Analysis and Improvement in Development of Gearbox Assembly Three Wheeler Cargo Vehicle

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Abstract: This Study investigated the process improvement and development for the gearbox of cargo three wheeler diesel vehicles by analysis through field complaints, observation and finding the root cause of gearbox dereliction. Solid Modelling and Stiffness Analysis in Solidworks 3D Modelling. The process includes modelling and corrective testing of vehicle on roads. The impact of development reflects on performances and engine smooth gear shifting

Index Terms **- Stress, Strain, Stiffness, Speed Gear, Ball bearing, Shim, Washer, CMM Program, GB Assy., NRB Bearing, Three Wheeler, CI and SI Engine.**

I. INTRODUCTION

ATUL AUTO LIMITED is leading Three-wheeler contrive industry in India. Vehicles manufactured in industry are Diesel Paxx and cargo vehicles with FE and RE engine. CI engines are heavy with high CR in comparison of SI engines. Atul Auto Limited had recently introduced their new model of Atul Gem Premium Cargo Dz. Gradually the grievance of gearbox failure is reported. Additionally, vehicles on the road and problems reports also increased [1].

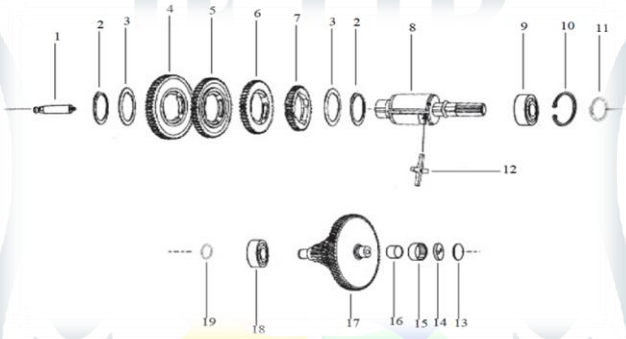

Fig. 1 Dismantling Speed gears and transmission

The absolute analysis and process improvements is needed to be done to increase the gearbox lifespan and vehicle sustainability in competitive market. The following field affliction are noted while vehicle on road testing.

1) Cluster gear needle bearing failure.
2) Cluster gear needle bush bore oval/damage/ restitution.
3) Main housing damage/crack/fracture ascribed to cluster gear.
4) ES cover crack/damage/crash ascribed to cluster gear.
5) Cluster gear bearing collapse/failure.

II. OBSERVATION

Above all problems emerges ascribed to needle bearing failure. After some running of vehicle excessive play occurs between needle bearing & cluster gear & This will disturb alignment of cluster gear. Moving component bearing disappointment investigation, tends to Rolling Contact Fatigue (RCF) happens because of the aftereffect of cyclic pressure created amid task and instrument that include in worrying disappointment of moving component bearing [1]. Load analysis, oil pressure, gear working, gear wear pattern, washer thickness, needle bearing overhanging, over load analysis etc. were the possibilities to find the failure of gearbox and prevent for failure [2].

III. ROOT CAUSE

1) Less defoliated area between washer & Cluster gear face, dimension 23.4mm contaminating ES cover.
2) In All most failure cluster gear face rubbing with washer & metal slug enter in bearing & get failed.
3) NRB force and torque analysis for bearing load.
4) Contrive defect in housing plant.
5) Vibration and axial play of cluster when power transmitted from cutch to cluster gear.

IV. DIMENSION OF NRB

1) Inner diameter without roller: - 22.53 mm
2) Inner diameter with roller: - 22.21 mm
3) Outer diameter of NRB Shell: - 28.04 mm
4) Inner cage f NRB shell: - 15.90 mm
5) Total height of NRB: - 16.17 mm

Fig. 2 Part Assembly of Needle Roller Bearing

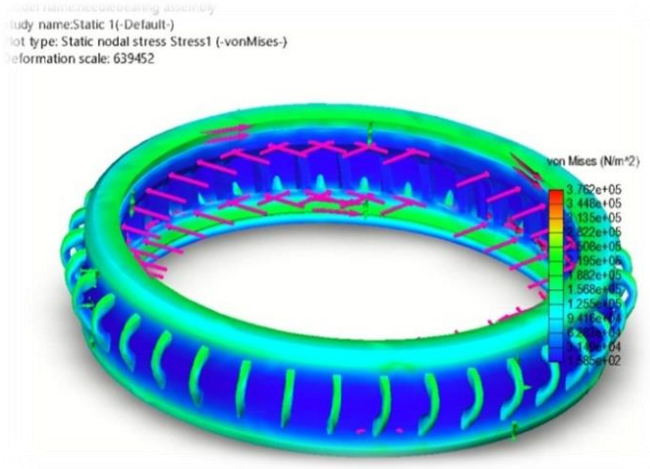

Fig. 3 Stress Analysis of Inner ring

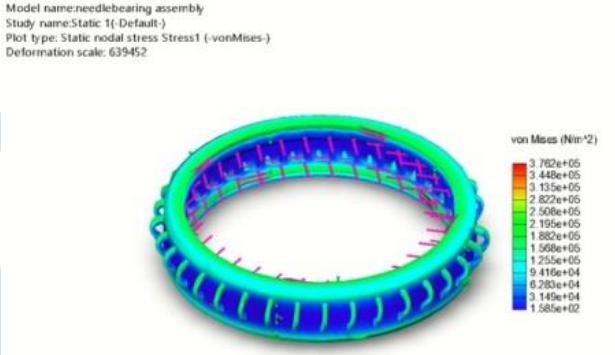

Fig. 4 Load Analysis of Needle Bearing Inner ring

From Research paper, with non-uniform preload conditions at 120N, 240N, 360N and 480N, the force on bearing is acted upon through both the axial preload and moment [9].

By strategies for thorough and deliberate examination concerning the base materials, process media, surface morphologies, little scale an area pieces and even organization circumstances, primary drivers of this failure were settled, separated instruments were discussed, and proper countermeasures were proposed [2]. We appertain out Stiffness Analysis of a model roller bearing in "build in a structure". Ascribed to the meshing of rollers and inner ring the examination takes rational running time. The modelling of needle roller bearing is shown.

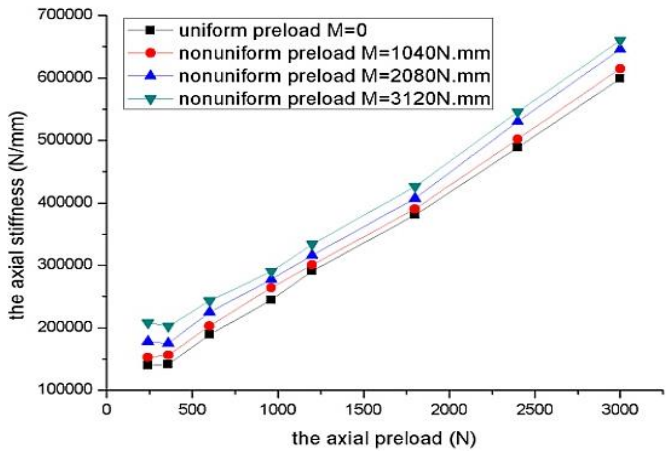

Fig 4.1 Angular stiffness v/s Equivalent Moment Graph

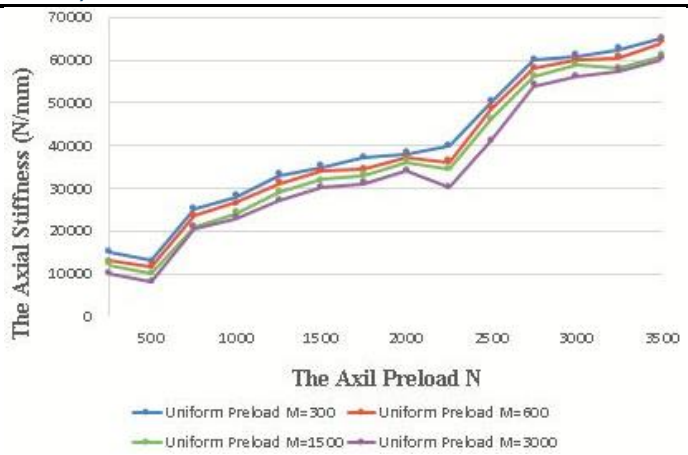

Fig. 5 Angular stiffness v/s Equivalent moment

V. PROPOSED ACTION

1) Engine side cover Dim. 22.9 – Corrected.
2) Washer thickness changed from 4.0mm to 3.5mm to create more defoliated area B/w. cluster gear face & washer.
3) Needle bearing pressing mandrill OD reduced to maintain bearing position wrt. Bore depth in main center housing.
4) Ball bearing pressing tool reorganized, while pressing on cluster gear reference changed from Outer ring to Inner ring of ball bearing (Because of closer tolerance b/w Cluster gear & Inner ring, compare to outer ring & ES cover).
5) CMM program modified to cover up all critical dim. Related to GB assy. For Main center housing, Engine side cover & Gearbox cover.

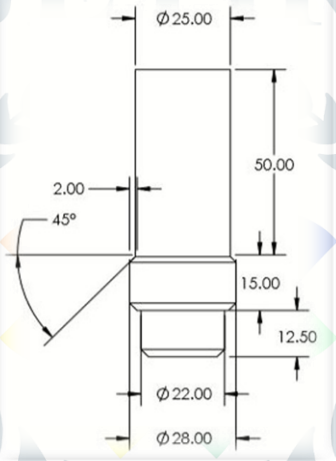

Fig. 6 Before modifying NRB Pusher

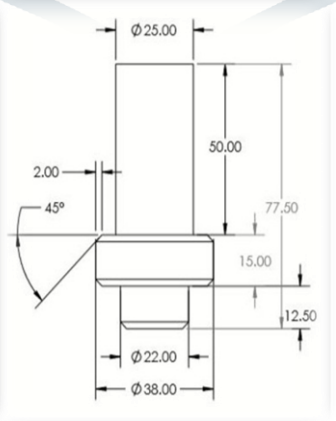

Fig. 6.1 After modifying NBR Pusher

6) Exhaust Cover Assy. Housing : Ball bearing pusher modified. While assy. of engine side cover on main center housing, hammering required on ball bearing to fix on cluster gear. Before hammering reference was outer ring of bearing with possibility to create excess play between inner ring and outer ring. After hammering reference started on inner ring of bearing and now no load emergence on ball or outer ring of bearing while assy.

Fig. 7 Main Shaft ES Cover

7) Gap between cluster gear face and washer (NRB Side): Washer Thickness changed from 4mm to 3.5 mm. this will create more defoliated area between Washer and Cluster gear face at needle bearing end. The washer placed in housing of cluster of NRB side gap between cluster gear face and washer before was 4 mm thickness with least gap of 0.3 mm and maximum gap of 1.3 mm. After modified washer the thickness reduced to 3.5 mm with least gap 0.8 mm and maximum gap of 1.8 mm.

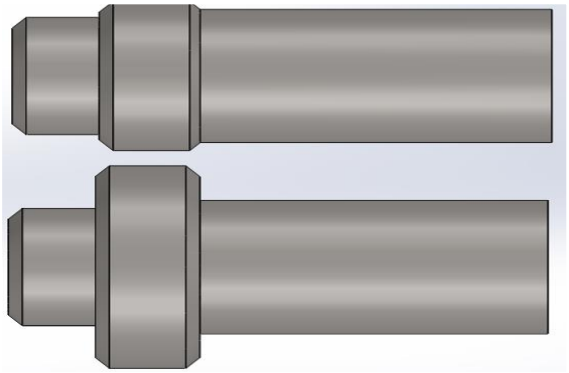

Fig. 8 NRB Pusher reorganized

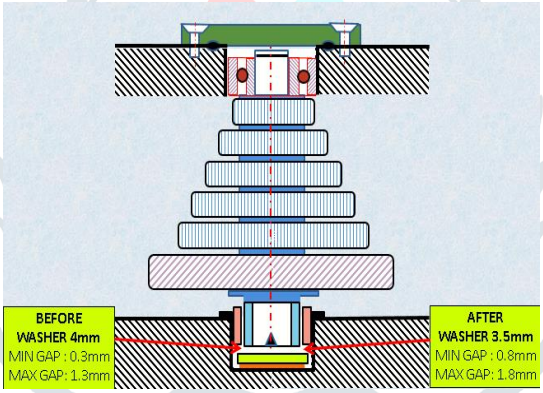

Fig. 9 Cluster Gear Reorganized

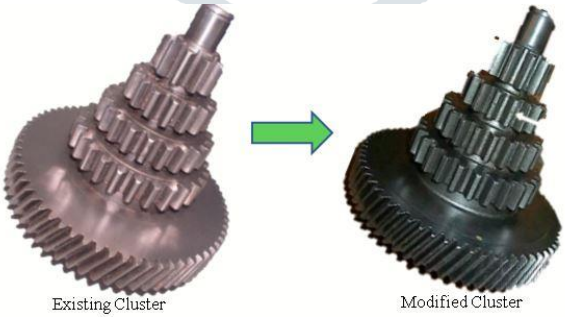

Fig 10 Cluster Gear Modified

8) ES cover Dimension corrected: ES COVER Dimension 22.9 (+0.1) corrected and reorganized up to 22.760 mm. It can be creating less defoliated area between washer and Cluster gear face at needle bearing end.
9) For the verification of the model simulation, research and simulation work one on needle roller bearing further field vehicle research conducted and daily report is made.

Table 1.1 Loads applied in ring part in analysis

Name	Points
2340 Steel 48 HRC (unnotched)	50000 1e+09
2340 Steel 48 HRC (unnotched)	100000 9.3999998e+08
2340 Steel 48 HRC (unnotched)	400000 8.6499998e+08
2340 Steel 48 HRC (unnotched)	1000000 8.2999998e+08
2340 Steel 48 HRC (unnotched)	3000000 8.2499997e+08
2340 Steel 48 HRC (unnotched)	10000000 8.2499997e+08
2340 Steel 48 HRC (unnotched)	1e+08 8.2499997e+08
Gray Iron: Alloy Iron, 1% Ni, 0.4% Cr, 0.6% Mo, 1.0% Mn	20000000 1.3651619e+08
Ductile Iron: Ferritic (60-40-18 annealed)	70000 1.95e+08
Ductile Iron: Ferritic (60-40-18 annealed)	100000 1.85e+08
Ductile Iron: Ferritic (60-40-18 annealed)	550000 1.5e+08

VI. EFFECT OF MODIFICATION

Modification appertains out on cluster gear and hardened shim in order to prevent failure of gearbox.

a) One step added at the support shaft diameter of 22 mm, Depth: - 1.5 mm
b) Cluster gear support end length increased to equalize with the length of the inner ring: 13 mm.
c) Shim diameter of 25.50 mm & Hardened 2 mm changed.

VII. INSPECTION PROCEDURE FOR MODIFICATION:

By pressing the needle bush in to a ring gauge of sufficient wall thickness to avoid distortion size of the truly round and cylindrical bore of gauge: 35.645 mm.

Plugging the bearing with: -
GO GAUGE: 28.621 mm
NO GO GAUGE: 28.673 mm.
Mass properties of Needle Inner Ring
Mass = 126.914 g
Volume = 16.482 cm^3
Surface Area = 954.97 cm^2

Center of mass: (cm)

$X = 9,3\ Y = 4.56, Z = 8.64$

Principal axes of inertia and principal moments of inertia: ($g.cm^2$)

Taken at the center of mass.

$I_X = (8672832.82, -1290.88, 4978149.17)$ $P_X = 4625.04$
$Iy = (4978142.64, 18645.16, -8672816.62)$ $P_Y = 4670.60$
$I_Z = (-8162.28, 9999982.53, 16813.26)$
$P_Z = 9140.53$

Moment of Inertia: ($g.cm^2$)

Taken at the center of mass and aligned with the output coordinate system.

$$L_{XX} = 4636.33$$
$$L_{XY} = 3.64$$
$$L_{XZ} = 19.68$$
$$L_{YX} = 3.64$$
$$L_{YY} = 9140.52$$
$$L_{YZ} = -7.52$$
$$L_{ZX} = 19.68$$
$$L_{ZY} = -7.52$$

$$L_{ZZ} = 4659.32$$

Moment of Inertia: (g.cm^2)
Taken at the output coordinate system.

$$I_{XX} = 125835.70$$
$$I_{XY} = 53831.56$$
$$I_{XZ} = 102069.58$$
$$I_{YX} = 53831.56$$
$$I_{YY} = 213791.79$$
$$I_{YZ} = 50006.22$$
$$I_{ZX} = 102069.58$$
$$I_{ZY} = 50006.22$$
$$I_{ZZ} = 140872.38$$

Principal axes of inertia and principal moments of inertia: (g.cm^2)
Taken at the center of mass.

$$I_X = (6260175.67, -8458.70, 7798084.96)$$
$$P_X = 3.62e+03$$
$$I_Y = (7798085.82, -2977.55, -6260179.60)$$
$$P_Y = 4.17e+03$$
$$I_Z = (7617.22, 9999995.98, 4732.17)$$
$$P_Z = 7.64e+03$$

Moment of Inertia: (g.cm^2)
Taken at the center of mass and aligned with the output coordinate system.

$$L_{XX} = 3.96e+03$$
$$L_{XY} = -2.93e+00$$
$$L_{XZ} = 2.70e+02$$
$$L_{YX} = -2.93e+00$$
$$L_{YY} = 7.64e+03$$
$$L_{YZ} = -2.01e+00$$
$$L_{ZX} = 2.70e+02$$
$$L_{ZY} = -2.01e+00$$
$$L_{ZZ} = 3.84e+03$$

Moment of Inertia: (g.cm^2)
Taken at the output coordinate system.

$$L_{XX} = 122939.24$$
$$L_{XY} = 51062.44$$
$$L_{XZ} = 98346.95$$
$$L_{YX} = 51062.44$$
$$L_{YY} = 204008.36$$
$$L_{YZ} = 48735.81$$
$$L_{ZX} = 98346.95$$
$$L_{ZY} = 48735.81$$
$$L_{ZZ} = 131973.93$$

The above procedure is the only capable of ensuring adequate inspection possible executive press fit or the bush in the ring gauge may render the bush unfit for subsequent satisfactory use.

To avoid damage ascribed to excessive press FIR the following procedure may be followed.

Ring gauge bore: - 34.695 mm
Go Gauge: - 28.621 mm
No Go Gauge: - 28.642 mm
Dynamic Capacity: - 1690 kg
Static Capacity: - 1620 kg
Limiting Speed: - 10500 rpm.

VIII. CONCLUSION

In Atul auto limited, Gem Premium Cargo Vehicle Model had a problem of power transmission failure through gearbox breakdown issue with parts, needle bearing, cluster gear, speed gears & gearbox housing damage increased. During the heavy load on vehicle by carrying on rough road with sudden load on transmission, gearbox failure occurs. Due to sudden load the needle bearing burs/chips enter the running gear transmission causing vibrations and teeth damage failures. Whole gearbox failed and vehicle stands.

The all above establishes technical feasibility modification appertain out on needle bearing, cluster gear and hardened shim in order to prevent failure of gearbox through software simulation analysis. This continual improvement is done to improve product durability which are continually revised from field trial vehicles through tracking sheet in company. Part Modeling works and Analysis is done in solid works. Part interchangeability process is advised in the new vehicles. Process improvement circulars are on processed and reorganized gearbox is taken place in premium vehicles.

IX. ACKNOWLEDGMENT

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