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Hydraulic system design of interior extension part of a self-propelled A-recreational vehicle(RV)

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ABSTRACT

RV is known as the title of "home" on wheels, having two big functions following both "room" and "car". But its attribute is car, and is a kind of portable car having the basic facilities of home. The common types of RV are self-propelled, pull-type, mobile villa and cross-country. In the paper, starting from the actual needs of people, the outward extension part of the self-propelled A-RV has been converted into a balcony in order to make the person having a large living room, kitchen or bedroom and let people travel at the same time find the feeling of the real home. But in this paper, the hydraulic parts and working principle of the extend balcony in the central body have been designed and calculated. According to the results, the balcony can make the internal space extension of 4 square meters, the working principle was reasonable, the calculation of hydraulic driving part conformed to the design requirements.

KEYWORDS

RV; Self-propelled; Balcony; Hydraulic system; Design.

INTRODUCTION

The popularity of cars has made more and more people start to look for the mobile life. Then, the industry of RV also prospers. By 1950, the RV has from homemade small canned room luxury villa development to 30 feet long. RV is known as the title of "home" on wheels, having two big functions following both "room" and "car". But its attribute is car, and is a kind of portable car having the basic facilities of home[1]. The common types of RV are self-propelled, pull-type, mobile villa and cross-country. RV accessories include: home supplies, camp supplies, antenna, electrical appliances, lamps, car maintenance supplies, hardware and tools, pipe interface parts, main facilities in RV appliances, gas monitoring, water supply and drainage system, RV supplies, and safety accessories[2]. In developed countries of Europe and the US, every weekend, the RV is flowing on the highway; the RV travel has become people's tourism and leisure style even part of the way of life. In China, many people are blurred on the concept of "RV". But in recent years, the tourism industry is booming in China[3]. By the implementation of the system of "Double cease day", "May 1", "October 1", and the "Spring Festival holiday, the level of people consumption constantly improving and the change of consumption idea, they provides a rare market foundation and broad market space to the development of the RV market in China. And the American RV industry association to make a survey: Camping travel on the human body health, interpersonal harmony and creativity have very big help. In addition, driving car journey will feel very relaxed. Because of their travel plans and time control, convenient to travel from the pack of trivial, also need not limited to the trunk[4].

In the paper, starting from the actual needs of people, the outward extension part of the self-propelled A-RV has been converted into a balcony in order to make the person having a large living room, kitchen or bedroom and let people travel at the same time find the feeling of the real home. But in this paper, the hydraulic parts and working principle of the extend balcony in the central body have been designed and calculated.

DESIGN PRINCIPLE

The most basic function of RV is firstly to realize the function of people eating and sleeping, and desk and chair bed are essential. According to the different needs, RV can be equipped with a variety of different bed, such as the super wide luxurious double bed, the standard double bed, the upper and lower bed, folding bed made from a combination of sofa or table, the bed stretched out to the outer space and recovered the contraction and so on. Fully meet the needs of personalized[5].

Of course, we still have some of the most basic requirements, that on the RV equipped with water supply and water discharge system, LPG (liquefied petroleum gas) tanks, power system, the room that defend bath, store content ark.

On the structural design, the outward extension part of self-propelled A-RV would be converted into a balcony, it more could highlight the theme of the family, and this was also the unique creative design.

Its working principle: the two hydraulic cylinders were connected to the skeleton of the extended part as the balcony. At the same time, the window and the frame of part stretched out were connected with the connecting rod. When the cylinder rod of the hydraulic cylinder was stretching out, the balcony was driven, at the same time the window at the top of connecting rod driving was rotating angle around the axis. It was to look as a shading device. During the anchor, the family can enjoy cool air, drink tea, chat on the balcony. In the traditional RV, it was unique in the shape of the rules, and with vivid intention and the feeling of losing stable.

The structure of the balcony was shown in Figure 1.

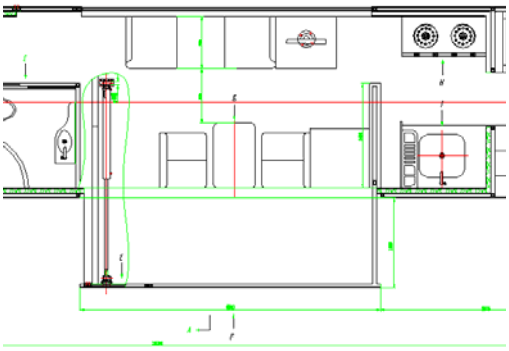

Figure 1 : The structure of the balcony

DESIGN AND CALCULATION OF HYDRAULIC SYSTEM[6,7]

Maximum working pressure of oil cylinder

Under the condition of the maximum lifting moment, the maximum thrust of a single cylinder:

$P_{\max} = 12820kN$

Length of oil cylinder fully stretching: $l_{\max} = 2693mm$;

Length of oil cylinder fully shrinkaging: $l_{\min} = 1493mm$;

Trip of oil cylinder: $L = 1200mm$;

The inner diameter of oil cylinder: $D = 80mm$;

Outer diameter of oil cylinder: $D_1 = 100mm$;

The inner diameter of the piston rod: $d_1 = 370mm$;

Outer diameter of the piston rod: $d = 400mm$;

Length of guide sleeve: $L_D = 200mm$;

Length of the piston: $L_H = 120mm$;

The maximum working pressure of oil cylinder:

$$p = \frac{4 \cdot P_{\max}}{\pi \cdot D^2} = \frac{4 \times 12820}{\pi \times 80^2} = 304.6kg/cm^2 = 30.5MPa$$

Stability checking of the oil cylinder

Moment of inertia of the piston rod:

$$J1 = \frac{\pi\left(d^4 - d_1^{\ 4}\right)}{64} = \frac{\pi \times \left(40^4 - 37^4\right)}{64} = 9070.88cm^4$$

Section area of the piston rod:

$$A = \frac{\pi\left(d^2 - d_1^{\ 2}\right)}{4} = \frac{\pi \times \left(40^2 - 37^2\right)}{4} = 134.5cm^2$$

Moment of inertia of the cylinder:

$$J_2 = \frac{\pi\left(D_1^{\ 4} - D^{\ 4}\right)}{64} = \frac{\pi \times \left(100^4 - 80^4\right)}{64} = 27372.4cm^4$$

Section area of the cylinder:

$$A_2 = \frac{\pi\left(D_1^{\ 2} - D^2\right)}{4} = \frac{\pi \times \left(100^2 - 80^2\right)}{4} = 191.1cm^2$$

Radio of length and thinness: $\frac{l}{k} = \frac{l}{\frac{1}{4}\sqrt{d^2 + d_1^{\ 2}}} = \frac{2693}{\frac{1}{4}\sqrt{40^2 + 37^2}} = 91.4$

$m\sqrt{n} = 85\sqrt{1} = 85$

According to Euler's formula, the stability critical load of the hydraulic cylinder P_K:

$$P_K = \frac{n\pi^2 EJ}{l^2}$$

In the formula, symbolic meaning with former, n is terminal condition coefficient; taking $n = 1$.

(I) : oil cylinder all stretched out, and when P = 128200 kN

$$P_K = \frac{n\pi^2 EJ}{l^2} = \frac{1\times\pi\times\pi\times 2.1\times 10^6\times\frac{\pi}{64}\left(40^4-37^4\right)}{2693^2} = 333785.2kN$$

Safety factor, $n_K = \frac{P_K}{P_{\max}} = \frac{333785.2}{128200} = 2.6$

Oil cylinder satisfied the requirement of stability of compressive bar.

(II) : When the oil cylinder was not completely stretched out (L = 71493 cm), P = 128200 kN.

$$P_K = \frac{n\pi^2 EJ}{l^2} = \frac{1\times\pi\times\pi\times 2.1\times 10^6\times\frac{\pi}{64}\left(40^4-37^4\right)}{1293^2} = 383135.2kN$$

Safety factor, $n_K = \frac{P_K}{P_{\max}} = \frac{383135.2}{128200} = 3.1$

Oil cylinder satisfied the requirement of stability of compressive bar.

Strength calculation of the piston rod

(1) Calculation of initial deflection value δ_0 of the hydraulic cylinder

$$\delta_0 = \frac{\left(\triangle_1 + \triangle_2\right)l_1 l_2}{2al} + \frac{Gl_1 l_2}{2pl}Cos\alpha$$

In the formula, $\triangle_1$ was the fitting clearance of the piston rod and guide sleeve, taking $\triangle_1 = 0.0922cm$; $\triangle_2$ was the fitting clearance of the piston and cylinder, taking $\triangle_2 = 0.2289cm$; l_1 was distance from pin hole of the piston rod head to middle of the guide sleeve, taking l_1=373.5cm; l_2 was distance fro m pin shaft hole of the cylinder bottom end to middle of guide sleeve, taking l_2=377cm; l was the distance between the hydraulic cylinder pin hole on both ends, the piston rod full stretching, taking l=750.5cm; a was distance from guide set of sliding front end to the end of the piston sliding surface, piston rod full stretching, taking a=56cm; G was the weight of the cylinder itself, G=1250kg; α was Angle between the hydraulic cylinder and the horizontal plane, $\alpha = 89^\circ$; P was oil cylinder maximum thrust, taking P=128200kg.

$$\delta_0 = \frac{\left(\triangle_1 + \triangle_2\right)l_1 l_2}{2al} + \frac{Gl_1 l_2}{2pl}Cos\alpha$$

$$= \frac{\left(0.0922+0.2289\right)\times 373.5\times 377}{2\times 47\times 750.5} + \frac{1250\times 373.5\times 377}{2\times 128200\times 750.5}\cos 89^\circ$$

$$= 0.641 + 0.012$$

$$= 0.653cm$$

(2) Calculation of maximum deflection $\delta_{\max}$ of the hydraulic cylinder

According $J_2 < 5J_1$, $l_1 \neq l_2$, the maximum deflection calculation formula.

$$\delta_{\max} = \frac{\delta_0 l}{\left(\frac{K_1}{t_1} + \frac{K_2}{t_2}\right)\cdot l_1 l_2}$$

In the formula:

$$K_1 = \sqrt{\frac{P_{\max}}{E_1 J_1}} = \sqrt{\frac{128200}{2.1\times10^6 \times 9070.88}} = 2.9\times10^{-3}$$

$$t_1 = tg\left(57.3K_1 \cdot l_1\right) = tg\left(57.3\times2.9\times10^{-3}\times373.5\right) = 1.89$$

$$t_2 = tg\left(57.3K_2 \cdot l_2\right) = tg\left(57.3\times1.67\times10^{-3}\times377\right) = 0.73$$

$$\frac{K_1}{t_1} = \frac{2.9\times10^{-3}}{1.89} = 1.53\times10^{-3}$$

$$\frac{K_2}{t_2} = \frac{1.67\times10^{-3}}{0.73} = 2.29\times10^{-3}$$

$$\delta_{\max} = \frac{\delta_0}{\left(\frac{K_1}{t_1}+\frac{K_2}{t_2}\right)\cdot l_1 l_2} = \frac{0.653}{\left(1.53\times10^{-3}+2.29\times10^{-3}\right)\times373.5\times377} = 1.21x10^{-3}cm$$

(3) Strength checking of the piston rod

In the axial compression load and weight of hydraulic cylinder, on the cross section of the maximum deflection of the piston rod, the synthetic stress was:

$$\sigma = \frac{P}{A} + \frac{P\cdot\delta_{\max}}{\omega}$$

In the formula, P was maximum thrust of the piston rod, taking $p = 128200kN$; $\delta_{\max}$ was maximum deflection value of the hydraulic cylinder, $\delta_{\max} = 0.324cm$; A was section area of the piston rod, $A = 87.2cm^2$; ω was section modulus of the piston rod, computation formula was as follows.

$$\omega = \frac{\pi\left(D^4 - d^4\right)}{32D} = \frac{\pi\times\left(20^4 - 17^4\right)}{32\times20} = 375.4$$

$$\sigma = \frac{P}{A} + \frac{P\cdot\delta_{\max}}{\omega} = \frac{122500}{87.2} + \frac{122500\times0.324}{375.4} = 1510kg/cm^2 = 151MPa$$

45 steel has been used to the piston rod, $\sigma_S = 3000kg/cm^2$.

Safety factor: $n = \frac{\sigma_S}{\sigma} = \frac{3000}{1510} = 1.98$

By the calculation, meet the design requirements.

Calculation of wall thickness of the cylinder

Material of the cylinder was 27SiMn, $\sigma_b = 10000kg/cm^2$, Taking safety factor $n = 4$, so the allowable stress was:

$$[\sigma] = \frac{\sigma_b}{n} = \frac{10000}{4} = 2500kg/cm^2 = 250MPa$$

The maximum working pressure of the oil cylinder $P = 216.5kg/cm^2 = 21.65MPa$

$$\delta \geq \frac{PD}{2[\sigma]} = \frac{21.65 \times 30}{2 \times 250} = 1.299cm$$

The actual wall thickness of the oil cylinder

$$\delta^{'} = 1.5cm$$

$\delta^{'} \succ \delta$ Meet the requirements.

CONCLUSIONS

The popularity of cars has made more and more people start to look for the mobile life. Then, the industry of RV also prospers. By 1950, the RV has from homemade small canned room luxury villa development to 30 feet long. RV is known as the title of "home" on wheels, having two big functions following both "room" and "car". But its attribute is car, and is a kind of portable car having the basic facilities of home. The common types of RV are self-propelled, pull-type, mobile villa and cross-country. In the paper, starting from the actual needs of people, the outward extension part of the self-propelled A-RV has been converted into a balcony in order to make the person having a large living room, kitchen or bedroom and let people travel at the same time find the feeling of the real home. But in this paper, the hydraulic parts and working principle of the extend balcony in the central body have been designed and calculated.

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