INTRODUCTION

Increasing the productivity and accuracy are the two basic aims of mass production. In this case the device that caters our needs is the use work holding device. As we all know the work holding device is a special tool for holding a work piece in proper position during manufacturing operation. For supporting and clamping the work piece, device is provided. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process is eliminated by fixture. This increase machining accuracy, productivity and reduce operation time, but the main concern is the fastening of the fixture. The fixture should be so chosen that the fastening of the job to the table is done quickly and accurately and it is mainly used in milling operation. Work holding device is widely used in the industrial practical production. To locate and immobilize workpieces for machining, inspection, assembly and other operations work holding devices are used. Work holding device are used to determine the position and orientation of a workpiece; Clamping has to be appropriately planned at the stage of machining fixture design. The design of a work holding device is a highly complex and intuitive process, which require knowledge. Work holding device design plays an important role at the setup planning phase. Proper work holding device design is crucial for developing product quality in different terms of accuracy, surface finish and precision of the machined parts in existing design the fixture set up is done manually, so the aim of this project is to increase the machining accuracy of front axle beam and to save time for loading and unloading of component. These work holding device also help in simplifying the network operations which are performed on special equipment.
Design considerations:
The points that are taken into consideration for designing a product are as following:
1. Work holding device should be so strong that the deflection in the device should be as less as possible. The deflection that includes the forces of cutting, clamping of workpiece to the machine table. The frame of the fixture should have sufficient mass to prevent vibrations during the machining of the job.
2. Another important design consideration is the clamping which should be fast enough.
3. Require less amount of effort and they should also have the arrangement for easy removal as well.
4. In swinging of clamp system is provided so that while removal of workpiece the clamp should swing as far as possible for unclamping the device.
5. The clamps and support points which are to be adjusted in due course of time should be preferred of same size.
6. If the surface area of clamping is more it will not fit the workpiece properly. This can be avoided by making the surface area of clamping as small and proper size as possible.
7. It is designed in such a way that parts can be easily replaced on failure of device.
8. The study of the design should be done thoroughly before analysis and designing. It should always be ensured that the work is done in proper sequence and order. This will ensure zero error during designing parts in NX software and during ansys stress acting.
9. It has been preferred that there is maximum operation in a single setting of the holding device.
10. The movement of the holding device is restricted i.e. there is zero degree of freedom of the workpiece after clamping the workpiece.
11. The design must possess enough rigidity and robustness to prevent vibration else it may lead to undesired movement of the workpiece and tools.
12. Minimum cost should be done during the fabrication of the project and the design should be as simple as possible.

Component Details:

![Fig.1. Front Axle Beam (HCV)](image)

This component is used in automotive applications. The component is made up of

| Table.No.1 |
|-------------|----------------|
| **Name**    | Front axle beam (HCV) |
| Material    | S 58C           |
| Component weight | 114.5 kg     |
| Yield tensile strength | 324           |
| Thermal expansion | 11.9 µm/m-k  |
| Density     | 7.8 gm/cm³     |
Design of Work Holding Device:

Force acting on the work holding device is \( R_B \) –

\[
R_B = \frac{\text{Weight of front axle beam (N)}}{2 \times \text{Inclination of front axle beam to the work holding device}}
\]

\[
= \frac{114.5 \times 9.81}{2 \times \cos(11)} = 561.22 \text{N}
\]

Various elements of a work holding devices are as follows
i. Power screw
ii. Spring
iii. Spherical rolling joint

Design of power screw:

Given data:
Force, \( F = 561.22 \text{N} \)

\[
\sigma_c = \frac{W}{\pi d_c^2}
\]

\[
162 = \frac{57.25 \times 9.81 / \cos 11}{\pi d_c^2}
\]

\[
d_c^2 = \frac{572.1342}{127.23} = 2.1205 \text{ mm}
\]

Normal series of power screw start

- Square head: \( d = 22 \text{mm} \)
  - \( p = 5 \text{mm} \)
  - \( D_i = d = 24 \text{mm} \)
  - \( P = 5 \text{mm} \)
  - \( D_o = D = d + p = 29 \text{mm} \)
  - \( \mu = 0.12 - 0.15 = 0.13 \)
  - \( \mu_c = 0.12 - 0.18 = 0.15 \)
  - \( \tau = \rho \times \frac{d_m}{2} \)
  - \( \rho = \frac{W \times \tan(\varphi + \alpha)}{\pi d_m} \)
  - \( \varphi = \tan^{-1} \left( \frac{1}{\pi d_m} \right) \)
  - \( = \tan^{-1} \left( \frac{5}{\pi (26.5)} \right) = 3.436^0 \)
  - \( \rho = W \times \tan(\varphi + \alpha) \)
\[ = 572.1342 \cdot \tan(7.4069 + 3.4369) \]
\[ = 109.59 \text{N} \]

\[ T = \rho \cdot \frac{d_m}{2} \]
\[ = 109.59 \cdot \frac{26.5}{2} \]
\[ = 1452.117 \text{N/mm}^2 \]

\[ T_c = \frac{\mu_c \cdot W}{0.15 \cdot 572.1342 \cdot [29 + 24]} \]
\[ = \frac{4}{4} \]
\[ = 1137.116 \text{N/mm}^2 \]

\[ T_t = T + T_c \]
\[ = 1452.117 + 1137.116 \]
\[ = 2589.233 \text{ N/mm}^2 \]

\[ \tau = \frac{\pi \cdot d_c^3}{16 \cdot 2589.233} \]
\[ = \frac{\pi \cdot 24^3}{16} \]
\[ = 0.95 \text{N/mm}^2 \]

\( \tau < \tau_{th} \), Hence design is safe.

\[ \sigma_t = \frac{W}{\frac{\pi}{4} \cdot d_c^2} \]
\[ = \frac{572.1342}{\frac{\pi}{4} \cdot 24^2} \]
\[ = 0.0525 \text{ N/mm}^2 \]

\( \sigma_t < \sigma_{cc} \), Hence design is safe.

**Design of spring:**

**Given:**

Force \( F = 561.22 \text{ N} \)

Material = Carbon steel wires oil-tempered wire.

\( C = 0.6 - 0.7 \)

\( M_n = 0.6 - 0.9 \)

Yield strength = 1400 N/mm\(^2\)

Tensile strength = 420 N/mm\(^2\) (Machine design S.S Wadhwa)

For the direct all loading \( W = 572.1342 \text{ N} \)

\[ K_w = \frac{4C - 1}{4C - 4} \cdot \frac{C}{4 + 5 - 1} \cdot 0.615 \]
\[ = \frac{4 + 5 - 4}{5} \]
\[ = 1.3105 \]

\[ \tau = \frac{8WC}{\pi d^2} \cdot K_w \]
\[ = \frac{420}{\pi \cdot 4.36^2} \cdot 5 \cdot 1.3105 \]
\[ = 19.56 \]

\( d = 4.36 \text{mm} \approx 4.5 \text{mm} \)

Spring Index

\[ C = \frac{d}{D} \]  \( D = C \cdot d = 4.5 \cdot 5 = 22.5 \text{mm} \)
The spring is design for only the swiveling mechanism & the swiveling mechanism till upto $30^\circ$

\[
\theta = 30^\circ
\]

\[
\delta = \frac{D}{2} \times \theta = \frac{22.5}{2} \times 30 \times \frac{\pi}{180} = 5.89
\]

Stiffness (K)

\[
K = \frac{w}{\delta} = \frac{572.1342}{5.89} = 97.1365
\]

\[
k = \frac{Gd}{8C^3n} = \frac{80 \times 10^3 \times 5}{8 \times 5^3 \times n} = 5
\]

Total number of coils
for square & ground ends, the number of in active coils is 2

\[
N = n + 2 = 5 + 2 = 7
\]

**Design of spherical rolling joint:-**
Spherical rolling joint is selected from the standard design based on total load acting on the joint as shown in below:

![Fig.2. Spherical Rolling Joint.](image-url)
Result and Discussion:-
The model is designed in Nx and analyzed in ANSYS software. This software is capable of giving the user post deformation and stress on the model after applying a force. This result includes maximum principal stress, von-mises stress and total deformation stress along x, y, z axes. By considering the milling operation on SPM, we analyzed that due to proper clamping of front axle beam with help of work holding device the accuracy of KP top face milling operation of front axle beam increases. Hence the following result has been achieved using work holding device.

![Fig.3. Maximum Principal Stress](image)

Table.No. 2:-

| MODEL | SHAFT THREAD RECOMMENDED TORQUE (N-m) | COMPRESSION LOADS | TENSILE LOADS | WEIGHT (kg) | MAXIMUM SWING ANGLE |
|-------|---------------------------------------|-------------------|---------------|-------------|---------------------|
|       | C (Nm) | Co (Nm) | T (Nm) | To (Nm) |               |
| SRJ004C | 0.6 | 128 | 100 | 38.4 | 30 | 0.015 | ±15° |
| SRJ006C | 1.57 | 320 | 280 | 96 | 84 | 0.036 | ±30° |
| SRJ008C | 3.22 | 490 | 540 | 147 | 162 | 0.06 | ±30° |
| SRJ012C | 23.19 | 720 | 770 | 216 | 231 | 0.16 | ±30° |
| SRJ016C | 40.45 | 1170 | 1300 | 351 | 390 | 0.37 | ±30° |
| SRJ024C | 64.37 | 2830 | 3020 | 852 | 1176 | 0.93 | ±30° |
| SRJ032C | 100.44 | 5000 | 6020 | 1760 | 2646 | 2.30 | ±30° |
| SRJ048C | 600.00 | 10000 | 10000 | 3180 | 4600 | 6.73 | ±30° |

C and T stand for working dynamic loads, Co and To for working static loads.
Conclusion:
Observing clearly the milling operation on special purpose machine we have concluded that, the Squareness of KP top face with bore of front axle beam which was out of tolerance because the locators are placed on rough surface. For this the outcome of work is to place the work holding device on prefinished surface due to which the errors are minimized as well as loading and unloading time decreases and increase in productivity simultaneously. For this operation, new work holding device was designed using screw jack and spherical rolling joint with helical compression spring mechanism for best accuracy.
References:
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