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Research and design of new type of leisure chair

Qiulei Du[1], Liai Pan[2]*, Zixuan Cheng[3]
[1,2]Changchun University, Changchun, Jilin, 130022, (CHINA)
[3]Institute of Automation, Chinese Academy of Sciences, Beijing, 100190, (CHINA)
E-mail: panli636@126.com

ABSTRACT

Desk seats are frequently and widely used in people's work and study. Comfort of seat directly impacts on their health. In this paper, a common single armrest sofa is design prototype, and a number of new features are added into it, including verification and chassis design calculation headrest design, pallet rack design and chassis of gear mechanism. The seat design can meet people's multifaceted needs for work, study, entertainment and leisure.

KEYWORDS

Ergonomics; Seat; Gear; Functional design.

INTRODUCTION

With the rapid development of modern living, more and more people are working or studying in front of computer, where the most critical is seat. When comfortable seats meet the needs of people at work, even if working longer and you will not find some physical discomfort, but can improve efficiency; on the contrary, when seat is not designed to meet comfort demand, users will feel after working a long time body burden, and work long-term damage to body somewhat. According to ergonomics, people want to be comfortable sitting on the bench, so seat is designed to comply with the principles of human body, such as anatomy and physiology related to its structure type should be possible to adapt the various operating activities require sitting, so the operator kept at work, learning, leisure, entertainment and other activities of the body comfortable, stable and can be accurately controlled and operated[1]. The design ergonomically meets on the basis of seat functional structure of rational design added to sofa for prototype design, and this is both functional and convenient several functions on its structure. The seat design can meet people's multifaceted needs for work, study, entertainment and leisure.

DESIGN FEATURES AGENCY

Headrest mechanism design

People long-term work on seat, the most likely to cause neck muscle fatigue, causing neck and shoulder pain, muscle spasm items, and even dizziness. Over time, it will bound to appear in adulthood prematurely cervical disc degeneration, leading to cervical spondylosis. Design a comfortable headrest on seat, can alleviate these problems to some extent. The design of the headrest mechanism can move up and down in the vertical direction and positioning height, while a small angle of rotation of front and rear direction. The structure is installed two sliding guide bars at the bottom of headrest, guide rod can be moved axially, a ring to limit the vertical displacement of the guide rod through the spring clip. For rotated by the rotation of the clutch mechanism to achieve a rotational movement of 0 °-45 °.

Chassis structure design

The overall design of seat is located on top of a chassis. Chassis by lifting mechanism and curved swing frame composition. Seat height can be adjusted by the lifting mechanism on chassis. There are many common lifting mechanism, such as a hydraulic lifting mechanism, electric lift mechanism, screw lifting mechanism, etc., for the above institutions comparison is as follows:

(1) Hydraulic lift

Ascent: card lock piston chamber into oil, card body lock support rod; the next card lock piston chamber back to oil, the next release of card body; the main piston chamber into oil, jack rose a stroke 90mm. By locking the piston chamber into oil card, card body under the locking support rod; on locking piston chamber oil return the card, card body is released, the primary piston chamber under the action of the main oil return spring force, recovery in situ. Repeat the cycle, the implementation of automatic rising cyclical movements. Descent: the under-card locking piston chamber into oil, the next card body lock support rod; card lock piston chamber back to oil, card body is released, the main piston chamber into oil, pushing down on card body in the main piston move down 90mm, card locking piston chamber into oil, card body lock support rod; under lock piston chamber back to oil card, card body is released under the main piston chamber back to oil, hydraulic lift in the main spring force and since moving downwards under gravity jack 90mm. Jack restitution, repeat the next cycle, implementation of automatic cyclical decline in action[2]. Hydraulic lifting and descending are more suitable for high-power movements, for this design is also more economical principle is not very suitable.

(2) Electric lift

Electric lift is open motor driven rotating wire, wire pulling objects rising. Like it and snorkels for power lifting, and be powered by the seat is expensive, inconvenient to use.

(3) Screw lift

Screw lifting mechanism uses of threaded helix angle, lets rise screw driven rotary screw sets, simple structure, smooth movements, and the economy is also practical.

The combination of design, smooth surface chair lift requirement, since lifting rate is not great, so three institutions in line with this design screw lift requirements. The use of screw driving seat after lifting a certain height, the other part of the chassis - arc swing frame along emerge, then seat will be able to moderate shaking back and forth, people can relieve fatigue, played recreation function. Chassis is shown in Figure 1.

Figure 1 : Chassis mechanism

Pallet rack design

Pallet racks installed on the seat, mainly for the convenience of people using keyboard, mouse, laptop, placing cups, pens and other small items. Because this design is based on couch for the prototype seat sofa with a pair of rail inside of the space can be fully utilized. Pallet racks are divided into left and right halves, respectively mounted inside two rails, use time to stretch out on both sides of tray are butted together and interlocking lock can be used. Since the force on both sides of the tray, and therefore more stable. Tray is shown in Figure 2.

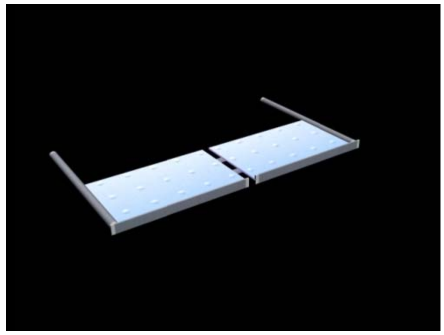

Figure 2 : Pallet rack

CHECK OF BEVEL GEAR ON CHASSIS

Chassis is main load-bearing part of this seat design, and the seat lifting is done by drive gear on the chassis. Thus gear chassis check is very important. Gear used to transmit motion and power between two intersecting axes. Because of bevel gear tooth width direction along section sizes, causing load along uneven distribution of tooth width direction, its force and strength calculations are quite complex, it is generally equivalent to the midpoint of tooth width spur gear as the basis for calculation[3].

The geometry of straight bevel gears equivalent gear

Z_1 is drive wheel with 25 teeth, Z_2 is driven wheel with 50 teeth.

u is gear ratio: $u = z_2 / z_1$ =50/25=2

Reference cone angle is: $tg\delta_1 = \frac{d_1}{2} / \frac{d_2}{2} = \frac{1}{u}$, $tg\delta_2 = \frac{d_2}{2} / \frac{d_1}{2} = u$, $\cos\delta_1 = \frac{u}{\sqrt{1+u^2}}$

$= \frac{1}{2}$ $=2$ $= \frac{2\sqrt{5}}{5}$

Virtual number of teeth is ： $z_{v1} = \frac{z_1}{\cos\delta_1}$, $z_{v2} = \frac{z_2}{\cos\delta_2}$

$= \frac{25\sqrt{5}}{2}$ $= 25\sqrt{5}$

Virtual number of teeth ratio is： $u_v = \frac{z_{v2}}{z_{v1}} = u^2$

=4

b is toothwidth and R is outer cone distance, then

Coefficient of toothwidth is： $\psi_R = \frac{b}{R_1}$

=5/20=0.25

Cone distance is： $R = 0.5d_1\sqrt{1+u^2}$

$=15\sqrt{5}$

Virtual diameter of gear is： $d_{v1} = \dfrac{d_{m1}}{\cos\delta_1}$, $d_{v2} = \dfrac{d_{m2}}{\cos\delta_2}$

$= \dfrac{70\sqrt{5}}{5}$ $= \dfrac{75}{\sqrt{2}}$

≈ 25 ≈ 25

Tooth width middle diameter： $d_{m1} = (1-0.5\psi_R)d_1$

=(1-0.5×0.25)×40=35

Tooth width midpoint modulus： $m_m = (1-0.5\psi_R)m$

=(1-0.5×0.25)×1.6=1.4

Stress analysis and load computation

In middle section of tooth width line in normal plane, normal force F_n can be decomposed into three components, circumferential force F_t, radial force F_r and axial force F_a.

(1) Magnitude of force

$$F_{t1} = \frac{2T_1}{d_{m1}} = \frac{2T_1}{(1-0.5\psi_R)d_1}$$

$$F_{r1} = F'_{r1}\cos\delta_1 = F_{t1}tg\alpha\cdot\cos\delta_1$$

=2.6/1.414=1.9

$$F_{a1} = F'_{r1}\sin\delta_1 = F_{t1}tg\alpha\cdot\sin\delta_1$$

$=1.9\ \dfrac{2\times 46}{(1-0.5\times 0.25)\times 40} = 2.6$

(2)Direction of force

Circumferential force F_t ：active in contrast to the steering wheel, a shift same with pulley;

Radial force F_r ：each point to wheel centre;

Axial force F_a ：each from little end to large end of wheel.

(3)Relationship of force

$F_{t1} = -F_{t2}$ $F_{r1} = -F_{a2}$ $F_{a1} = -F_{r2}$

(4)Load computation

$$F_{ca} = F_t K = F_t K_A K_v K_\beta K_\alpha$$

Where : K_A is valued as 1 according to the table ;

$K_v = 1.1 \sim 1.4$; $K_\beta = 1.1 \sim 1.3$; $K_\alpha = 1$

$$F_{ca} = F_t K = F_t K_A K_v K_\beta K_\alpha$$

$= 2.6 \times 1 \times 1.1 \times 1.2 \times 1$

=3.4

Tooth surface contact fatigue strength conditions[3]

Tooth surface contact fatigue strength by the midpoint of tooth width equivalent spur gear calculation. Strength due to straight bevel gears are generally lower precision manufacturing, can ignore the impact of overlap degree, namely omitted Z_ε, and take effective tooth width $b_{eH} = 0.85b$, the equivalent of the relevant parameters generation gear spur gear straightening formula, it can be gotten that

$$\sigma_H = Z_H Z_E \sqrt{\frac{2KT_{v1}(u_v + 1)}{b_{eH} d_{v1}^2 u_v}} \leq \sigma_{HP} \quad \text{(MPa)}$$

Substitute into the formula, and straight bevel gear contact strength calculation can be reached.

$$T_{v1} = F_{t1} \cdot \frac{d_{v1}}{2} = F_{t1} \cdot \frac{d_{m1}}{2\cos\delta_1} = \frac{T_1}{\cos\delta_1}$$

calibration formula:

$$\sigma_H = Z_H Z_E \sqrt{\frac{4KT_1}{0.85\psi_R(1-0.5\psi_R)^2 d_1^3 u}} \leq \sigma_{HP} \quad \text{(MPa)}$$

calculation formula:

$$d_1 \geq \sqrt[3]{\left(\frac{Z_H Z_E}{\sigma_{HP}}\right)^2 \cdot \frac{4KT_1}{0.85\psi_R(1-0.5\psi_R)^2 u}} \quad \text{(mm)}$$

Where : Z_H 、 Z_E 、 σ_{HP} is the same with that of straight spur gear.

Tooth bending fatigue strength condition

Same as contact fatigue strength calculation, ignore contact ratio coefficient Y_ε, according to tooth width of midpoint equivalent straight tooth cylindrical calculation, the parameters of equivalent gear, it can be gotten that

$$\sigma_F = \frac{2KT_{v1} Y_{Fa} Y_{Sa}}{b d_{v1} m_m} \leq \sigma_{FP} \quad \text{(MPa)}$$

Substitute T_{v1}, d_{v1} and m_m into the formula, we can get bevel gear tooth root bending fatigue strength condition calibration formula：

$$\sigma_F = \frac{4KT_1Y_{Fa}Y_{Sa}}{\psi_R(1-0.5\psi_R)^2 m^3 z_1^2 \sqrt{1+u^2}} \le \sigma_{FP} \quad \text{(MPa)}$$

design formula：

$$m \ge \sqrt[3]{\frac{4KT_1Y_{Fa}Y_{Sa}}{\psi_R(1-0.5\psi_R)^2 z_1^2 \sigma_{FP} \sqrt{1+u^2}}} \quad \text{(mm)}$$

SELECTION AND CHECKING OF THE BEARING

In this design, according to the size of the selected axis, the roller bearing 6206 has been selected. Inside diameter d = Φ 30 mm, outside diameter d = 62 mm Φ, width of the bearing B = Φ 16 mm[4].

Radial load of the bearing F_{r1} and F_{r2}

Space force system of the shafting components has been decomposed into two force system such as lead plane and horizontal plane. In this way, by another plus torque, one translated to the specified axis. This is that one of the Fac also should pass plus bending to translate to the axis. Assuming that weight of the people was 1400 N, the dynamic load was 1000 N. By mechanics analysis:

$$F_{r1v} = \frac{F_{re} \times 200 - F_{ae} \times \frac{d}{2}}{200+300} = \frac{1000 \times 200 - 1400 \times \frac{314}{2}}{200+300} = 225.38$$

$$F_{r2v} = F_{re} - F_{r1v} = 1000\text{N} - 225.38\text{N} = 674.62\text{N}$$

$$F_{r1\text{H}} = \frac{200}{200+300} F_{te} = \frac{200}{520} \times 2200\text{N} = 846.15\text{N}$$

$$F_{r1\text{H}} = F_{te} - F_{r1\text{H}} = 2200\text{N} - 846.15\text{N} = 1353.85\text{N}$$

$$F_{r1} = \sqrt{F_{r1}{}^2{}_v + F_{r2}{}^2{}_\text{H}} = \sqrt{225.38^2 + 846.15^2} = 875.65\text{N}$$

$$F_{r2} = \sqrt{F_{r2}{}^2{}_v + F_{r2}{}^2{}_\text{H}} = \sqrt{674.62^2 + 1353.85^2} = 1512.62\text{N}$$

Calculation of The bearing axial force F_{a1} and F_{a2}

For bearing 6206, axial force of the bearing Fd = ef. In the formula, e was coefficient of judgment. Its value has been determined by $\frac{Fa}{C_0}$, but now axial force of the bearing was unknown, so firstly taking e = 0.4, so you could estimate:

$$F_{d1} = 0.4F_{r1} = 350.26\text{N}$$

$$F_{d2} = 0.4F_{r2} = 605.05\text{N}$$

According to the formula, it could be calculated:

$$F_{a1} = F_{ae} + F_{d2} = 400\text{N} + 605.5\text{N} = 1005.05\text{N}$$

$$F_{a2} = F_{d2} = 605.5\text{N}$$

$$\frac{F_{a1}}{C_0} = \frac{1005.05}{20000} = 0.0503$$

$$\frac{F_{a2}}{C_0} = \frac{605.05}{20000} = 0.0303$$

Look-up table to $e_1 = 0.422, e_2 = 0401$ 。
Then, calculating:

$$F_{d1} = e_1 F_{r1} = 0.422 \times 875.65\text{N} = 369.53\text{N}$$

$$F_{d2} = e2F_{r2} = 0.401 \times 1512.62\text{N} = 606.56\text{N}$$

$$F_{a1} = F_{ae} + F_{d2} = 400\text{N} + 606.56\text{N} = 1006.56\text{N}$$

$$F_{a2} = F_{d2} = 606.56\text{N}$$

$$\frac{F_{a1}}{C_0} = \frac{1005.05}{20000} = 0.0503$$

$$\frac{F_{a2}}{C_0} = \frac{605.05}{20000} = 0.0303$$

The difference of the two the value calculating $\frac{F_{a2}}{C_0}$ was not big.
So, $e_1 = 0.422, e_2 = 0401$, F_{a1} =1006.56N, F_{a2} =606.56N

Equivalent dynamic load of the bearings P_1 and P_2

Thus obtained:

$$\frac{F_{a1}}{F_{r1}} = \frac{1006.56}{875.65} = 1.149 > e1$$

$$\frac{F_{a2}}{F_{r2}} = \frac{606.56}{1512.62} = 0.401 = e2$$

By interpolation calculation respectively, coefficients of the radial load and axial load were

X_1=0.44

In the practical work, working conditions of bearing were variety. To this end, the actual work load has been conversed to the experiment load under the same condition of the imaginary life, which was equivalent load.

For Only bearing radial load:

$P = rf_p$

For only bearing axial load

$P = af_p$

For other kinds of bearings:

$P_r = f_p\ (Xr+Ya)$

In the formula: r was actually radial load of the bearing; a was actually axial load of the bearing; X was the radial conversion coefficient of load; Y was the axial conversion coefficient of load; f_p was load coefficient, considering the change of the load and stress, such as machine inertia.

When human sited down, the axial dynamic load was:

$$P_1 = f_p(X_1F_{r1} + Y_1F_{a1}) = 1.5\times(0.44\times875.65 + 1.327\times1006.56)\text{N} = 1922.26\text{N}$$

$$P_2 = f_p(X_2F_{r2} + Y_2F_{a2}) = 1.5\times(1\times1512.62 + 0\times606.56)\text{N} = 2268.93\text{N}$$

Calculating formula of the bearing life

By the following formula of bearing, its life has been calculated.

$$L_{10} = \left(\frac{C}{P}\right)^{\varepsilon}$$

In the formula: L_{10} was the basic rating life (106), when the bearing load was P; C was the basic dynamic load, N; ε was index. For the ball bearing: ε= 3. For roller bearings: ε= 10/3.

$$L_h = \frac{10^6}{60n}\left(\frac{C}{P_1}\right)^{\varepsilon} = \frac{10^6}{60\times520}\times\left(\frac{30500}{2581.49}\right)^3 = 52960.17h > L'_h$$

So,

Therefore, the bearing what selected met requirements.

CONCLUSIONS

In this design, sizes of some structures combined ergonomics and the basic size of sofa. Checking the results of the chassis bevel gears and bearings of the main body met the requirement of the design. Functions what the leisure chairs added could effectively alleviate the pressure what people work and learning, and had a good reflect in terms of recreation. Chairs what been designed can meet people's work, study, entertainment, leisure, the various requirements. It is a reasonable, multi-function and good product.

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