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Design of clamp tightening machine for automobile exhaust pipe

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Abstract: When the exhaust pipe is installed in the automobile assembly shop, the exhaust pipe clamps will be in different spatial positions, which leads to difficulty in installation. The design of the tightening machine can satisfy point-to-point or point-to-multipoint, but this space Uncertainty raises the challenge of the design of the clamp tightening machine. This article uses CATIA software to model the exhaust pipe clamp tightening machine to try to solve the problem. First determine the part size of each part of the tightening machine and design the parts. After the component design is completed, the assembly design is followed and the final design becomes an assembly. The problem described above is solved by simulation of the assembly.

Keywords: CATIA; clamp tightening machine; 3D modeling.

1. Introduction

With the rapid development of the times, China's manufacturing industry has entered a new stage. As a connecting device, bolts play an increasingly important role in various types of connections [1]. When more mechanical parts are found in the factory, it has become a history to tighten the bolts with hand wrenches. At this time, the industrial sector urgently needed a new technology to liberate productivity and thus increase production efficiency. Therefore, the tightening machine came into being.

The tightening machine has the following two characteristics: Firstly, from the control principle, the torque control method and the torque-angle control method are more; secondly, from the control precision, the general torque is $\leq \pm 3\%$; the rotation angle: $\leq \pm 2$ [2].These two features largely solve the problem of production speed and strength while maintaining high precision. However, the uncertainty of the direction

of the clamp cannot be maximized. For example, the annular clamp applies a pre-tightening force to the exhaust pipe through the bolt and the clamp V-groove [3].
Therefore, this paper designs a three-dimensional model of the tightening machine for the clamp with the clamp as the direction. It combines CATIA and a tightening machine to achieve a quick modeling approach. Establishing the corresponding three-position model of the tightening machine plays an important role in improving the efficiency of the design tightening machine and the promotion and development of the tightening machine.
In this paper, the three-position model of the clamp tightening machine based on CATIA is introduced in detail. In particular, the parts design and assembly design have been studied in detail.

2. The selection calculation of the key parts of the tightening machine.

2.1 Load size calculation

Due to the large size of the clamp tightening mechanism, the torque is very large, which requires torque analysis of specific parts. This selection calculation uses the LM Guide as an example. The LM Guide can withstand loads or moments in all directions from installation, thrust position, acceleration, and cutting resistance. When using the LM Guide, only one LM block can be used or an adjacent double slider can be used due to space position and the like. At this time, the load distribution will be very uneven, and the end faces will become large. If you continue to work in this way, it will fall off at a position where the load is large, and the life calculation value may become shorter. Therefore, it is necessary to multiply the torque equivalent coefficient Q by the torque value to obtain the actual load.
Therefore, the LM rail load calculation formula is 1-1:

$$W=Q\cdot M \qquad (1\text{-}1)$$

W: equivalent load per LM Guide (N)
Q: Torque equivalent coefficient
M: load torque (N·mm)

Table 1 Equivalent coefficients

Type	Q_{AR}	Q_{AL}	Q_{B1}
8	0.439	0.0675	0.439
10	0.309	0.0533	0.309
12	0.208	0.0374	0.208
15	0.168	0.0295	0.168
20	0.125	0.0228	0.125
25	0.112	0.0201	0.112
30	0.089	0.0173	0.089

35	0.078	0.0155	0.078
45	0.067	0.0121	0.067
55	0.059	0.0103	0.059

Q_{AR}: Equivalent coefficient of M_A radial (reverse radial) direction when using one LM block

Q_{AL}: Equivalent coefficient of $M_A$radial (reverse radial) direction when two LM blocks are in close contact

Q_{B1}: Equivalent coefficient of M_B when using one LM block

Q_{B2}: Equivalent coefficient of M_B when using 2 LM sliders

Q_{CR}: Equivalent coefficient of $M_C$radial (anti-radial) direction

The load moment M is divided into three parts: M_A pitching moment, M_B yaw moment and $M_C$rotating moment. Only the torque equivalent coefficient of M_A is analyzed in this paper. The moment equivalent coefficient of M_A is divided into the radial direction equivalence coefficient and the reverse radial direction equivalent coefficient, which are shown by formulas 1-2 and 1-3 and 1-4:

$$Q_{AR} = \frac{C_0}{M_A} \tag{1-2}$$

$$Q_{AL} = \frac{C_{0L}}{M_A} \tag{1-3}$$

$$\frac{C_0}{Q_{AR} \cdot M_A} = \frac{C_{0L}}{Q_{AL} \cdot M_A} = 1 \tag{1-4}$$

C_0 :Basic static load rating (radial direction)(N)

C_{0L}:Basic static load rating (reverse radial direction)(N)

2.2 Rated life calculation

Operating and manufacturing under the same conditions, the life of the LM Guide will be slightly different. Therefore, in order to calculate the service life of the LM Guide, the following rated life is used as a reference. Rated life refers to the total running distance that 90% of the same linear motion system can operate under the same conditions without surface peeling (scale peeling of the metal surface)[4]

The rated life calculation formula of the LM Guide using steel balls is shown in Equation 1-5.:

$$L = \left(\frac{f_H \cdot f_T \cdot f_C}{f_W} \cdot \frac{C}{P_C}\right)^3 \times 50 \tag{1-5}$$

L:Rated life (km) ; C:Basic dynamic load rating (N); P_c:Load calculation value (N)

f_H:Hardness factor (in general, the f_H value is usually 1); f_T:Temperature Coefficient

f_c:Contact coefficient ; f_w:Load factor;

3. 3D modeling based on CATIA

3.1 Parts and assembly design

Dassault Systèmes' large-scale high-end CAD/CAE/CAM integrated application software is in the leading position in the world CAD/CAE/CAM field[5]. Among them, in the automotive field, CATIA software is the core software used by major automakers in Europe, North America and Asia. Its customers include Volkswagen, Mercedes-Benz, BMW, Toyota, Honda, Nissan, FAW Group, SAIC and other mainstream domestic and international auto companies[6]。

General steps for 3D modeling of the tightening machine:

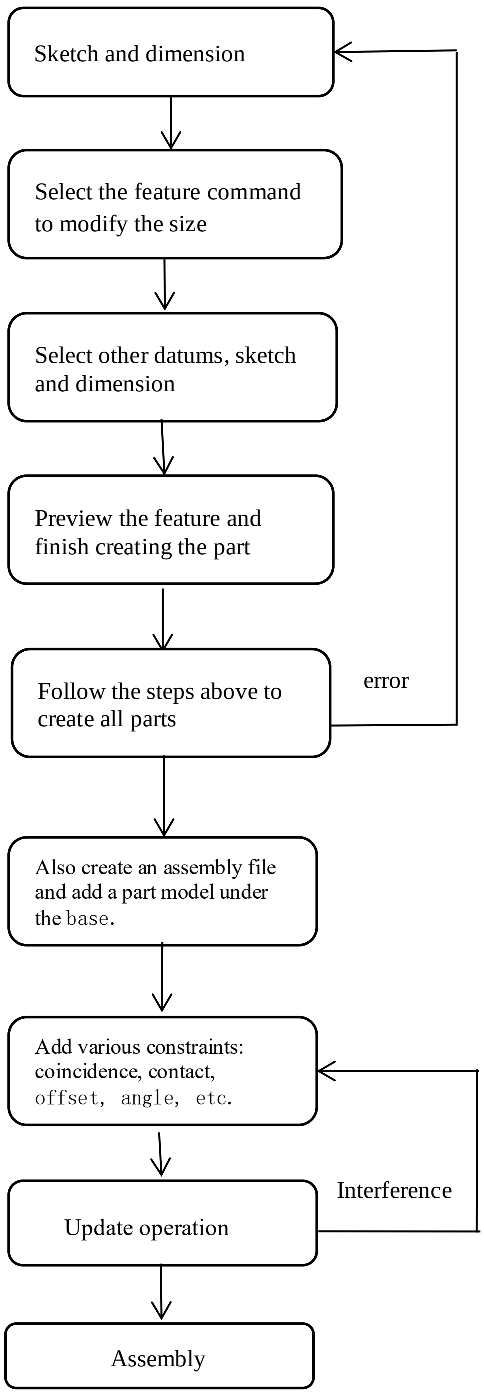

Fig 1 General steps for part design

According to the above steps, the automobile exhaust pipe clamp tightening machine is designed and formed. It is not difficult to find that the part design is the basis of product design, and it must be able to carry out subsequent modification, assembly and parameter correlation between various components [7]. Component assembly is the most basic function module of CATIA, which is different from other drawing software [8].

Here we show the typical parts and assembly drawings.

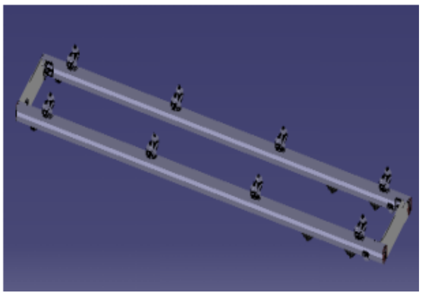

Fig 2 guide rail

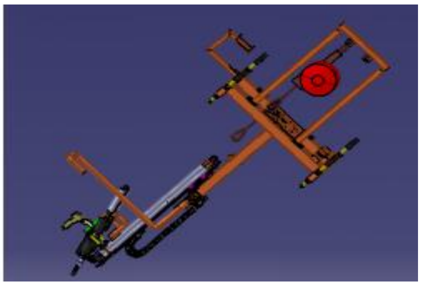

Fig3 TRAVEL section

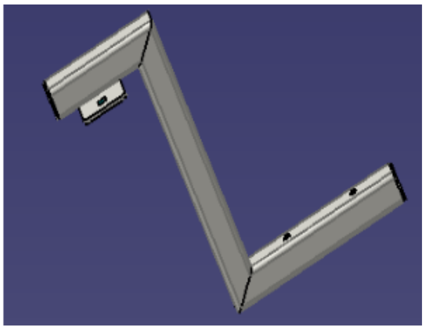

Fig 4 hook mechanism

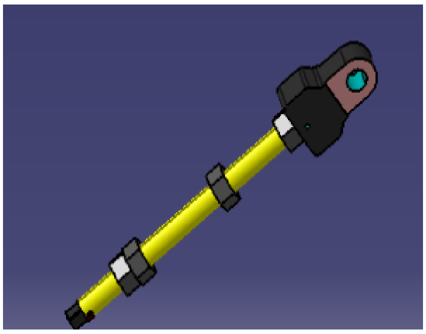

Fig 5 Adjustment arm

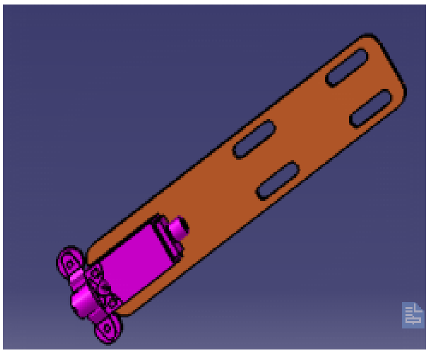

Fig 6 Switch bracket

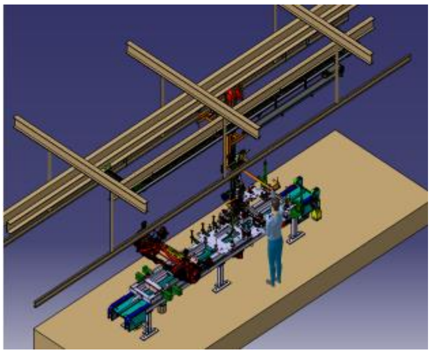

Fig 7 Tightening machine model

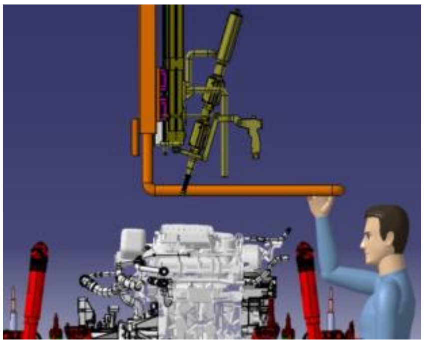

Fig8 Operation process

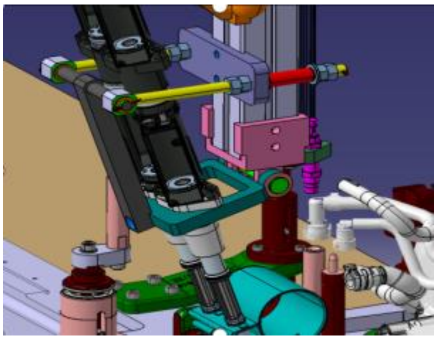

Fig 9 limit conversion mechanism

3.2 Practical application of the clamp tightening machine

After the establishment of the clamp tightener model, we need to perform simulation practice. Below are some specific simulation scenarios, as shown in Figure 8.

First, the operator needs to fix the rail so that the clamp tightener moves freely on the fixed rail: there is a position sensor for receiving electrical signals and issuing control commands to move the rail; secondly, the clamp tightening machine It has the characteristics of space rotation to adapt to the difficulty of the uncertainty of the clamp in space. Therefore, when the clamp needs to be tightened, the clamp tightening machine can be directly pulled down to perform the tightening work, as shown in Figure. 7 and Figure.9.

In fact, we can easily find out from Figure 7 and Figure 8 and Figure 9. The biggest feature of the clamp tightening machine is to solve the uncertainty of the clamp space. As long as it is within a certain range of space, the tightening work can be performed. The establishment of this tool model will bring about a significant improvement in the automotive industry tightening technology.

4. Conclusion

1) By calculating the load size of the LM Guide, the value of the actual load torque is obtained.

2)Based on CATIA's part design and assembly design, the vehicle exhaust pipe clamp tightening machine was three-dimensionally modeled. Solved the problem caused by the uncertainty of the clamp in space.

Acknowledgements

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