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RESEARCH ARTICLE

STUDY OF INFLUENCE OF PROCESS PARAMETERS ON RUNOUT IN DIFFERENTIAL AXLE MANUFACTURE

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ABSTRACT

Manufacturing of differential housing includes many process namely shot blast, welding, swaging, facing, cooling etc. where after each process the change in dimensions of the component is seen and hence gives rise to change in axis of axle and runout is generated. The main aim of study is to identify the change in runout after every process and identify the maximum runout creating process. Cold swaging process has major effect on runout when done before welding cover on the housing. Therefore the effect of cold swage process before and after welding cover is being discussed in the paper. Housing part number R145.7 QC667 is being studied over this study.

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INTRODUCTION

In this project the main aim of study is to reduce the cycle time for the straightening operation by identifying the change of dimensions after each process and their effects on the Axle Housing. Straightening is the process carried out in order to maintain runout on both the ends of housing in a defined value of less than 0.1mm. Also face height and center shift is to be maintained in permissible limit. Cold swaging process is being carried out after seam welding in order to reduce the diameter at the ends of the differential housing and also to make it concentric. During cold swaging process due to high hydraulic pressure the axle housing lifts up creating a bending effect and thus the runout is generated in the process. There is a chance of generating a positive runout due to which the time required in the straightening operation in order to reduce runout it is more. Thus the change in cold swaging process is done in order to control or avoid the bending of housing. Cover is being welded before cold swaging process and housing is placed on the cold swaging machine such that cover is on the top thus restricting the bending effect. This in order controls the lifting of housing against large hydraulic forces during swaging process. The experimental and analytical results are being discussed in this paper.

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Objectives

In my project given by "Automotive Axles Ltd.", we have to identify the effect of cold swaging process on housing manufacture and bring out change in process in order to reduce the runout in the earlier stage so as to reduce cycle time required for the straightening process. Housing part number QC667 is being studied over this study.

Problem Statement

Cold swaging process on the axle housing to reduce diameter at ends and make the end concentric lifts up the axle housing during processing due to large hydraulic process which creates bending of housing and difference in axis at both ends. Hence cover is welded over the differential housing which in turn reduces the bending of housing and runout obtained is less comparatively.

LITERATURE REVIEW

Meeran Mohideen V, Kesavan: Reduction of run out specification in tractor rear wheel through DMAIC approach

Reduction of run out specification in tractor rear wheel using DMAIC methodology, It encompasses various phases namely Define, measure, analyze, improve and control.

Scope of project is to reduce the lateral run out specification from 5mm to 3mm in tractor rear wheel 12”x28” size. The scope confined to run out reduction in front side of the tractor rear wheel as the rear side already within 3mm specification.

Ramya R, Vinod Kumar M S: Automatic control of ring and cover welding of axle housing through plc

The main objectives of any manufacturing industry is the improvement in productivity, reduction cost of production and labor, PLC is being used extensively in industries to control the machine and process. The present project work deals with replacing the delta PLC with Mitsubishi PLC, considering all the disadvantages of the former PLC, and thus improving efficiency of the machine and process in which it is implemented.

Darshan Jayaram, Dr. B.R. Narendra Babu, Dr. K. Chandrasekhar: Electrical and Mechanical Runout as a Problem in Manufacturing Industry

This article explains what runout is, why it is important, and the root causes of runout in machinery shafts. It also outlines common methods for reducing runout to allowable levels and suggests best practices to observe during fabrication and machining to help avoid runout difficulties in the first place. Material electromagnetic anisotropy of revolution parts poses a potential hazard to the operation of rotary machine (such as rotor) and interferes the vibration monitoring. The maldistribution of electromagnetic property of material is detected by eddy current sensor as electrical runout, Mechanical Runout is a measure of the shaft’s deviation from a perfectly uniform radius as its circumference is traversed.

EXPERIMENTAL VALIDATION

Housing without cover

Firstly the cold swaging is being done over the housing without cover. The axle housing after seam welding is loaded on the machine fixture of cold swaging machine then the feed is given where cold swage in order to reduce the diameter at ends is carried out. During this process housing end on the other side of swaging end is being lifted upwards due to large hydraulic forces which in turn bends the housing thus giving rise to larger runout. The dimensions of the housing and end to end lift is being measured manually using measuring instruments and tabulated.

Fig 3.1. Represents Hosing without cover

Tabulated results are being analysed and plotted which shows that the housing after being cold swaged (ACS) the more runout is seen. On the graph plotted we can see that the orange line representing housing after cold swaging is not parellel to the blue line that represents housing before cold swaging.

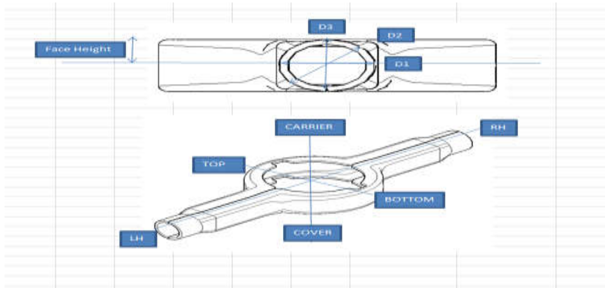

Fig 3.2. Represents Dimentions measured on axle housing

Table 3.1. Parameters before and after cold swage for housing without cover

Hsg.No	Diameter D (mm) 1 D1	1 D2	1 D3	6 D1	6 D2	6 D3	Center Shift (towards top +ve)	Face Height	End face LH Center from surface	End face RH Center from base	Runout (LH-RH)
1 BCS	145.3	144.9	146	146.2	146.4	146.5			429.2	431.5	2.3
1 ACS	134.4	135.7	134.3	135.4	135.1	134.2	-1.4	70.17 (C) 71.73	429.8	432.8	3.00
2 BCS	144.4	145.1	146	146.3	146.8	145.5			429	430.5	1.5
2ACS	135.2	135.2	134.4	135.5	135	134.2	-1.64	70.42 (C) 72.23	429.4	431.1	1.70
3 BCS	143.1	145.8	145.3	145.9	145.45	145.3			429.1	432.2	3.1
3ACS	135.1	136	134.5	135	135.1	135.4	0.34	70.64 (C) 71.98	429.26	432.8	3.54

*BCS– Before cold swage
*ACS – After cold swage

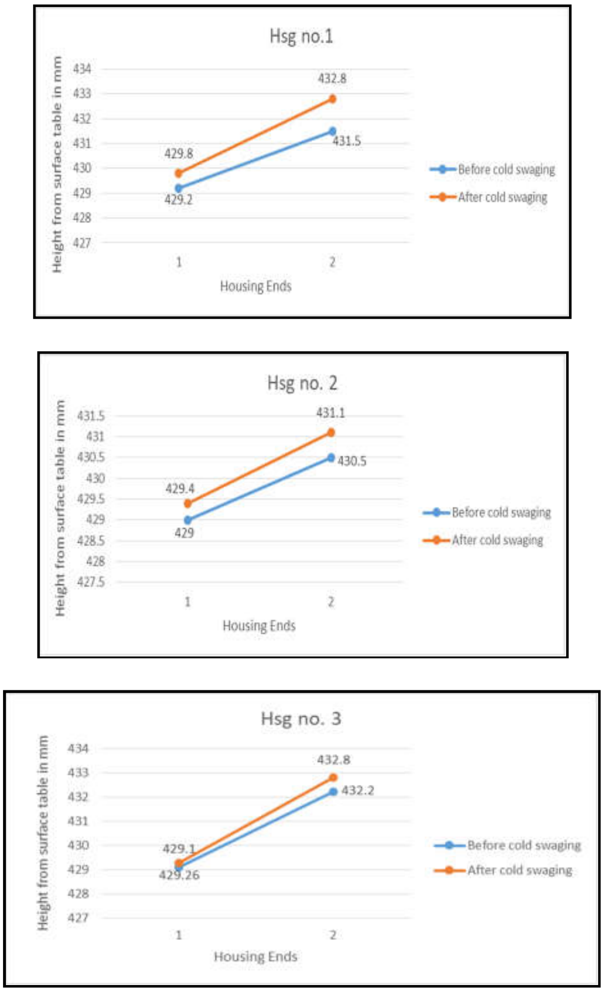

Fig 3.3. Graph Representing difference in height between both housing ends from surface table for housing without cover.

This shows that the housing is seem to be bend on the other side i.e at point 2. And the difference in value for BCS and ACS varies from 0.7, 0.2 and 0.44mm for different housing of same type.

Housing with cover

Here axle housing with cover is being processed for cold swaging so as to reduce the effect of runout and the results are being tabulted for the change in dimentions of axle houing with cover before and after cold swaging process.

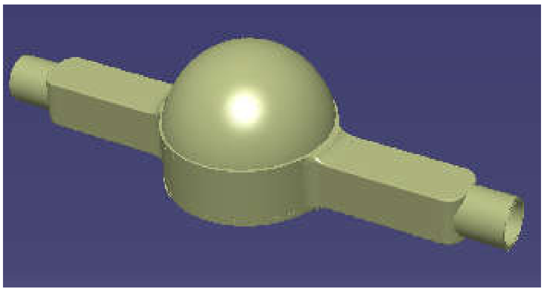

Fig 3.4. Represents Hosing with cover

Table 3.2. Parameters before and after cold swage for housing without cover

Hsg.No	Diameter D (mm) 1 D1	1 D2	1 D3	6 D1	6 D2	6 D3	Center Shift (towards top +ve)	Face Height	End face LH Center from surface	End face RH Center from base	Runout (LH-RH)
1 BCS	144.3	145.01	146.12	144.55	146.4	146.25			428.5	431.5	3
1 ACS	134.2	134.4	134.3	133.4	135.1	134.6	-1.25	71.17 (C) 70.65	428.8	431.9	3.10
2 BCS	142.9	144.1	146.55	145.3	146.8	145.55			430.5	432.4	1.9
2ACS	135.2	134.2	134.4	134.9	135.5	134.25	-1.48	70.55 (C) 71.23	430.6	432.6	2.00
3 BCS	144.1	144.8	144.95	145.9	144.45	145.3			429.3	432.6	3.3
3ACS	136.1	136.55	134.5	135.12	135.1	135.4	0.58	70.68 (C) 71	429.33	432.95	3.62

*BCS– Before cold swage
*ACS – After cold swage

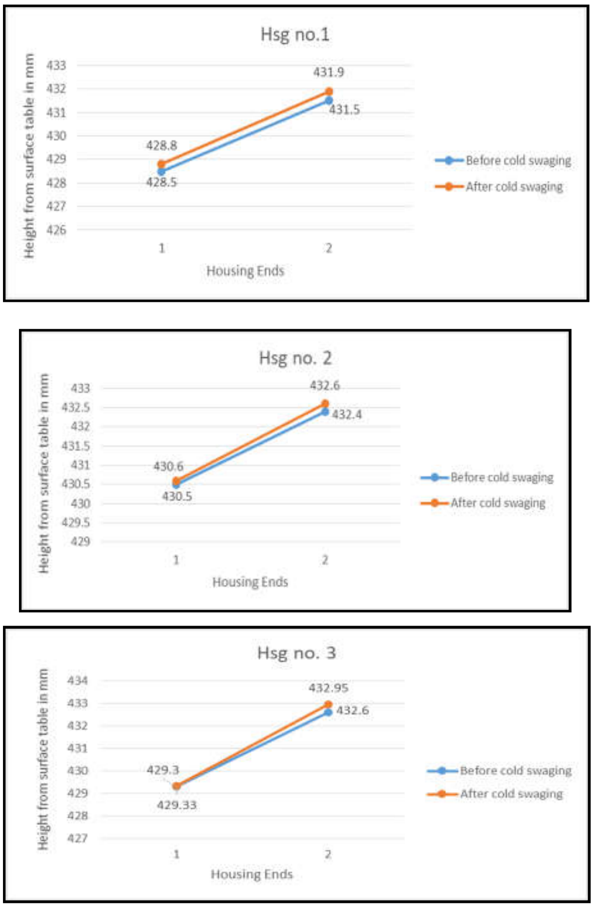

Fig 3.5. Graph Representing difference in height between both housing ends from surface table for housing with cover.

From the graphs obtained we can see that the runout generated in this type is very less. Orange line (after cold swaging) is almost parellel to the blue line(before cold swaging line). Here the runout generated is 0.1,0.1 and 0.32mm for the different housing of same type.

ANALYTICAL VALIDATION

FE Analysis for the housing without and with cover is being carried out using a software package Ansys 14.0. Model of axle housing is being created using Catia V5 and is imported in Ansys workbench. For material as structural steel with young's modulus 200MPa and cold swaging pressure as 1MPa is being adopted for analysis purpose. Directional deformation is being noted. Here X direction is chosen as the deflection direction.

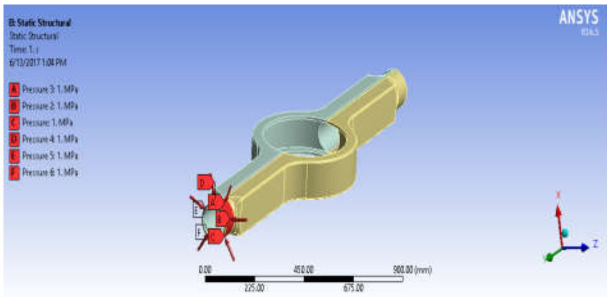

Fig 4.1. Represents Applied swaging force on Hsg

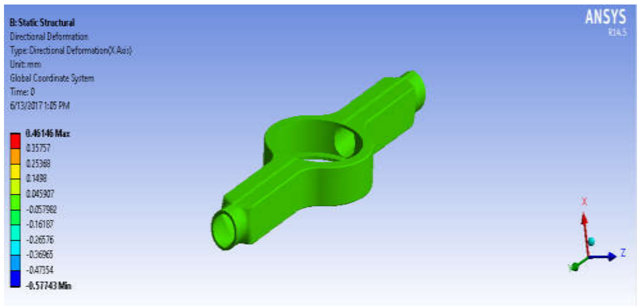

Fig 4.2 Represents Hsg before Deformation

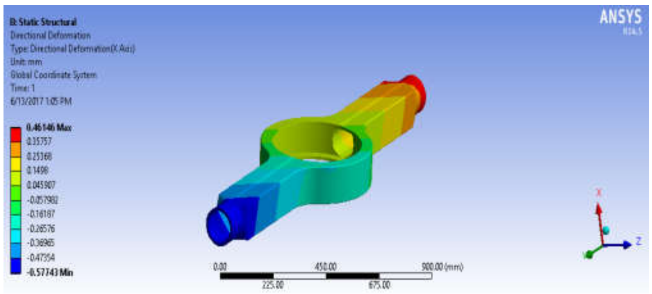

Fig 4.3. Represents directional deformation of Hsg during swaging

Table 4.1. Represents Magnitude of applied pressure

Model (B4) > Static Structural (B5) > Loads

Object Name	Pressure	Pressure 2	Pressure 3	Pressure 4	Pressure 5
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	1 Face				
Definition					
Type	Pressure				
Define By	Normal To				
Magnitude	1. MPa (ramped)				
Suppressed	No				

Table 4.2. Represents Maximum and Minimum valvue of Deformation

Model (B4) > Static Structural (B5) > Solution (B6) > Results

Object Name	*Total Deformation*	*Directional Deformation*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Total Deformation	Directional Deformation
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Identifier		
Suppressed	No	
Orientation		X Axis
Coordinate System		Global Coordinate System
Results		
Minimum	518.78 mm	-0.57743 mm
Maximum	518.87 mm	0.46146 mm
Minimum Occurs On	Solid	
Maximum Occurs On	Solid	

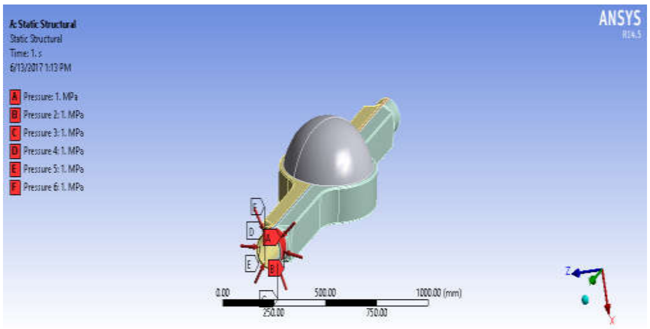

Fig 4.4. Represents Applied swaging force on Hsg with cover

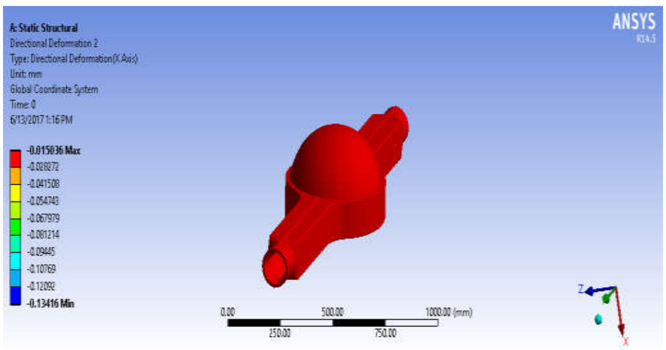

Fig 4.5. Represents Hsg with cover before Deformation

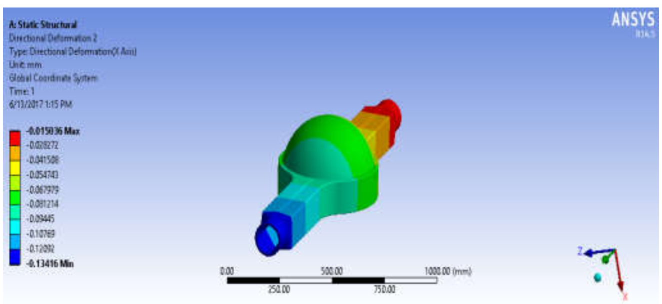

Fig 4.6. Represents directional deformation of Hsg with cover during swaging

Table 4.3. Represents Magnitude of applied pressure

Model (A4) > Static Structural (A5) > Loads

Object Name	*Pressure*	*Pressure 2*	*Pressure 3*	*Pressure 4*	*Pressure 5*
State	Fully Defined				
Scope					
Scoping Method	Geometry Selection				
Geometry	1 Face				
Definition					
Type	Pressure				
Define By	Normal To				
Magnitude	1. MPa (ramped)				
Suppressed	No				

Table 4.4. Represents Maximum and Minimum valvue of Deformation

Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Directional Deformation 2*
State	Solved	
Scope		
Scoping Method	Geometry Selection	
Geometry	All Bodies	
Definition		
Type	Total Deformation	Directional Deformation
By	Time	
Display Time	Last	
Calculate Time History	Yes	
Identifier		
Suppressed	No	
Orientation		X Axis
Coordinate System		Global Coordinate System
Results		
Minimum	436.51 mm	-0.13416 mm
Maximum	436.61 mm	-1.5036e-002 mm
Minimum Occurs On	Solid	
Maximum Occurs On	Solid	

Directional deformation in X direction for both housing with and without cover is being analysed and from the results we can see that the maximum deformation for housing without cover is 0.46146mm and minimum valvue is -0.57743mm thus runout is (0.46146-(-0.57743))=1.03889mm.Where as the maximum deformation value for housing with cover is -0.13416mm and minimum value is -1.5036e-02mm thus runout obtained is (-0.13416-(-1.5036e-02)=0.1191mm. Therefore the runout generated in housing with cover in cold swage process is very less compaired to the runout generated in housing without cover.

FUTURE SCOPE

- This is the best approach in order to reduce the effect of runout generation and bending of axle housing.
- This is time saving hence it will increase the productivity.
- Less effort is required in the straightening operation as controlled dimensions are seen comparatively.

Conclusion

In this study, the effort and time required for the straightening operation is seen to be reduced by welding cover before the cold swaging process where the lifting of housing is avoided and in turn the runout is reduced as compared to the housing without cover. Analytical results shows that there is variation in the directional deformation of the housing before and after welding cover over the axle housing. Thus the housing with cover in swaging process shows good results than without cover.

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