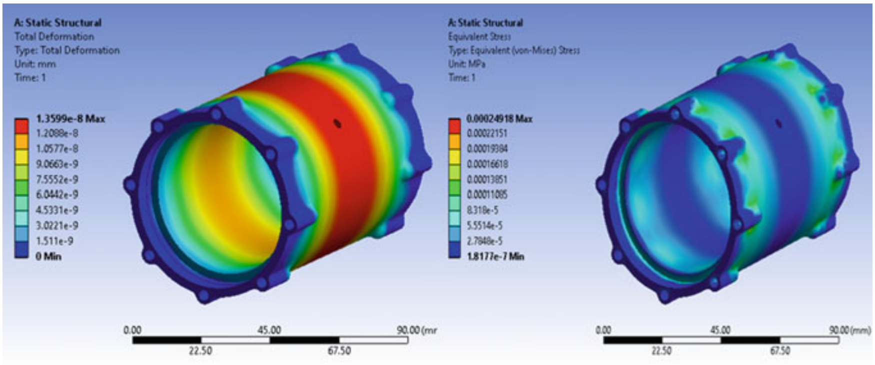

Fig. 11 Displacement and stress of rotor of MR brake

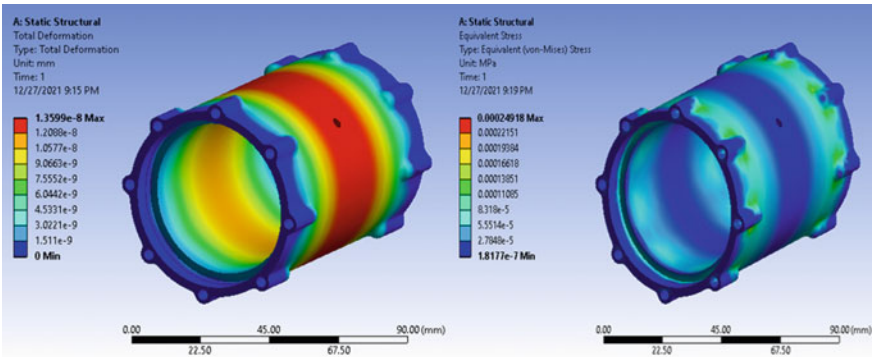

Fig. 12 Displacement and stress of stator of MR brake

Table 5 Max stress with diameter 14 and 15

Steel marks		AISI 1065	SAE 5160	SAE 9262
Max stress (MPa) with diameter	14	1222.9	1200.3	1195
	15	1091.5	1070.4	1065.3

Evaluation: The time required to construct, simulate and determine the reaction and stress of the rod is also not too long. It is possible to repeatedly seal the balance bars with different materials as well as bars with different sizes and materials used. To find the optimal solution designed balance bar.

Anti-roll bar: We have the maximum allowable tensile strength of steel grade.

After simulation we get the following results (Table 5).

Inference: Only one SAE 5160 material is qualified for durability.

MR brake assembly: According to simulation, the highest stress and displacement of the Rotor are 1.9147e−8 MPa and 2.0093e−004 mm, respectively, of the Stator is 1.3599e−008 MPa and 2.4918e−004. The stress and displacement of the MR brake assembly are satisfactory under the operating conditions, making it suitable for long-term use.

5 Conclusion

The study has produced a detailed design for the active anti-roll bar using MR brake, from that design, a simulation of testing and durability assessment was conducted, choosing the optimal diameter from two values of 14 and 15, and select materials with high strength and stress tolerance in AISI 1065, SAE 560, SAE 9262 materials for the anti-roll bar and test with AISI 1018 material for rotor and stator. The simulation results show that the rod size with diameter Ø15 and SAE 5160 material is the optimal material to ensure the conditions during operation, this is a reliable material for designing and manufacturing for the bar, max stress of each rotor and stator part is lower than the allowable stress value of AISI 1018 steel of 370 MPa and the displacement of the assembly is very small. With the design size and simulation conditions as above, it is completely reasonable. From the above results, it can be seen that the details are super durable, which can be extended to a number of further research directions: fatigue strength, dynamic durability, … in the case of moving vehicles, building optimization problems to improve detail quality.

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