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# Research on Application of AGV Drive Unit Based on Finite Element Method

Yanxia Wang[1,*], Ningqiang Wu[2] and Yuan Shao[2]
[1]Department of Aeronautical Engineering, Shaanxi Polytechnic Institute, Xian yang, China
[2]School of Vehicle Engineering, Xi'an Aeronautical University, Xi'an, China
*wyxdycg@163.com

## Abstract

**AGV (Automatic Guided Vehicle) drive unit mounting frame is installed with drive motor, deflection motor, and other accessories, drive unit mounting frame is one of the key stable structure in the whole heavy-load vehicle. Once the drive unit installation frame fails or is damaged, it will endanger the driving safety, which can lead to disastrous consequences. Therefore, statics analysis and mode analysis are needed. The static and modal analysis of the installation frame based on ANSYS Workbench analysis software in this paper shows that the new framework meets the use requirements under various working conditions and can provide theoretical basis and reference for the reliability design of AGV in the future.**

## Keywords

**AGV; frame; Ansys; Static mechanics analysis; Modal analysis.**

## 1. Introduction

AGV is a driverless autonomous guidance transport vehicle, AGV system involves mechanical, electronic, optical, computer and other fields of [1-2].At present, AGV is developing towards miniaturization and heavy load.Heavy AGV has trackless, intelligent, site automatic identification, automatic guidance, wireless communication capabilities, but heavy AGV requires the strength and rigidity of its framework.If the strength is not enough or the rigidity is poor, it will affect the assembly accuracy of the chassis and body; increase the difficulty of process setting of the line side operating equipment; increase the path deviation of AGV during walking, and the turning place will be more obvious [3-5].

Heavy load automatic guide vehicle drive installation frame installed with drive motor, deflection motor, and other accessories, in the process of movement by large load and from the road through the wheel, if the strength is not enough, in the process of damage, in the vehicle vibration analysis, the installation frame inherent vibration characteristic is critical, so the need for static analysis and modal analysis, using finite element analysis method, shorter than the experimental period, low cost of [6-9].

## 2. Model Building

According to the technical indicators and requirements used, Catia software was used to model the AGV as a driving unit, as shown in Figure 1.AGV power unit mainly includes: drive motor, rotating motor, drive wheel, transmission structure, drive housing, connection structure.The AGV drive unit mainly relies on the drive motor as the power source through the gear drive power to the drive wheel, through the connection structure with the car body to provide the whole AGV car forward power.

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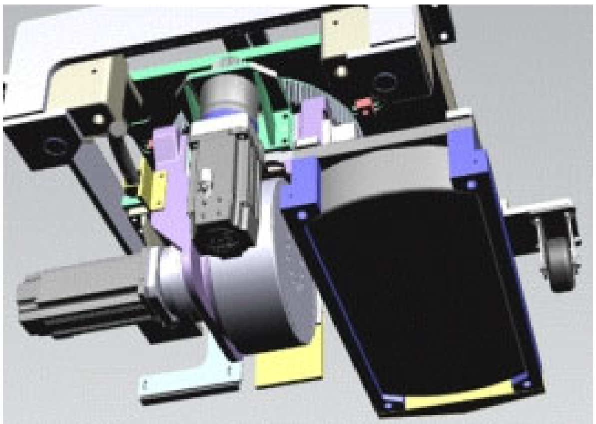

**Figure 1.** 3 D model of the driving unit

## 3. Frame and Finite Elements Calculation

### 3.1. Framework Import

The framework model established in CATIA was imported into ANSYS / Workbench to simplify the model. The accuracy and speed of analysis calculation are affected by the number of grids, and the accuracy of the grid parameters according to the size of the model, the accuracy of the finite element model will directly affect the accuracy of the final analysis results, the smaller the accuracy, the imported installation frame is shown in Figure 2.

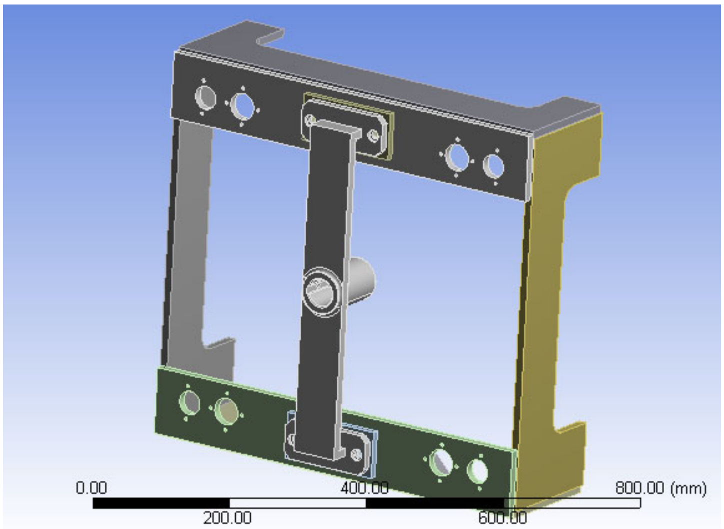


**Figure 2:** Drive unit mounting frame model

### 3.2. Grid division

Details such as small holes and some sheets are ignored to obtain high grid quality. Since the structure is complex, advanced 3-dimensional 10-node tetrahedral Solid187 unit are selected with 5mm grid size. Figure 3 is the installation frame after grid division, Total number of nodes: 656289; Total units: 417520. Although the calculation amount is increased, the irregular model is better simulated, and local topology optimization is performed.

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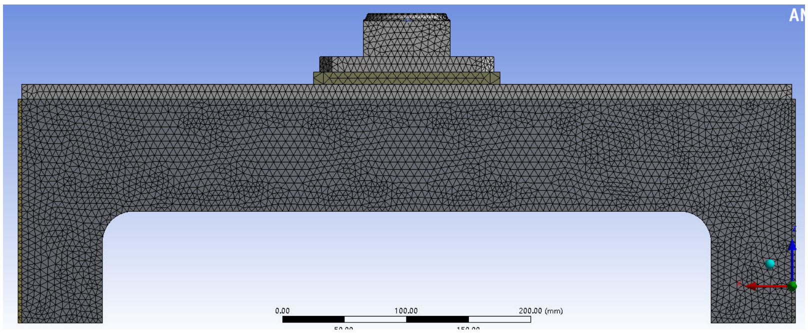


**Figure 3:** Grid division

## 3.3. Grid division Boundary conditions are associated with the load of the applied

The frame adopts Q235, Q235 has good toughness and plasticity, certain elongability and good welding performance and thermal processing type. The material properties are shown in Table 1 and Table 2.

**Table 1.** Chemical Composition of Materials

| Material | C | Si | Mn | S | P | Cr | Ni | Cu |
|---|---|---|---|---|---|---|---|---|
| Q235 | 0.14~0.22 | ≤0.3 | 0.3~0.65 | ≤0.05 | ≤0.045 | ≤0.03 | ≤0.03 | ≤0.03 |

**Table 2.** Frame material properties

| Material | Modulus of elasticity | Poisson ratio | Density | Tensile strength (MPa) | Yield Strength (MPa) | Elongation (%) |
|---|---|---|---|---|---|---|
| Q235 | 2.12x105MPa | 0.288 | 7.86x10-6kg/mm3 | 375~460 | ≤16:≥235 | ≤16: ≥26 |

The total constraint is "Fixed Support", "Moment", "Moment" Force "and" Standard Earth Gravity ".Static analysis is used to analyze the response of the structure under a given static load, and concerns the relevant deformation, stress, strain and restraint counterstress parameters. The general equation of classical theoretical objects is [2]:

$$[M]\{\ddot{x}\}+[C]\{\dot{x}\}+[K]\{x\}=\{F(t)\} \tag{1}$$

In the equation, [M] is the mass matrix; [C] is the damping matrix; [K] is the stiffness coefficient matrix; is the displacement vector; is the force vector.

In the linear static analysis, all time-related factors were excluded, and the following equations were obtained:

$$[K]\{x\}=\{F(t)\} \tag{2}$$

In this paper, the following conditions are met: the matrix is continuous, the material meets the theory of small deformation and linear elasticity, the matrix is a static load, not the load over time, not the influence of mass, damping, etc.The specific applied loads and boundary conditions are shown in Figure 4.

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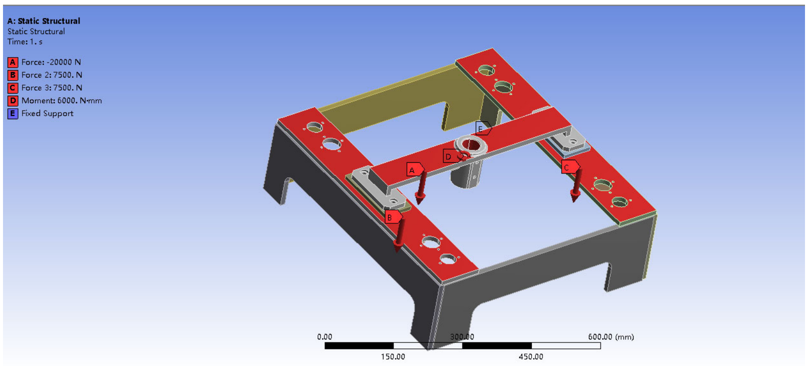


**Figure 4.** Load and boundary simulation on the frame

### 3.4. Calculation of the Stress Safety Factor

The stress safety factor $S_f$ is calculated by the following formula:

$$S_f = \sigma_s / r_m \sigma_v \tag{3}$$

In, the yield strength of the materialis $\sigma_s$; the material safety factor is $r_m$; the Von-Mises stress of the frame is $\sigma_v$.The material safety factor is 1.05, and the safety factor of the load is already considered when the load is applied.

## 4. Result

### 4.1. Static Mechanics Analysis

After the Solution solution of ANSYS Workbench, the maximum stress and maximum deformation of the drive unit mounting frame assembly are shown in Figure 5 and Figure 6.In terms of equal effect force, the maximum equal effect force of the drive unit installation frame is 216.21MPa;

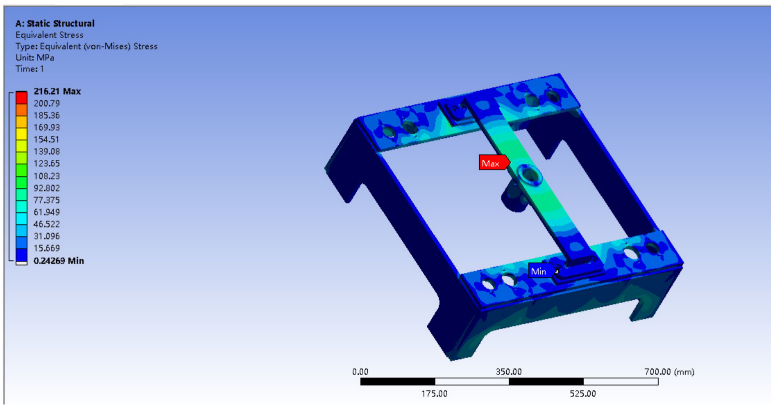


**Figure 5.** Equivalent stress

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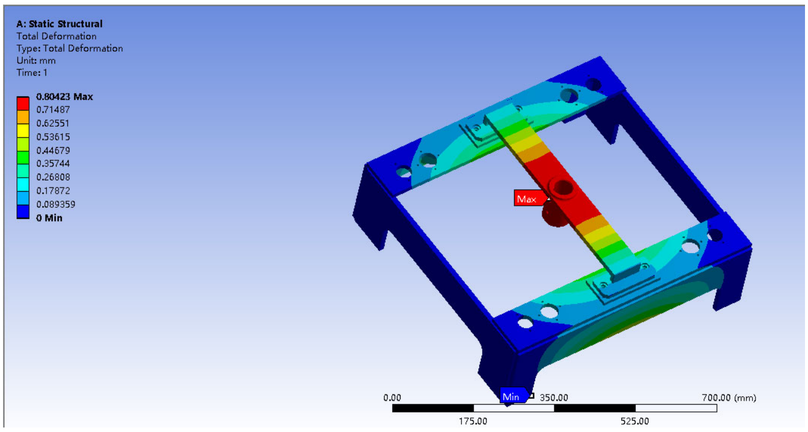


**Figure 6.** Total deformation

The maximum deformation of the overall drive unit mounting frame occurs at the middle bearing; the maximum general shape of the beam bearing is 0.80423mm in vertical direction; the maximum shape variable is 0.26808mm; the shape variable is 0.35744mm.

According to the results of the above stress analysis, the equal effect force is 216.21Mpa, the maximum deformation is 0.80423mm, and the safety factor is 1.03.

## 4.2. Modal Analysis

The main purpose of mode analysis is to determine the vibration frequency of different components through matrix analysis, which is used to determine the mode parameters of different mechanical materials.Click Analysis settings in Modal and select max modes to find in the lower left corner to set order 6 for the modes of each order as shown in Figure 7-1 to 7-12:

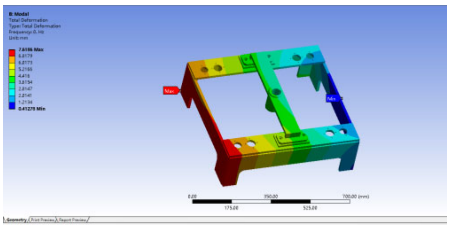

**Figure 7-1:** First mode

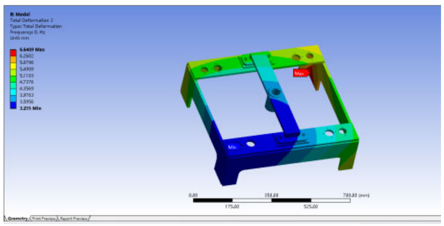

**Figure 7-2:** Second mode

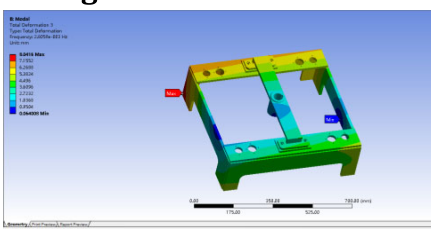

**Figure 7-3.** Third mode

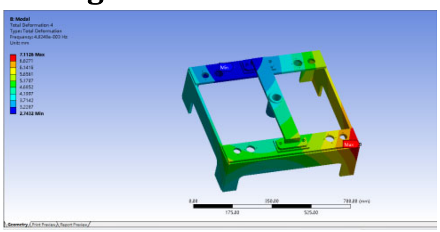

**Figure 7-4.** Fourth mode

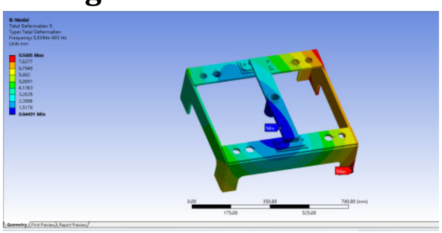

**Figure 7-5.** Fifth mode

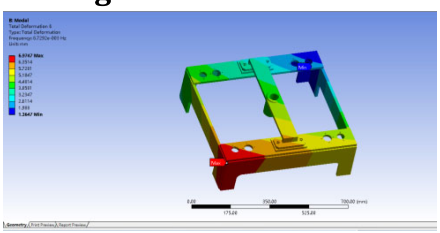

**Figure 7-6.** Sixth mode

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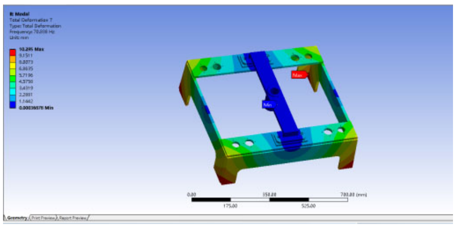

**Figure 7-7.** Seventh mode

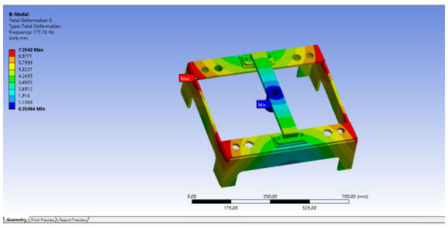

**Figure 7-8.** Eighth mode

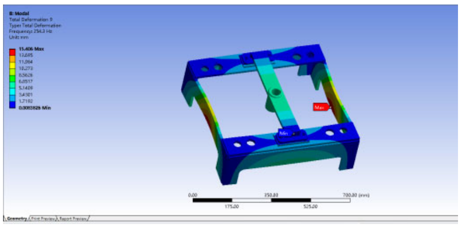

**Figure 7-9.** Ninth mode

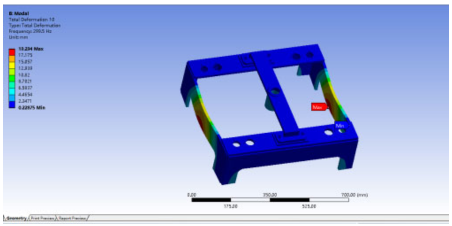

**Figure 7-10.** Tenth mode

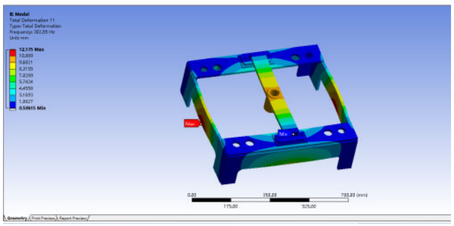

**Figure 7-11.** Eleventh mode

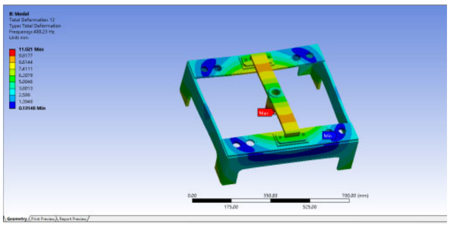

**Figure 7-12.** Twelfth mode

**Table 3.** Twelfth-order natural frequencies

| Number | Mode | Unit /Hz |
|---|---|---|
| 1 | First mode | 0 |
| 2 | Second mode | 0 |
| 3 | Third mode | 2.8059E-03 |
| 4 | Fourth mode | 4.8248E-03 |
| 5 | Fifth mode | 5.5394E-03 |
| 6 | Sixth mode | 8.7292E-03 |
| 7 | Seventh mode | 70.838 |
| 8 | Eighth mode | 177.16 |
| 9 | Ninth mode | 254.9 |
| 10 | Tenth mode | 299.5 |
| 11 | Eleventh mode | 302.55 |
| 12 | Twelfth mode | 697.36 |

It is known from Figures. 7-1 to 7-12 that the vibration frequency in the first 6 order is basically 0, and the natural frequency and vibration modes of the structure will change under different constraint states. Therefore, the mode analysis after applying the constraint can reflect the real vibration situation of the structure and study the influence of the constraints on the modes. At the seventh order to the eleventh order, the frequency is in the low frequency band within 70Hz to 300Hz.In the eleventh order, the frequency of 302.55Hz is in the medium frequency vibration state. From then on, the vibration frequency gradually increases and eventually tends to a fixed value without changing.

## 5. Conclusion

(1) During static analysis, under the maximum load, the stress is 216.21MPa; a certain shape variable, the maximum deformation is 0.80423mm, strength and rigidity meet the

requirements of working condition. In mode analysis, due to the constraints of various supports and bolt fasteners, the overall mode of the drive unit mounting frame is more complex vibration according to different frequencies. Generally speaking, the higher order mode is mainly torsional vibration. The mode analysis truly reflects the vibration shape of the drive unit installation frame in the actual working conditions.

(2) The installation frame has been applied to AGV, and the operation is stable and reliable. This paper has certain application reference value in theory and practice.

## Acknowledgments

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