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Analysis of The Ball Joints Rolling Process Deformation

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Abstract: Ball joint is a part of car suspension system. Analysis of ball joint deformation by using Finite Element Analysis (FEA) were study. Rolling process assemblies is a way of ball joints to obtain rotating torque. Good deformation process produces a good quality of a ball joint. Bad quality of ball joint can cause a failure to a vehicle control arm. Normally if the ball joint deformation is unfinished, the output of ball joint produce out of specification rotating torque. Unfinished deformation of the ball joint is dangerous, it will make a safety problem. Every ball joint have different dimension, every dimension required different jig and fixture in the production line. Right load apply will make good deformation. Due to the pandemic situation full data as per primary objective can't be achieve. The result of the study may be less because to develop automatic roller size selection and to study torque required site visit to the manufacturing line production. In this study, using SIMULIA Abaqus software can determined the right position to apply rolling load and mimic the deformation by using the simulation process.

Keywords: Ball Joint, Deformation Process of Ball Joint, FEA Analysis.

1. Introduction

Every human moves their body with the help of the joint. For humans, the joints are one of the special structures that functions as a movement medium behind the bones. This also applies to vehicles joining, as a vehicle it requires a ball pin to drive the between one component to another. Normally ball pins are used on the front end of most vehicles. Ball pins act as the pivot point between the suspension system and car tires. Ball pins help to support the weight of the cars and it may be also used to set alignment on the wheel. The ball pin is one of the moveable parts in a control arm assembly. Ball pins allow the front wheels to move up and down, as well as side to side [1]. A ball pin is made up of housing, ball stud, bearings, end cover or dust cover and Belleville washer or spring. There are two commonly use of ball pin, which are the small ball pin and the bigger one. The small ball pin commonly uses on the component part which an absorb small amount of torque or pressure, such as tie rod which the bigger one is for higher torque and force application such as on control arm.

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The common failure on the ball pin is on the dust cover, if the dust cover is damage the dust enters into the ball pin and this can cause the damage of the ball pin and the plastic seat. Therefore, the ball pin becomes loose and vehicle control becomes lesser. For the ball pin, the critical failure is at the neck of the ball pin if it is broken it will cause too many problems in the suspension system as well as to the vehicle safety. Other issue from manufacturing is, sometime when production of ball joint the torque is not achieved. So this research is based on the study of deformation of ball joints.

This project is to study the ball joint rolling process deformation using FEA (Finite Element Analysis)

2. Literature Review

No.	Author/Year	Title	Finding
1	J. Shinde, S. Kadam, A. Patil, and S. Pandit / 2016	Design modification and Analysis of Suspension Ball Joint Using Finite Element	The authors analyze and investigate the cause of the sudden failure on suspension system ball joint. From the analysis, they found the ball joint element showed a complete fracture which occurred midway between the top and bottom section changes of the element [1].
2	J. Shinde and S. Kadam / 2016	Design of Suspension Ball Joint Using FEA and Experimental Method	Further reduction of the cross section of the ball pin leads the higher stress concentration which is it reduces the life time of the ball joint [2].
3	B. H. Jang and K. H. Lee / 2014	Analysis and Design of a Ball Joint Consideration Manufacturing Process	This research work describes a simulation strategy for a ball joint analysis, considering the manufacturing process. [3].
4	R. J. Zhu./ 2013	Rolling Machine Manufacturing	Rolling machine was use in production line to make a assembly ball joint and to generate torque while the deformation process. [4].

3. Methodology

This study and analysis carried out were focused on the deformation of the ball joint while rolling process.

To ensure the right pressure apply to the housing of the ball joint was modeled in three dimensional by using Solidwork® and simulation was conducted by using SIMULIA Abaqus software. Material meshing was also conducted as in completing the process study. Fixed geometry was followed to the real situation in the production line. Then, the result of the deformation will show by using SIMULA Abaqus.

3.1 Modelling and Analysis of Ball Joint Socket

Based on Figure 1 shows a 2D drawing of the ball joint socket. This drawing were followed to the real ball joint socket in the production line.

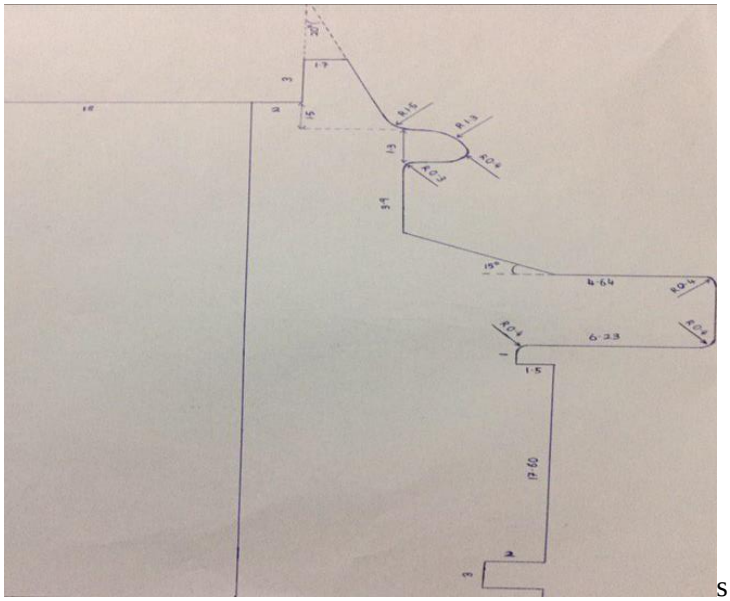

Figure 1: Ball joint housing drawing

To make the 2D drawing into 3D, Solidwork® software was used to transfer all data and measurements from 2D into 3D. Figure 2 shows the 3D ball joint socket.

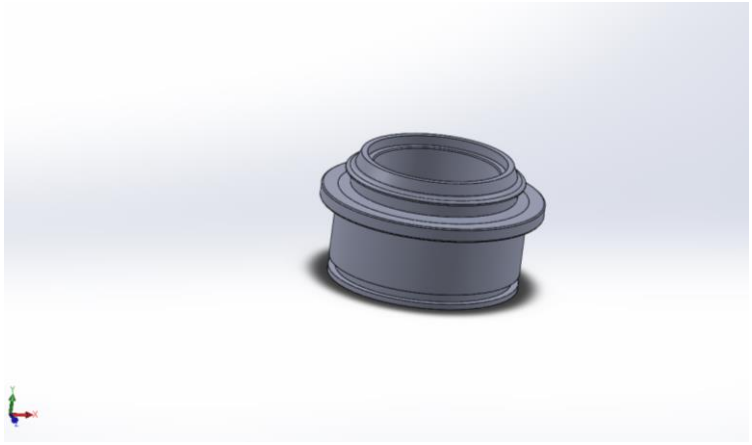

Figure 2: 3D ball joint Socket

3.2 Material

Table 1 shows mechanical properties of a material according to ball joint socket manufactured campany. This model manufactured using SM4C carbon steel. SM4C properties:

Table 1: Mechanical Properties [5, 6]

Property	Value	Values
Young's Modulus	*E*	207.0 Gpa
Shear Modulus	*G*	80.0Gpa
Poisson's Ratio	*v*	0.3
Density	*ρ*	7600 kg/m
Yield Strength	*Sy*	370 Mpa
Shear Strength	*Ss*	370 Mpa

3.3 Meshing

Meshing of a given model will be done depending on dimension of the model, it is better to have more degree of freedom hence more number of elements so that results obtained will be closure to analytical results.

On this model shows in Figure 3, the type of the meshing that use is Fine type or Standard Mesh type. This type of meshing, it wills representing small feature and curved geometries the mesh can experience large aspect ratio or failure. When a symmetrical mesh is required, this mesh type is ideal because it is better to have more degrees of freedom hence more number of the elements so that the results obtained will be closure to analytical results. Based on the Table 2, it shows the characteristic of the Standard Mesh type of meshing. The number of the elements size and tolerance are too small and from that it will make the quality of the mesh is better and the total node and total elements shows the high value.

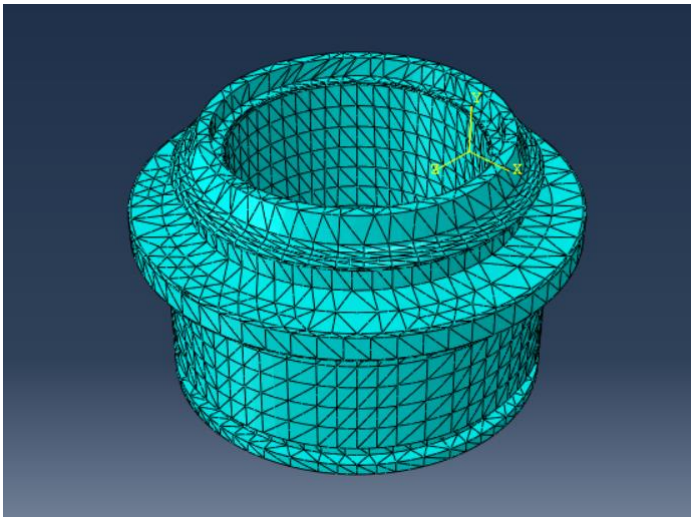

Figure 3: Meshing of ball joint housing

Table 2: Characteristic of the meshing used

Mesh Type	Solid Mesh
Mesher Used	Standard Mesh
Elements Size	1.31 mm
Tolerance	65.42 x 10^{-3} mm
Mesh Quality	High
Total Nodes	63415
Total Elements	43328
Maximum Aspect Ratio	8.20
Percentage of Elements with Aspect Ratio < 3	98.9
Percentage of Elements with Aspect Ratio > 10	0

4. Result and Discussion

The simulation was conducted using standard material as follow to the industry. In this study, to find the relationships between force into a surface and deformation of a ball joint in FEA result.

4.1 Simulation of deformation ball joint socket

By using simulation method, the result of the simulation will show how the ball joint deforms when a specific load applies onto the surface of the ball joint housing. The result may be differ if the applied load to incorrect position, and will resulted in proper rolling process. In this step, the applied load can be set to get the best deformation for ball joint assembly process. Figure 4. shows the location of the applied load.

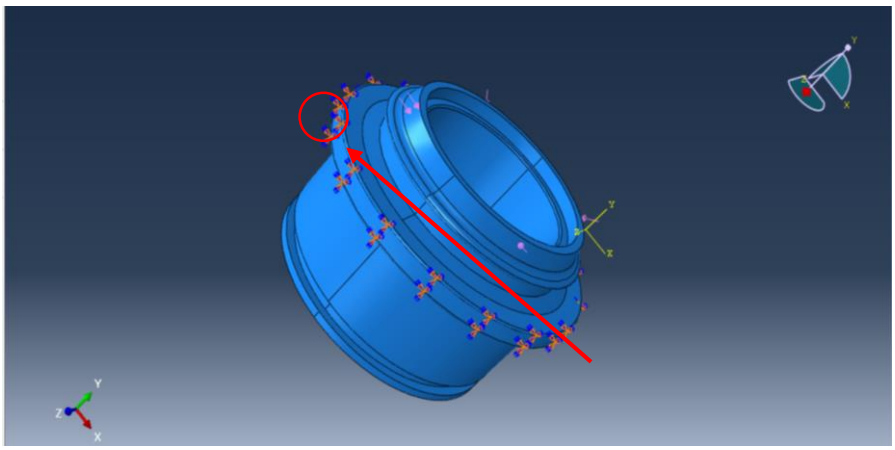

Figure 4: Location of the apply load

From Figure 4, the red circle shows the nodes of load that apply to the housing of a ball joint. Load must be applied on the housing surface to achieve a good ball joint deformation.

4.2 Model Constrain

Model constrain is important to mimic the actual condition while doing the rolling process. Because some of the location need to be fixed before the rolling process occur. Figure 5 shows nodes place for surface constrain.

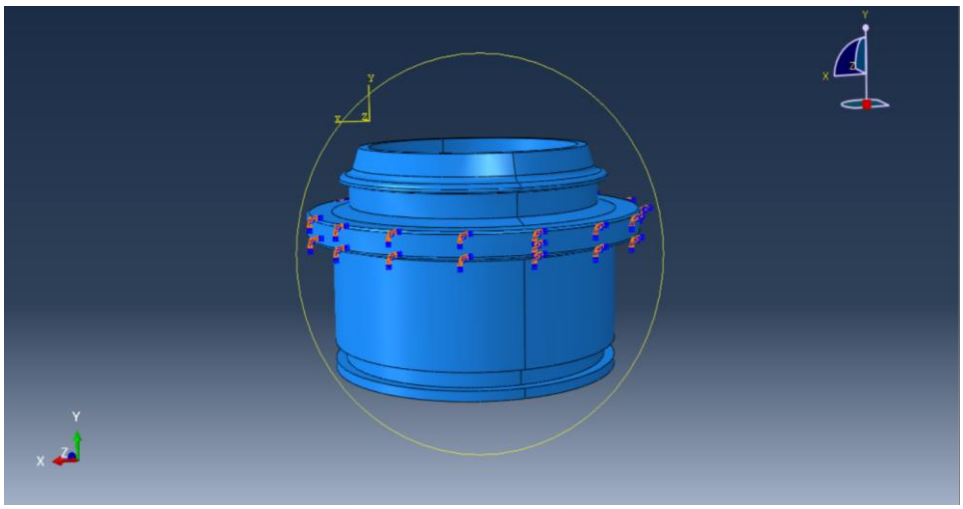

Figure 5: Surface constrain

4.3 Simulation of deformation ball joint socket

The applied force and surface constrain is important to achieve a good housing deformation. By using simulation process, suitable selection of jig and fixture can be made before the process. Good deformation can produce a good rotating. Figure 6 shows the deformation of ball joint using a SIMULIA Abaqus software.

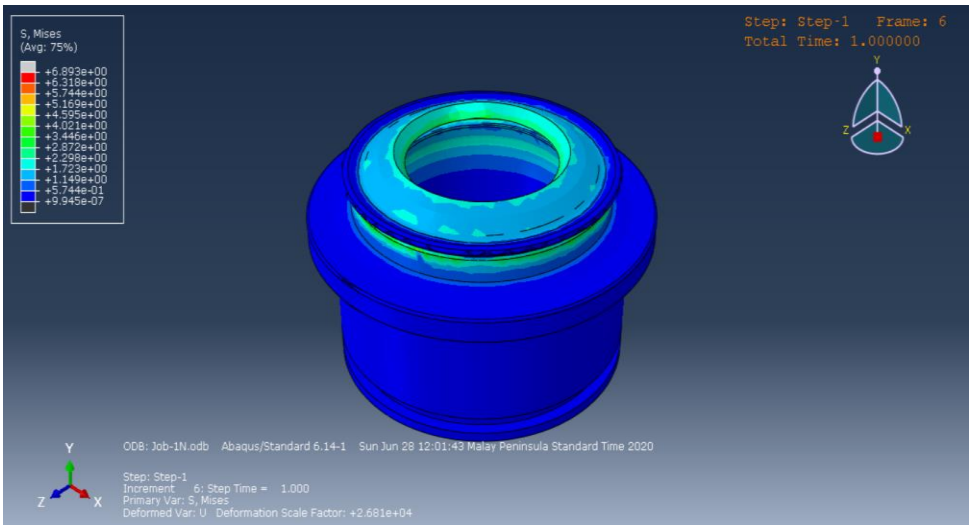

Figure 6: Deformation of ball joint housing

Based on the Figure 6, the result shows the end result deformation after ball joint rolling process on the actual manufacturing. By using the simulation software, engineer can make right selection of jig and fixture during manufacturing process. This simulation can generate a good result which is almost similar with the actual rolling process. All data actual manufacturing process will be transferred to the simulation software to simulate the rolling result before select the jig and fixture.

4.4 Stress analysis for deformation of ball joint socket

In this model, the 1N force was applied. Based on Figure 7 shows FEA stress analysis that interacts when 1N force is applied to the ball joint housing. The minimum stress generate is 9.945-06 and the maximum stress is 6.893e+00. Based on the data result, the load applies is good for the ball joint housing. From Figure 7 show, the model of the ball joint housing is not exceeding the stress analysis when 1N load was applied to this model.

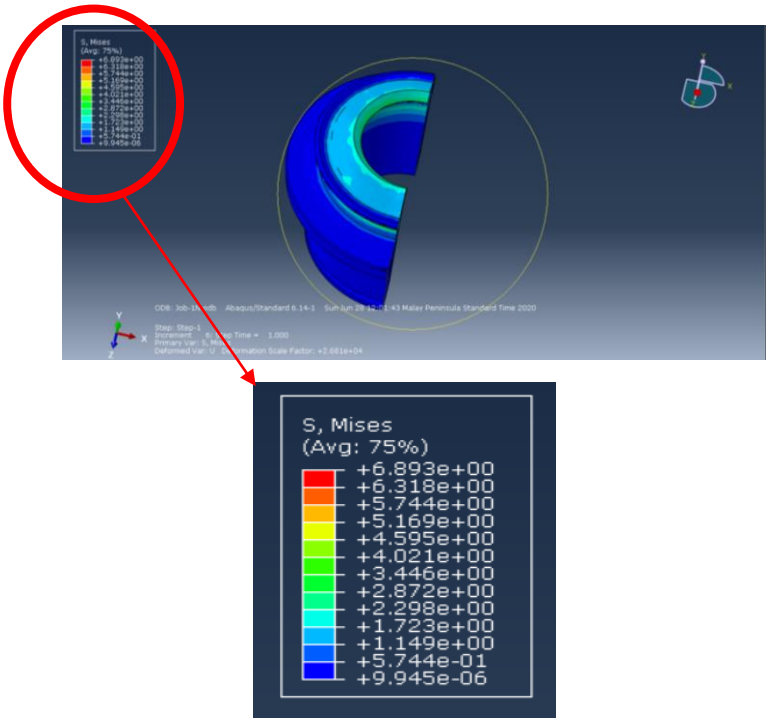

Figure 7: FEA Stress Analysis

4.5 Deflection analysis

The deflection ball joint housing is important to the ball joint assemblies. If the deflection is not good, torque cannot achieve. By using simulation software, data results can get and load can be set before do the actual process on the manufacturing. The different force applied have different ball joint housing deflection. Based on Figure 8 shows, the node applies to get data deflection.

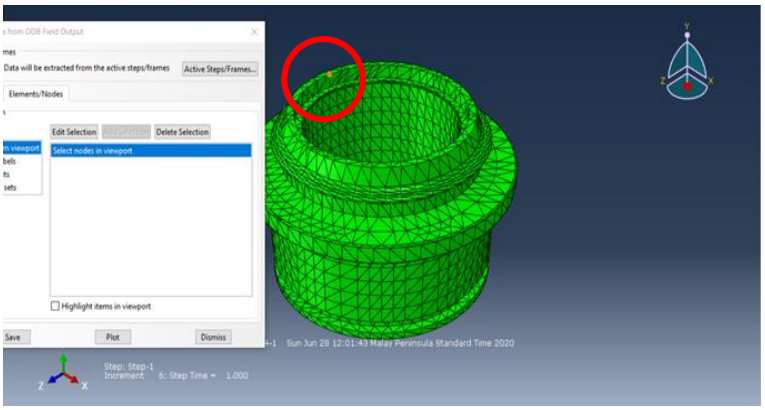

Figure 8: Node apply to housing

The red circle shown in figure 8 is where the node is applied to the data result for the deflection of the ball joint housing. Figure 9 shows graph time vs displacement (a). Data table X and Y (b).

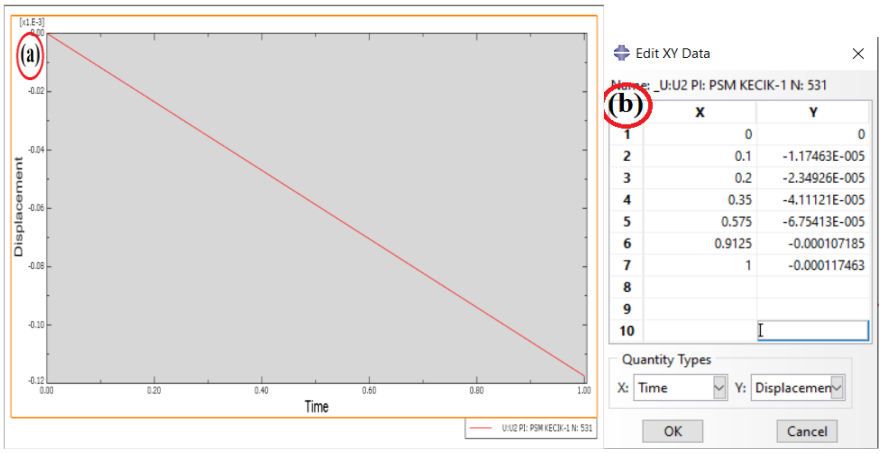

Figure 9: Graph displacement vs time (a). Data table X and Y (b)

From Figure 9, data table X and Y (b) show the result of the deflection ball joint housing. Where X is represented as time and Y is represent the deflection of the ball joint housing. From this data result, an engineer can make a decision and solution by using simulation before proceeding to the actual rolling process of the ball joint assemblies.

5. Conclusion

In conclusion, this study was carried out to fulfill the objective that has been set out to analyze ball joint deformation during the rolling process using FEA (Finite Element Analysis). Therefore, the right pressure applies to the ball joint socket should be correctly determined to obtain the appropriate deformation. In addition, the factor that also affects the deformation is the force applied. The force value is important to determine the deformation of the ball joint. The pressure applied to the surface is important to ball joint deformation. If the deformation is not perfect, torque can't be achieved and the ball joint is dangerous if used. Based on these studies, by using simulation software such as SIMULIA Abaqus engineers can investigate the deformation and analysis before proceeding to an actual production process. Due to the pandemic situation full data as per primary objective can't be achieve. The result of the study may be less because to develop automatic roller size selection and to study torque required site visit to the manufacturing line process. In this paper, only the FEA result are analyzed.

Acknowledgement

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