International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Dynamic Simulation & Analysis of BMW E60 Accessory Belt Drive System Using ADAMS Software

P V Mallari[1], Sai Rohith G[2], E Kumara Gouda[3], Kiran D V[4]

[1-4] UG Students, Department of Mechanical Engineering, RYM Engineering College, Ballari, Karnataka, India

---***---

Abstract - *This work aims at modelling and analysing the BMW E 60 accessory belt drive system by MSC Adams/View. The system dynamical model was developed using the Lagrangian formulation taking into consideration the effects of external disturbance due to clearance fault. The model was confirmed by a three-dimensional simulation.*

Key Words: Belt Drive MSC Adams/View, Dynamic simulation, Kinematic analysis, Multibody dynamics

1. INTRODUCTION FOR MSC SOFTWARE

MSC Software is recognized as one of the pioneering companies in the software industry, standing out as a global leader in enabling manufacturers to enhance their engineering processes through simulation software and services. As a trusted collaborator, MSC Software assists organizations in improving product quality, reducing design and testing time, and cutting costs associated with product development. The company's technology is widely used by academic institutions, researchers, and students to broaden their understanding and further the capabilities of simulation.

MSC Software's simulation tools are utilized by top manufacturers for a wide range of applications, including linear and nonlinear finite element analysis (FEA), advanced material modeling, acoustics, fluid-structure interaction (FSI), multi-physics, optimization, fatigue and durability analysis, multi-body dynamics, controls, and manufacturing process simulations. The company's products provide accurate and dependable predictions of real-world product behavior, empowering engineers to design more innovative solutions.

1.1 ADAMS

MSC Adams (Automated Dynamic Analysis of Mechanical Systems) Adams is the world's most widely used multibody dynamics simulation software. It lets you build and test functional virtual prototypes, realistically simulating on your computer, both visually and mathematically, the full–motion behavior of your complex mechanical system designs.

Adams provides a robust solution engine to solve your mechanical system model. The software checks your model and automatically formulates and solves the equations of motion for kinematic, static, quasi-static, or dynamic simulations. With Adams, you don't have to wait until the computations are complete to begin seeing the results of your simulation. You can view animations and plots – and continue to refine your design – even as your simulation is running, saving valuable time. For design optimization, you can define your variables, constraints, and design objectives, then have Adams iterate automatically to the design, providing optimal system performance.

1.2 Introduction to Belt Drive

A belt drive is an efficient mechanism that uses a flexible belt and pulleys to transfer power between two or more shafts. It typically operates through friction, though it can also function as a positive drive-in certain case. One of the standout advantages of belt drives is their adaptability they can accommodate a wide range of power requirements and speeds while maintaining high efficiency.

In terms of cost, belt drives are significantly more affordable than gear or chain drives. They are less expensive to install and maintain. Furthermore, over time, the pulleys or sheaves of a belt drive experience minimal wear, unlike chain drive sprockets, which tend to wear down more quickly with extended use.

2. LITERATURE REVIEW

The belt drive system, commonly used in various mechanical and automotive applications, plays a vital role in transferring power between shafts through pulleys and flexible belts. Belt drives are valued for their efficiency, versatility, and cost-effectiveness. These systems, often powered by friction, can accommodate a wide range of power and speed requirements, making them suitable for

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

many industries, including automotive, manufacturing, and machinery [1].

Multi-body dynamics (MBD) simulation tools such as MSC Adams are increasingly used to analyze belt drive systems. The ability of these tools to simulate dynamic behavior such as belt tension, pulley interaction, and contact forces—has proven crucial for understanding system performance and improving the design and efficiency of belt drive systems [2]. Simulations help in evaluating factors such as belt vibrations, tension, and potential wear, leading to better predictions of system lifespan and performance.

Research on belt drive systems, such as that by Karam and Gadelmawla [3], has demonstrated the importance of multi-body dynamics in modeling and understanding belt drives. Their work emphasizes the effectiveness of MBD tools in analyzing the interactions between components, and how these interactions can affect system stability and efficiency.

Furthermore, studies by Wang et al. [4] explore the use of Adams software for simulating serpentine belt drive systems in automotive engines. Their findings suggest that by modifying pulley dimensions and belt tensioner settings, engineers can significantly influence the performance of the drive, including reducing vibrations and improving system efficiency.

Additionally, resources such as YouTube guides offer practical tutorials on creating and simulating belt drive systems using MSC Adams. These guides provide step-by-step instructions on setting up simulations, from defining pulley geometry to adjusting belt routing and actuation inputs [5]. Such resources are invaluable for both beginners and experienced users seeking to refine their simulation techniques.

3. PROCEDURE AND RESULTS FOR Belt Drive

3.1 Belt Drive

Problem Description

This model consists of a Poly-V grooved belt system featuring 6 grooved pulleys and one tensioning device, which incorporates a smooth pulley. All 9 pulleys are constrained via revolute joints. One of the grooved pulleys is actuated to generate motion. Contact forces, including friction between the discrete belt segments and the pulleys, transmit the motion throughout the system.

Step 1. Create a new Adams Database

a Click on Create a new model.

b Under Working Directory, browse to the folder where you want to save your model.

c Type the name of the new Model name as Belt Drive and click OK(E).

d Make sure that the Gravity is set to Earth Normal (C)(-Global Y) and the Units is set to(D) MMKS - mm,kg,N,s,deg.

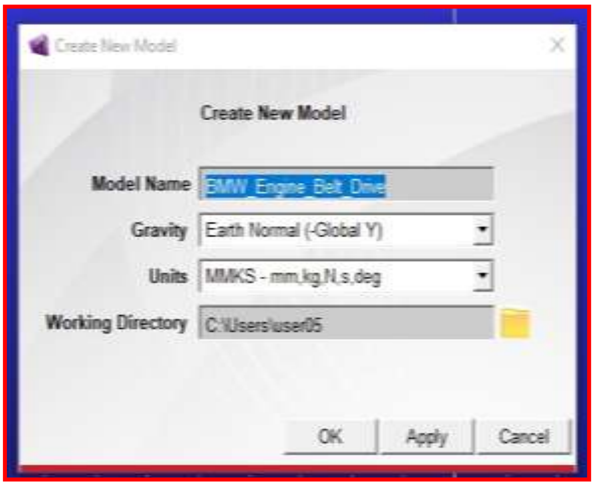


Figure 2: Create a New Adams database.

Step 2. Create pulley

a. From Machinery ribbon, double click Rigid Belt:
b. The pulley creation wizard will Open. On the first page, under the Type select, select Poly-V Grooved from the dropdown menu and click Next.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

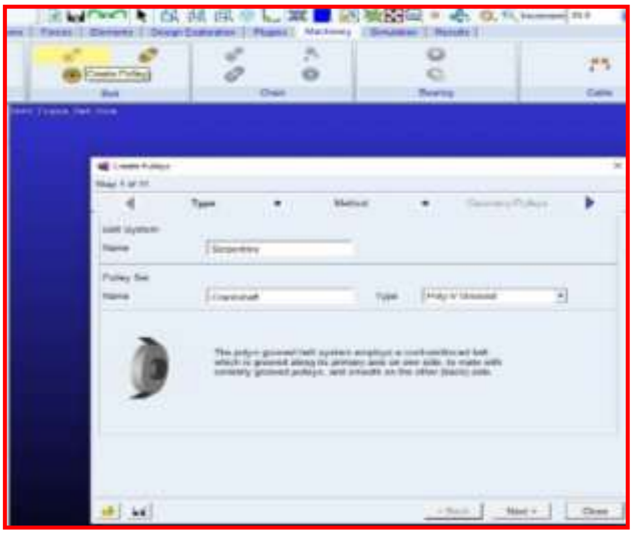


Figure 3: Create a Pulley.

c. On the following page (Method), choose 2D Links from the Method dropdown menu, then click Next.

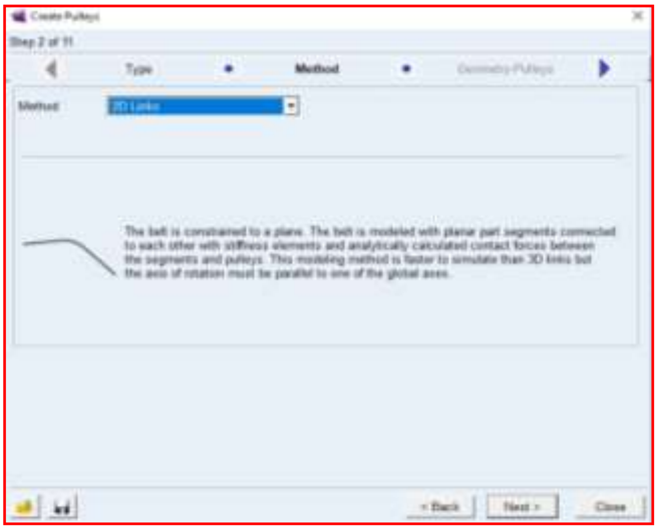


Figure 4 . Create a Pulley Method.

d. On the next page (Geometry), fill out the four tabs defining each pulley's geometry as shown below and then click Next:

- Pulley1 name as Crankshaft, Pulley2 name as Water, Pulley3 name as Idler, and Pulley4 name as Power-Steering.
- Pulley1 center location as 0,0,0, Pulley2 center location as 0,210,0, Pulley3 center location as 220,210,0, and Pulley4 center location as 220,-30,0.
- Pulley1 Geometry Width 30, Diameter 75; Pulley2 Geometry Width 30, Diameter 80; Pulley3 Geometry Width 30, Diameter 60; and Pulley4 Geometry Width 30, Diameter 80.

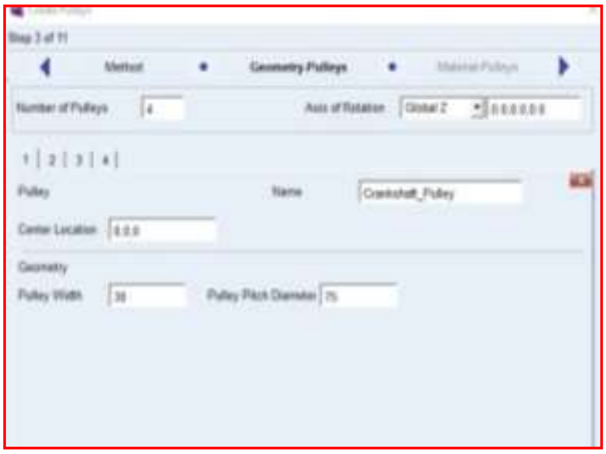


Figure 5 . Create a 1 Pulley Geometry

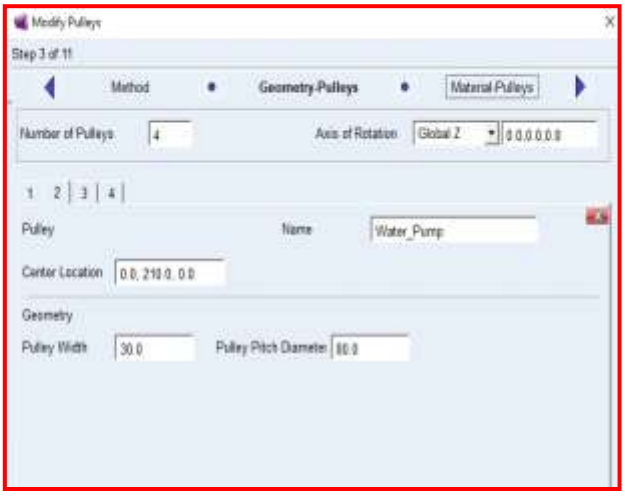


Figure 6 . Create a 2 Pulley Geometry

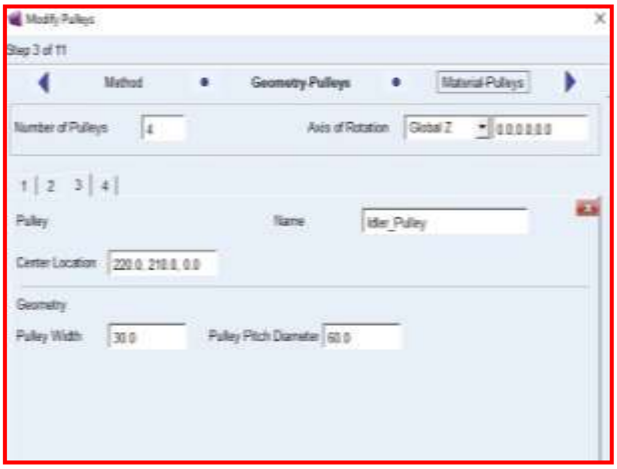


Figure 7 . Create a 3 Pulley Geometry

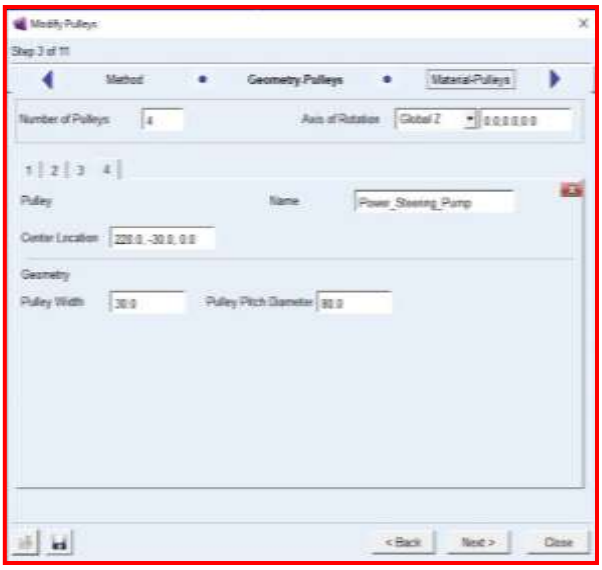


Figure 8 . Create a 4 Pulley Geometry

e. The next page (Material-Pulleys) defines the material properties to be used for the mass property calculations for each pulley. Accept the defaults and move on by clicking Next.

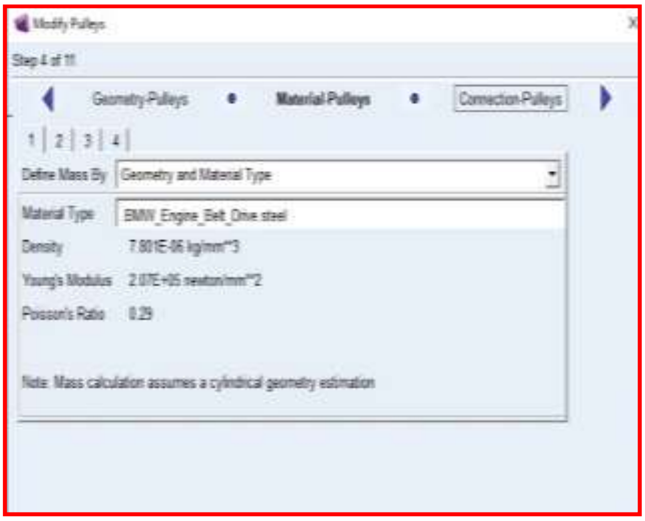


Figure 9 . Create a Pulley Material

f. On the next page, titled Connection-Pulleys, you'll set how each pulley is connected to the rest of the system. For this example, simply stick with the default settings, which attach each pulley to the ground using revolute joints. Afterward, click Next.

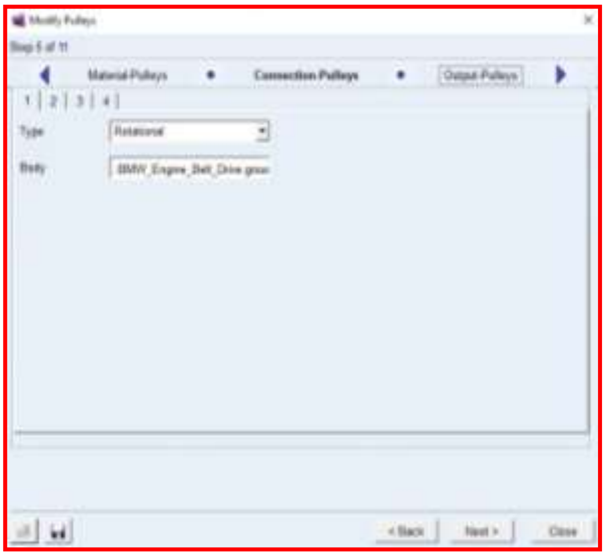


Figure 10 . Create a Connection Pulley.

g. On the next page, titled Output-Pulleys, you have the option to reduce the amount of post-processing information about the pulleys that will be made available as Adams requests. For this example, simply accept the default settings to receive all available information, then click Next.

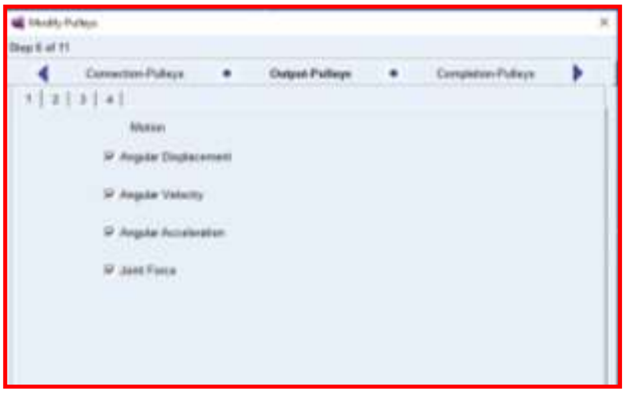


Figure 11 . Create a Pulley Output.

h. The next page (Completion-Pulleys) informs you that all the information required for the grooved pulleys has been entered. Click Next to proceed to tensioner definition.

i. On this page, titled Geometry - Tensioners, enter 2 in the Number of Tensioner with Deviation Pulley field. Then, fill out the tabs defining the tensioner arm and deviation pulley geometry:

- Select Tensioner Name as Main Accessory Tensioner, Center as 30,110,0, Geometry: Length 50, Width 10, Depth 5, Installation Angle 0.
- Select Deviation Pulley Name as 1_Tensioner, Pulley Radius 25, Belt Face Side out, and then click 2nd.

- Select Tensioner Name as Alternator Tensioner, Center as 320,110,0, Geometry: Length 50, Width 10, Depth 5, Installation Angle -180.
- Select Deviation Pulley Name as 2_Tensioner, Pulley Radius 30, Belt Face Side out, and then click Next.

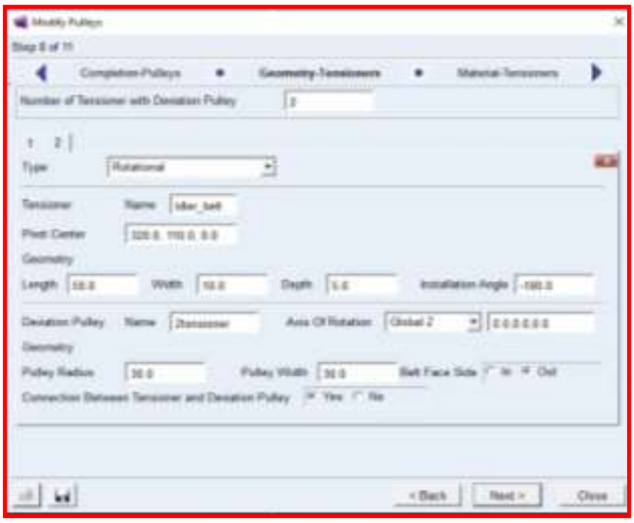


Figure 12 . Create a 1_Tensloner Geometry.

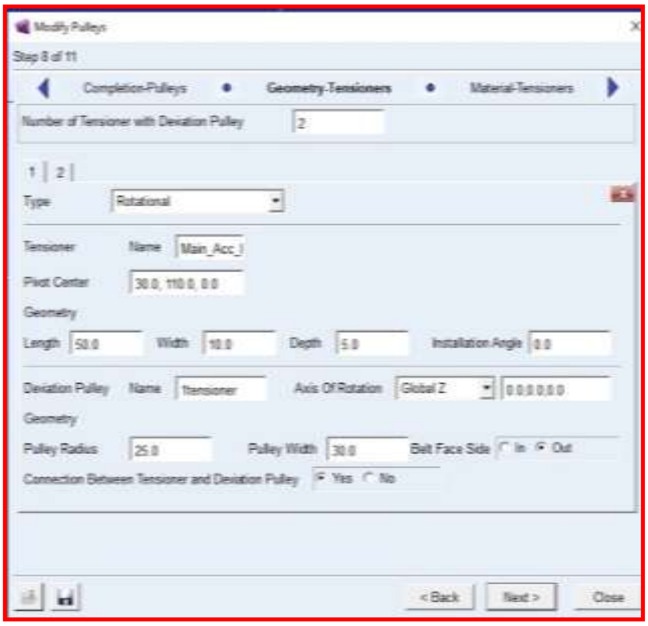


Figure 13 . Create a 2_Tensloner Geometry.

j. The next page (Material-Tensioners) defines the material properties to be used for the mass property calculations for the tensioner arm and deviation pulley. Accept the defaults and move on by clicking Next.

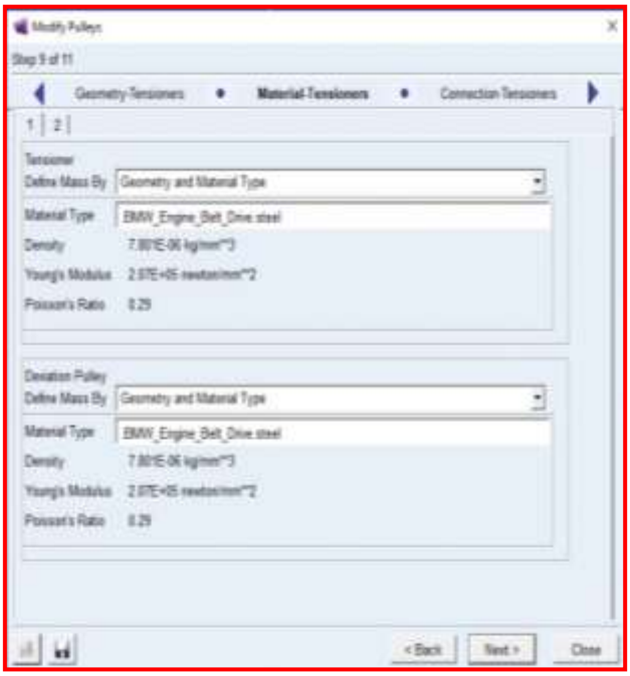


Figure 14 . Create a Pulley Material Tensioners.

k. On the next page (Connection-Tensioners) select Stiffness give 1E05 damping 100

Figure 15 . Create a Pulley Connection-Tensioners.

l. The next page (Completion) informs you that all the information required for the pulley set has been entered. Optionally save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the pulley set.

Step 3. Create Belt

a. From the Ribbon, go to the Machinery tab's Belt container and click the icon for Create Belt.

b. The Belt Creation wizard is launched. In the Name field, enter the name of the pulley_set you just created (right-mouse-click in the field and use Pick or Guesses to quickly select serpentine Crankshaft) and then click Next.

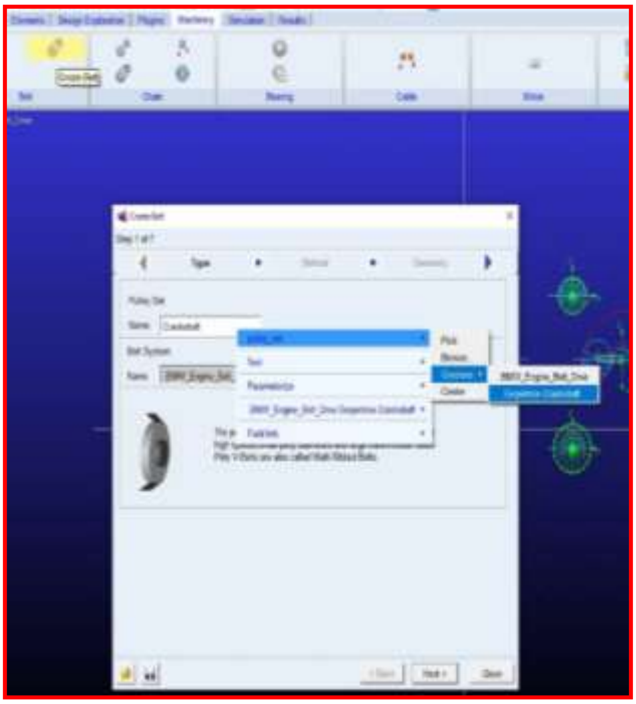


Figure 16 . Create a Belt

c. The next page (Method) defaults to the method you chose when creating the pulley set. Accept this default by clicking Next.

d. The next page (Geometry) is for specification of the Belt geometry. Make the modification as shown below and click Next to move on.

e. The next page (Mass) defines the material properties to be used for the mass property calculations for the belt segments. Accept the defaults and move on by clicking Next.

f. On the next page (Wrapping Order), the belt routing is defined. Right-click in the field and use the Guesses menu to first pick the pulleys (as shown below), then the Tensioners, and finally the Power_Steering_pully, so that the field is populated as follows: "Crankshaft_pulley, 1_Tensioner, Water_pump, Idler_pulley, 2_Tensioner, Power_Steering_pully." Then, click Next.

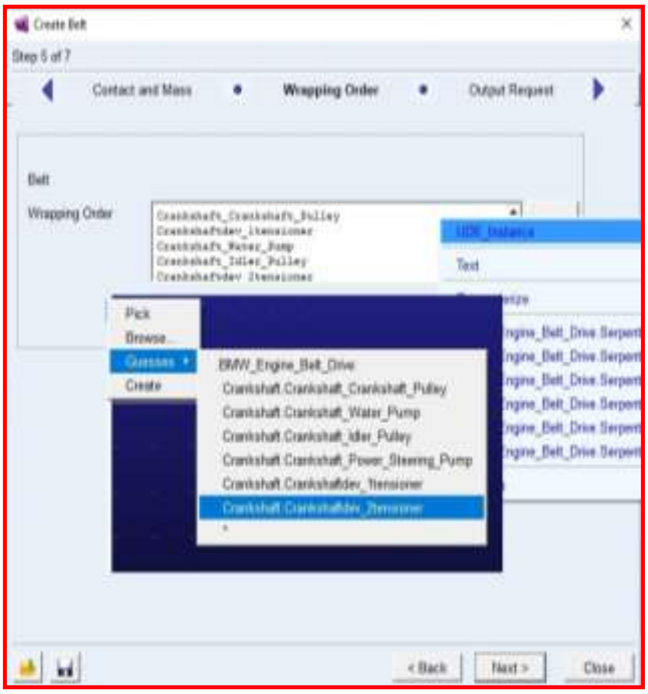


Figure 17 . Create a Belt Wrapping Order

g. When prompted about the belt number of segments, tension, and strain, click OK to continue. A warning message will be displayed informing you that the 2D parts for the belt segments are unique to the Adams Solver executable (the default mode).

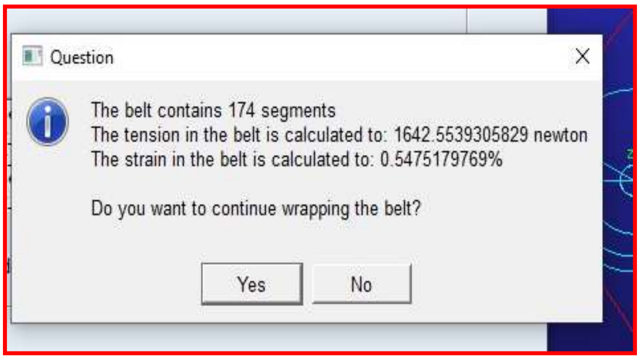


Figure 18 . Create a Belt segments warning message.

h. Now you will be on the Output Request page. Create a request of type Segment Request and populate the Link Part(s) field (for example, via right-click Pick) with a belt segment (25) near the bottom of the follower pulley. This will create output requests to track the forces on that segment as the belt runs around the pulleys. You may want to toggle the icon display off to better see the belt (one way is to select a * icon). Click Next.

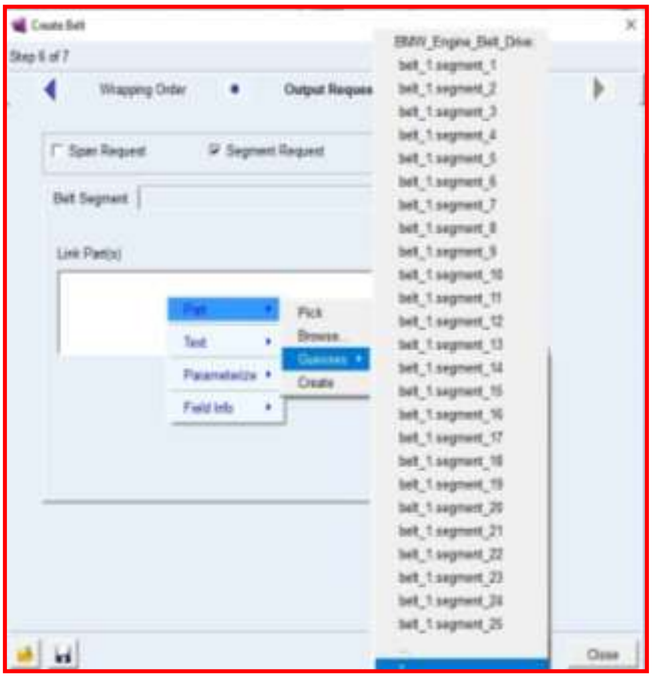


Figure 19 . Create a Belt segment Request

i. The next page (Completion) informs you that all the information required for the belt has been entered. Optionally save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the belt.

Step 4. Create Belt Actuation Input

a. From the Ribbon go to the Machinery tab's Belt container and click the icon for Belt Actuation Input.

b. The Actuate Belt wizard is launched. In the Pulley Set Name field, enter the name of the pulley set you just created (right-mouse-click in the field and use Pick or Guesses to quickly select). In the Actuator UDE_Instance field, enter the name of the Power_steering_pump (right-mouse-click in the field and use Pick or Guesses to quickly select). Then click Next.

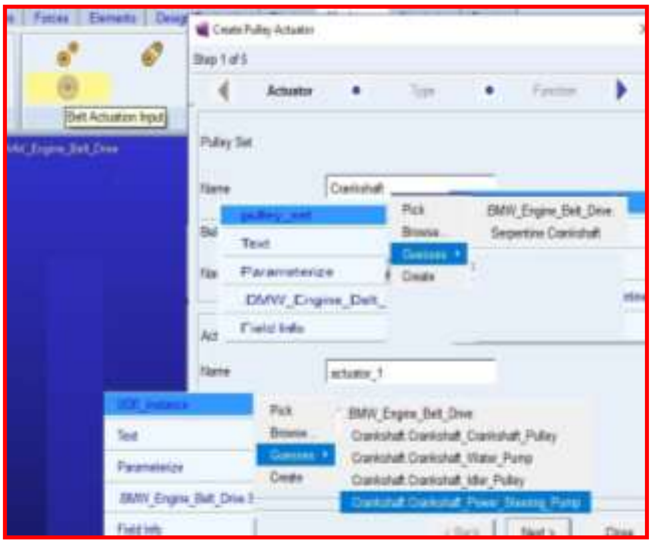


Figure 20 . Create a Belt Actuation Input

c. On the next page (Type) select Motion and click Next.

d. Complete the next page, Function select User Defined, enter 30D*TIME in the User Entered Function Box, set the Direction to Anti Clockwise, and click Next.

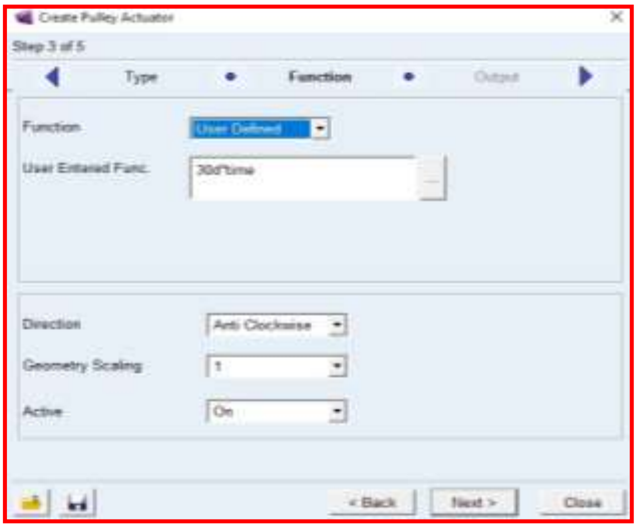


Figure 21 . Create a Belt Actuation Input Function

e. On the next page (Output), you can optionally reduce the amount of post-processing information about the actuator to be made available as Adams Requests. For this example, accept the defaults (to get all information) and click Next.

f. The next page (Completion) informs you that all the information required for the actuation has been entered. Optionally, save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the actuator

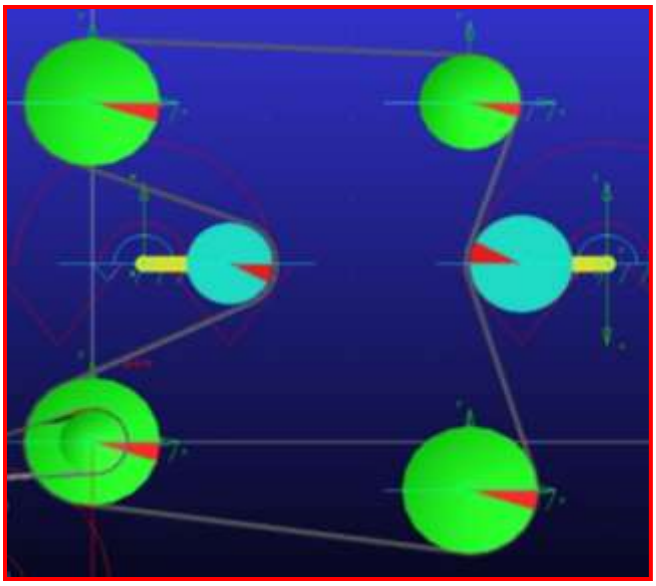


Figure 22 . Create 1 Solidified the part.

Step 5. Create pulley

a. From the Machinery ribbon, double-click Rigid Belt.
b. The pulley creation wizard will launch. On the first page (Type), select Poly-V Grooved from the Type option menu and click Next.
c. On the next page (Method), select 2D Links from the Method option menu and click Next.
d. On the next page (Geometry), fill out the four tabs defining each pulley's geometry as shown below and then click Next:
a. Pulley1 name as Crankshaft_2 and Pulley2 name as A/C Compressor.
b. Pulley1 center location as 0,0,0 and Pulley2 center location as -150, -50,0.
c. Pulley1 Geometry: Width 30, Diameter 40 and Pulley2 Geometry: Width 30, Diameter 40.
e. The next page (Material-Pulleys) defines the material properties to be used for the mass property calculations for each pulley. Accept the defaults and move on by clicking Next.
f. On the next page (Connection-Pulleys), you define how each pulley is to be connected to the rest of the model. For this example, accept the defaults, which mount each pulley to ground via revolute joints and click Next.
g. On the next page (Output-Pulleys), you can optionally reduce the amount of post-processing information about the pulleys to be made available as Adams Requests. For this example, accept the defaults (to get all information) and click Next.
h. The next page (Completion-Pulleys) informs you that all the information required for the grooved pulleys has been entered. Click Next to proceed to tensioner definition.
i. On this page (Geometry - Tensioners), enter 1 in the Number of Tensioner with Deviation Pulley field and fill out the tabs defining the tensioner arm and deviation pulley geometry:
a. Select Tensioner Name: Main Accessory Tensioner, Center: -65,-100,0, Geometry: Length 50, Width 10, Depth 5, Installation Angle 90.
b. Select Deviation Pulley Name: 3_Tensioner, Pulley Radius 15, Belt Face Side out, then click Next.
j. The next page (Material-Tensioners) defines the material properties to be used for the mass property calculations for the tensioner arm and deviation pulley. Accept the defaults and move on by clicking Next.
k. On the next page (Connection-Tensioners), select Stiffness: 1E05, Damping: 100.
l. The next page (Completion) informs you that all the information required for the pulley set has been entered. Optionally save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the pulley set.

Step 6. Create Belt

a. From the Ribbon, go to the Machinery tab's Belt container and click the icon for Create Belt.
b. The Belt Creation wizard is launched. In the Name field, enter the name of the pulley_set you just created (right-mouse-click in the field and use Pick or Guesses to quickly select serpentine Crankshaft) and then click Next.
c. The next page (Method) defaults to the method you chose when creating the pulley set. Accept this default by clicking Next.
d. The next page (Geometry) is for the specification of the Belt geometry. Make the modifications as shown below and click Next to move on.
e. The next page (Mass) defines the material properties to be used for the mass property calculations for the belt segments. Accept the defaults and move on by clicking Next.
f. On the next page (Wrapping Order), the belt routing is defined. Right-click in the field and use the Guesses menu to first pick the Crankshaft_pulley, then the Tensioners, and finally the A/C Compressor so that the field is populated as follows: "Crankshaft_pulley, 3_Tensioner, Water pump, A/C Compressor". Then click Next.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

g. When prompted about the belt number of segments, tension, and strain, click OK to continue. A warning message will be displayed informing you that the 2D parts for the belt segments are unique to the Adams Solver executable (the default mode).
h. Now you will be on the Output Request page. Create a request of type Segment Request and populate the Link Part(s) field (for example, via right-click Pick) with a belt segment (25) near the bottom of the follower pulley. This will create output requests to track the forces on that segment as the belt runs around the pulleys. You may want to toggle the icon display off to better see the belt (one way is to select a * icon). Click Next.
i. The next page (Completion) informs you that all the information required for the belt has been entered. Optionally save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the belt.

Step 7. Create Belt Actuation Input

a. From the Ribbon, go to the Machinery tab's Belt container and click the icon for Belt Actuation Input.
b. The Actuate Belt wizard is launched. In the Pulley Set Name field, enter the name of the pulley set you just created (right-mouse-click in the field and use Pick or Guesses to quickly select). In the Actuator UDE_Instance field, enter the name of the A/C Compressor (right-mouse-click in the field and use Pick or Guesses to quickly select). Then click Next.
c. On the next page (Type), select Motion and click Next.
d. Complete the next page: Function select User Defined, enter 30D*TIME in the User Entered Function Box, set the Direction to Anti Clockwise, and click Next.
e. On the next page (Output), you can optionally reduce the amount of post-processing information about the actuator to be made available as Adams Requests. For this example, accept the defaults (to get all information) and click Next.
f. The next page (Completion) informs you that all the information required for the actuation has been entered. Optionally save the content of the entire wizard to a file for re-use later by clicking the Save icon. Click Finish to create the actuator.

Step 8. Create Solidified the part

a. Shift + s

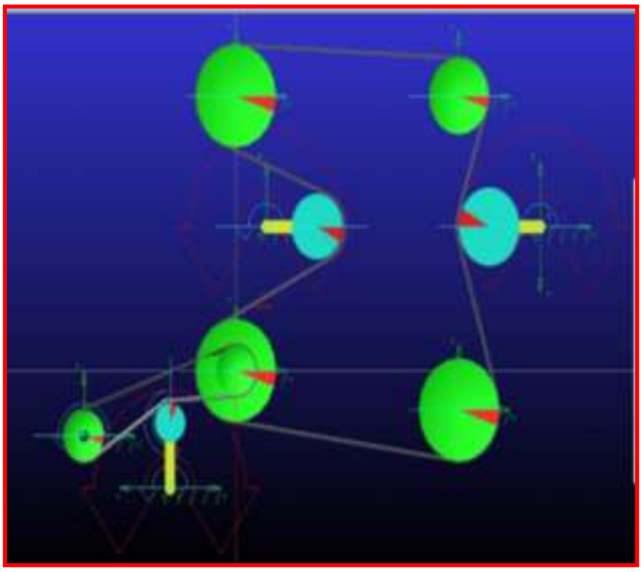
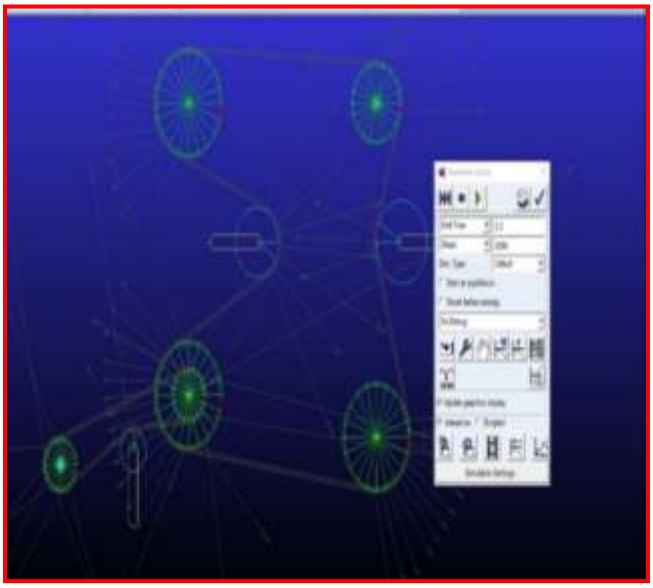


Figure 23 . Create 2 Solidified the part.

Step 6. Testing the Model

a From Simulation ribbon, select Run an Interactive Simulation
b Set duration to 2 and Step Size to 2000
c Click Start,
d Click Plotting
e Create a CM position plot for link OA in X component
f Create a CM angular velocity plot.
g Follow the plot curve. Find the angular velocity



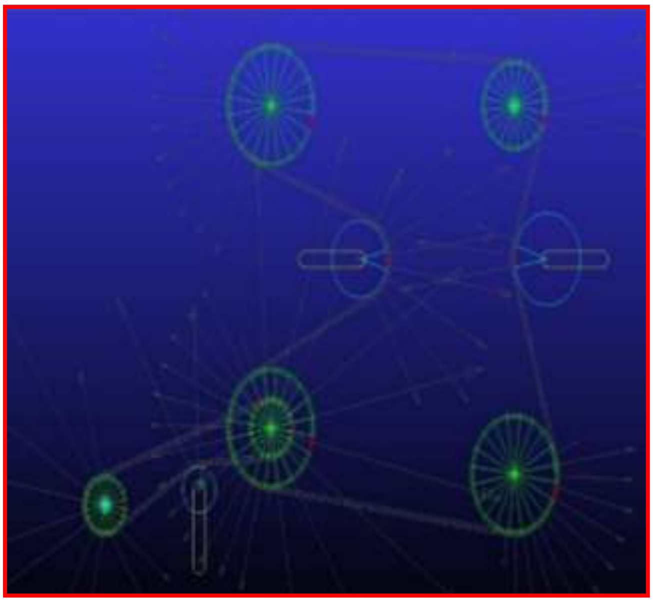


Figure 24 . Simulation the Belt Drive.

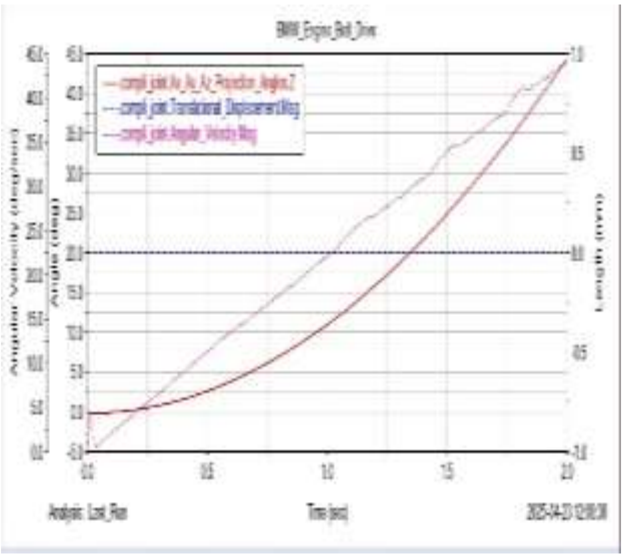


Figure 25. Power_steering_pump Plot the Belt Driven.

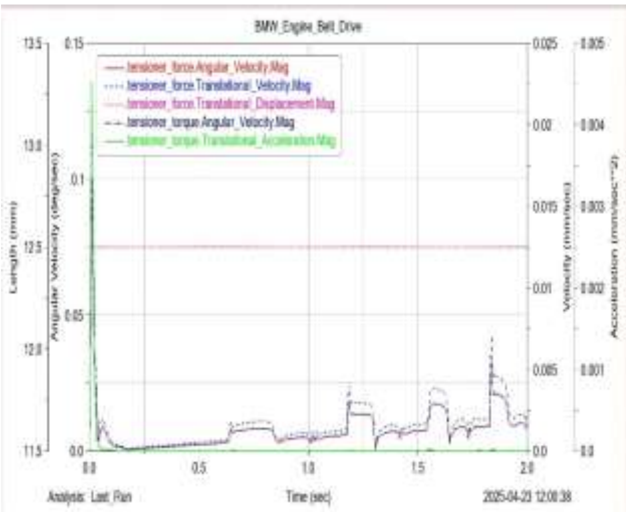


Figure 26. Idler_pulley Plot the Belt Driven.

.

4. CONCLUSION

This dissertation has focused on the simulation of the dynamic behavior of the BMW E60 accessory belt drive system using MSC Adams in order to simulate dynamic motion of critical components such as the pulleys and belts, based upon various settings. The simulation also took into consideration the dynamic behavior of the system based upon the various operational parameters that were changed, and through the Adams/View module you were able to see how these adjustments affected the behavior of the system. In this regard, the changes to system dynamics based on variations in pulley interaction and/or belt tension have been clearly shown, and the results have provided useful information about the motions of system components that are contradictory to the performance measured of the belt drive.

REFERENCES

1. **Karam, A. M., & Gadelmawla, E. S.** (2015). "Analysis of Belt Drives Using Multi-Body Dynamics." *International Journal of Mechanical Systems*, 22(1), 45–53.
2. **Hexagon Manufacturing Intelligence.** (2021). *Getting Started Using Adams Machinery*. Retrieved from https://help-be.hexagonmi.com
3. **Wang, Y., Chen, H., & Liu, X.** (2017). "Dynamic Simulation of Serpentine Belt Drive System in Automotive Engines Using Adams." *Journal of Mechanical Engineering Research*, 9(3), 35–42.
4. **MSC Software.** (2021). *Adams/Machinery User Guide*. Hexagon Manufacturing Intelligence.
5. **YouTube.** (n.d.). *How to Create a Belt Drive Simulation in MSC Adams*. Retrieved from https://www.youtube.com/watch?v=H0MbYLmMLu

BIOGRAPHIES

P V Mallari
UG Student Mechanical Engineering, RYM Engineering College, Ballari

Sai Rohith G
UG Student Mechanical Engineering, RYM Engineering College, Ballari

E KUMARA GOUDA
UG Student Mechanical Engineering, RYM Engineering College, Ballari

Kiran D V
UG Student Mechanical Engineering, RYM Engineering College, Ballari