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A PATH FOR HORIZING YOUR INNOVATIVE WORK

FAILURE SAFE DESIGN AND ANALYSIS OF PIVOT PIN IN GEARBOX

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Abstract: A gearbox is for transmitting mechanical power from a prime mover into some form of useful output. It is referred to the metal casing in which a number of gears are sealed and under the gearbox pivot pin is fitted for shifting the gear. It is seen that the component Pivot Pin has failed in few Vehicles after completion of certain Kms. So we assumed that the problem is of fatigue failure and for that we made some changes in machining process and with the help of that changes calculation analysis are done to verify the design. In the proposed work, calculations are done for design of lever and design of modified pivot pin in gearbox. Later on it is verified with the help of ANSYS. This technical paper is on Failure safe Design & Analysis of Pivot Pin in Gearbox. ANSYS is used for stress analysis. The main purpose of the work is to make Failure safe design and for improving the life of the pivot pin. After the analysis of pivot pin from existing gearbox the safe design is made.

Keywords: Pivot pin, Lever, FEA, Knob, Bending stress, Fatigue Failure, Von Mises stresses.

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INTRODUCTION

Pivot pin fitted in lever of gearbox and it is used for shifting the gears in gearbox. It is seen that the component Pivot Pin has failed in few Vehicles after completion of certain Kms.

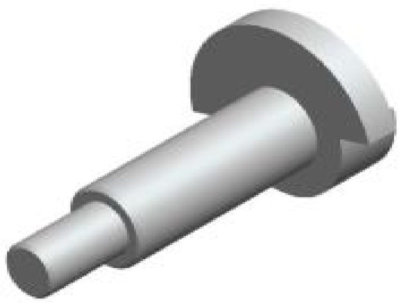

Fig 1

So for that we made some changes in machining process because the problem of fatigue failure. The modification work is already given in previous paper "Failure Diagnosis & Design Modification of Pivot Pin in Gearbox for Avoiding Failure" in IJETAE journal Volume 4 Issue 2.

We found the reason for failure of the pivot pin is due to fatigue failure. It is seen that all pin breaks in same manner at the same cross section near the Relief Groove. To relieve these stress concentration modifications in the design of pivot pin were done.

So, we have considered a failure problem of pivot pin in gearbox. In this paper, calculations are done on modified Pivot Pin and these calculation results are verified with help of FEA software ANSYS.

I. Design Calculation :

01) Design of Lever

This component is normally subjected to Bending and Buckling Loading.

The material used EN 8.

Material Properties EN8 as shown in table,

	EN 8 / AISI 1040
Young's Modulus E (GPa)	195
Max.Stress S_u (MPa)	520
Yield stress S_{yp} (MPa)	245
Allowable Stress S_a (MPa)	260

The following basic elements considered for designing LTV shifter lever.

Internal design inputs from calculation sheet,

The output load:

Load at knob L_1 = 5 kg

Load at knob L_2 = 8 kg

Load at knob L_3 = 15 kg ………..(Critical load)

The operating environment:

General environment condition for India

Max. Operating Temperature 100˚ will not affect Thermal loading.

Heavy Vibrating Conditions

Factor of Safety (N_{fs}): 3

Design for Buckling:

Dimensions are already available,

Diameter 12mm,

Length of Lever 328mm,

L/D > 20 (For long column)

27.33 > 20

It is the case of **long column**.

$Fbe = (\pi^2 \times E \times I) / L_{effc}^2$ ……………..(1)

Where,

Fbe = Buckling Force by Euler's Formula.

L_{effc} = 2.1L = 688.8 (One end fixed and other free)

E = Modulus of elasticity

= 200 GPa (Approx.)

I = Area Moment of inertia of the cross-section of column

$= \pi d^4 / 64$ ....(2)

= 1017.87 mm^4

L = length of the column

= 328 mm

Obtained value from the formula,

Fbe = 134.7 kg (calculated value)

By considering factor of safety 3 the load arrives 44.9 kg.

Maximum bucking load can be withstand by this Lever is 44.9 kg in static condition. Design will be safe as per buckling load condition.

02) Design of Select Pivot Pin

Calculation for maximum Bending Load at Select Pivot Pin, (Where Pin is Broken)

Allowable Bending Stress $S_{AB} = S_y / 3$ = 81.66 MPa

Pivot Pin Dia. = 12.15mm

I = 1069.73mm^4

Length of Pivot Pin = 32.55mm

S_b = Bending Stress

Moment at Pivot end = W_M x 32.55

W_M =Maximum Load at End of the Lever (Unknown)

S_{ab} = (M x Y) / I ....(3)

Y = Neutral axis = 12.15 / 2 = 6.07 mm (According to Drawing)

W_M = 44.2 kg (Calculated manually)

Pivot can withstand maximum Load up to **44.2 kg** in very critical condition.

Calculation for maximum Shear Load at Select Pivot Pin, (Where Pin is Broken)

Allowable Shear Stress S_{AS} = S_y / 4 = 61.25 MPa **(Factor of safety is 4)**

Pivot Pin Dia. = 12.15mm (According to Drawing)

W_{MSL} = 177.24 kg (Calculated manually)

Pivot can withstand Maximum Shear Load up to 177.24 kg in very critical condition.

Calculation for Breaking Load at Select Pivot Pin, (Where Pin is Broken)

The Select Pivot Pin is broken due to the load which is induced by the Load on knob.

This design is based on Maximum load (L_3 =) 15 kg.

Solution of the problem can be solved by understanding of the simple mechanics.

The below figure tells the arrangement of the Shifter where AB indicates the Select Pivot Pin Length (The total length is 32.55mm divided by 2 where Lever is assemble), BC indicates Lever Length 328mm

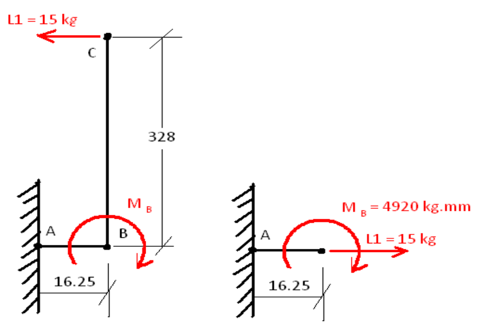

Fig 02. Simplified Diagram

Due to 15 kg of load and 328mm length moment force will be act over the point B.

This Moment will be M_B = 15 x 328 = 4920 kg.mm

Sign will be positive.

But, Select Pivot Pin having Length 16.25 mm.

So Load at point A will be,

F_A = 4920/16.25 = 302.76kg.

This load is the maximum Shearing load at the face where pin is broken.

By calculating simple shearing at the Select Pivot Pin,

Load = 302.76 kg (Calculated)

Critical diameter of the Pin = 12.15 mm (as per Drawing)

S = P/ (Cross sectional area of Pin) ……………………….(4)

S = 26.11 MPa …………(Ans)

This arrived value is very less as compare to Allowable Shear Stress (S_{AS})

Allowable Shear Stress $S_{AS} = S_Y$ / 4 = 61.25 MPa (Factor of safety is 4)

Calculation for Maximum Load at Knob, (Where Pin is Broken)-

This calculation will be gives the maximum value of load which can break the Select Pivot Pin.

If Allowable Shear Stress $S_{AS} = S_Y$ / 4 = 61.25 MPa (Factor of safety is 4)

Here FOS is taken for Non homogeneity of the Material Properties.

This value can gives us the results in worst condition.

Then what will be the maximum Shear Load at Pivot Face.

By using equation (4),

P_{MAX} = 710.14 kg ………(Calculated)

Moment at Point B will be M_B,

M_B = 710.14 x 16.25 = 11539.77 kg.mm Breaking Load at Knob can be calculated as,

L_{BL} = 11539.77 / 328 = 35.18 kg ……………….. (Calculated)

This value is arrived by considering factor of safety 4 which shows worst condition results.

To break Select Pivot Pin the load 35.18 kg is required.

II. FEA of Pivot Pin:

Design Analysis by FEA Results

In previous chapters we have shown manual calculations for Lever and Select Pivot Pin.

All generated data will be verified by FEA approach here in this chapter.

Select Pivot Pin is failure due to bending load is our assumption.

To making model very easy for fast computation on FEA we have removed undercut and threaded portion of the Select Pivot Pin. Generally FEA is all about garbage in garbage out but for making more understanding.

Pin is welded at two points one is from its bake support and then from wedge portion. Where Pin is welded we have provide constrains.

By focusing worst scenario of braking of Pin the load will be form due to Knob then Lever.

This force will form on one face of the Pin but not entire Pin (Only Half Portion).

There are two types of cases explained

(1) Load at knob is 15 kg and Resultant 302kg (Calculated Earlier)

When load of 15 kg applied over the knob then resultant will form at Select Pivot Pin is 302 kg.

This 302 Kg static load we have apply at Pin portion,

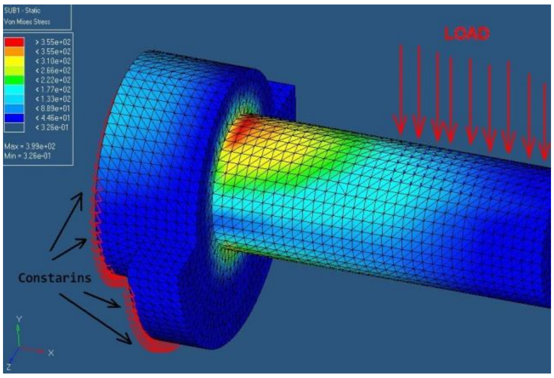

Fig. 03, Knob Load 15kg and Max. Stress value 399 MPa

Figure shows the Von-Mises Stress value at corner of the Pin.

(1)Load at knob is 20 kg and Resultant 400kg.

When load of 20 kg applied over the knob then resultant will form at Select Pivot Pin is 400 kg.

This 400 Kg static load we have apply at Pin portion,

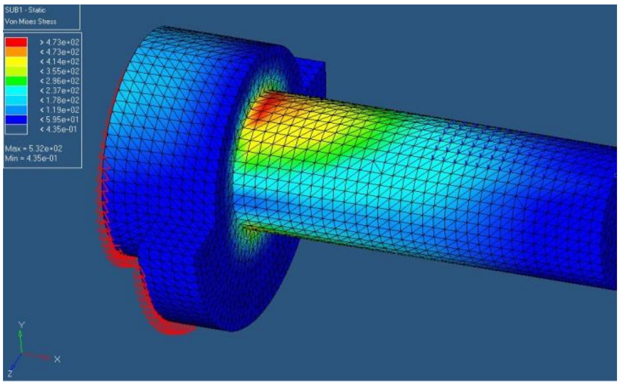

Fig. 04- Knob Load 20kg and Max. Stress value 400 MPa

Figure shows the Von-Mises Stress value at corner of the Pin.

Design is safe for 20 kg loading at Knob.

III.Result & Discussion:

We have successfully verified the Design of modified pivot pin.

1] The Maximum Stress value is 399 MPa which is less then ultimate Stress value 520 MPa.

Design is safe for 15 kg loading at Knob

This Modification shall over design the Part thereby making it Failsafe at Much Higher Loads.

2] The Maximum Stress value is 532 MPa which is almost at ultimate Stress value 520 MPa.

In above Figure the RED region indicates the maximum stress area where stress values are very high. It will not break the Pin because high stress region cover up to 2 nodes only.

Design is safe for 20 kg loading at Knob.

Further work can be done in a few areas of the fatigue failure of pivot pin as mentioned earlier. Overall, these would improve the life of Pivot pin for better performance.

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