AE342- MANUFACTURING PROCESSES LAB
MANUFACTURING SIMULATION
COLD ROLLING

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I. INTRODUCTION

Cold rolling is a fundamental process in the manufacturing industry, particularly in the production of metal sheets, strips, and coils.This method imparts unique mechanical properties and surface characteristics to the metal, making it indispensable across various sectors, including automotive, aerospace, construction, and electronics.The cold rolling process involves passing metal through a series of rollers at ambient temperature, gradually reducing its thickness and altering its shape.

II. INPUT PARAMETERS

- Roller Diameter(200 mm, 190 mm, 180 mm)
- Percentage Reduction(50%, 35%, 20%)
- Angular velocity of the roller(100 rpm, 140 rpm, 160 rpm)

III. OUTPUT PARAMETER

- Average Rolling Force

IV. ROLLER DIAMETER AND ANGULAR VELOCITY CONSTANT

IV.1. Inputs

- Time=0.11 seconds
- Workpiece velocity=550 mm/sec
- Roller Diameter=200mm
- Angular velocity of roller=100rpm
- Young Modulus=69000 Mpa
- Poission Ratio=0.33
- Density=2660 kg/m^3
- Shear stress=117 Mpa
- Friction coffecient=0.25

IV.2. Case 1:50%reduction

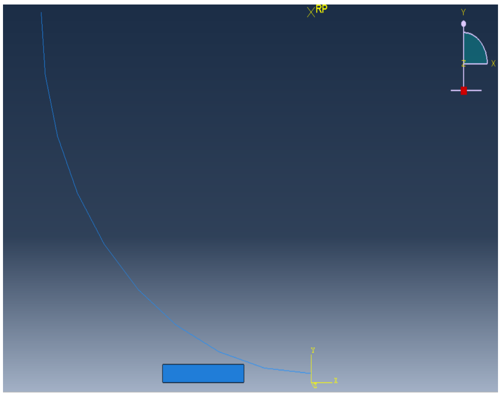

FIG. 1. Assembly of Roller and workpiece

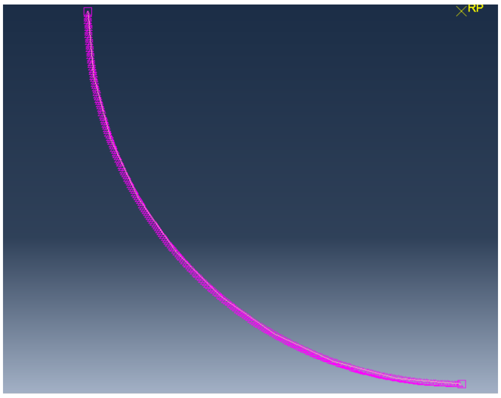

FIG. 2. Meshing of roller

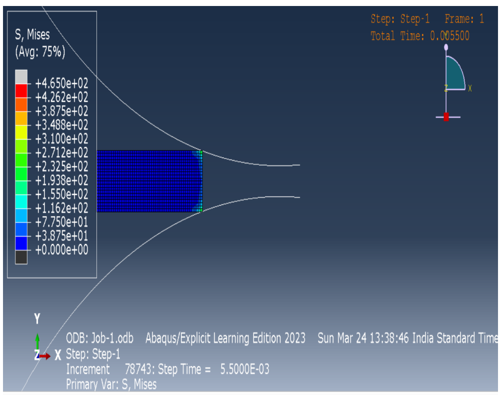

FIG. 3.

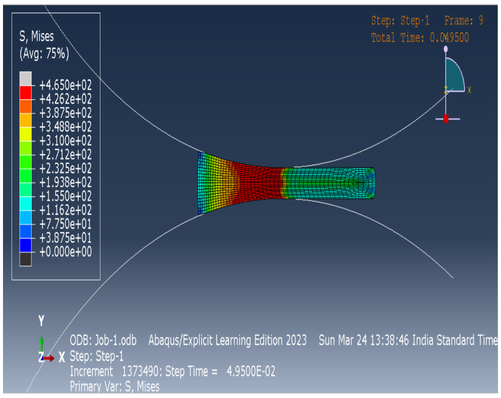

FIG. 4.

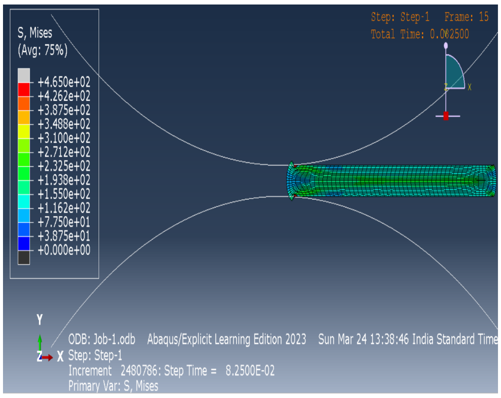

FIG. 5.

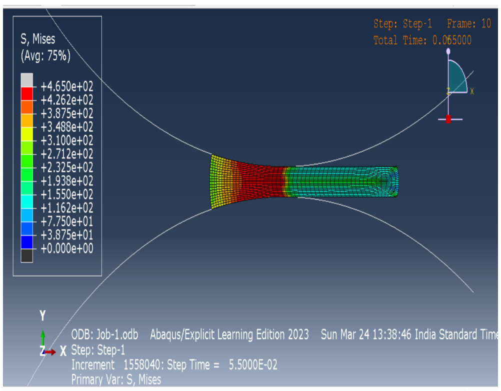

FIG. 6.

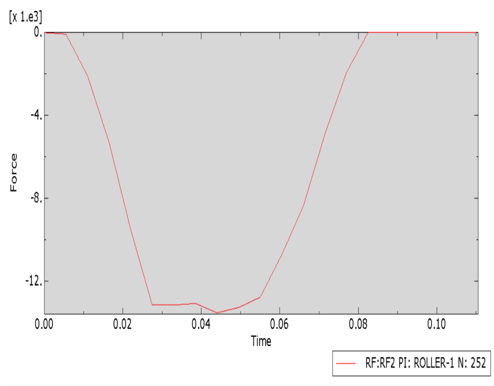

FIG. 7. Rolling force vs time graph 50%

IV.3. Case 2:35%reduction

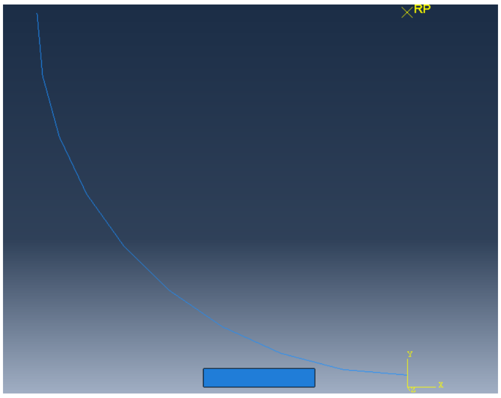

FIG. 8. Assembly of Roller and workpiece

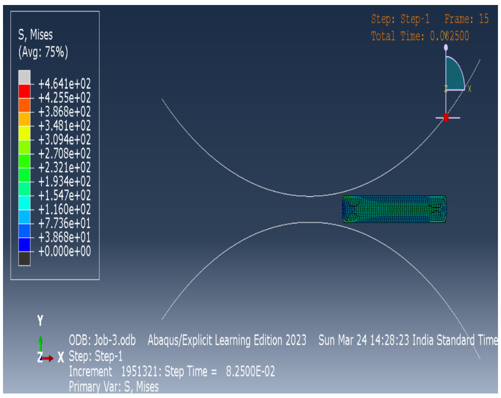

FIG. 9.

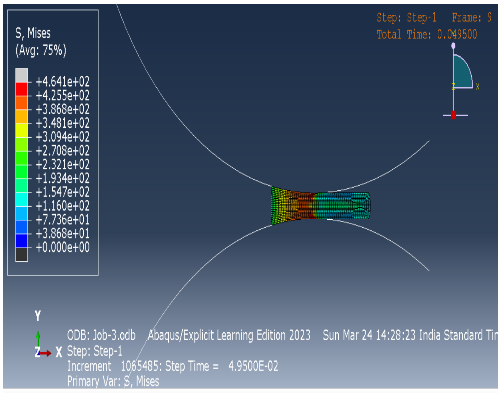

FIG. 10.

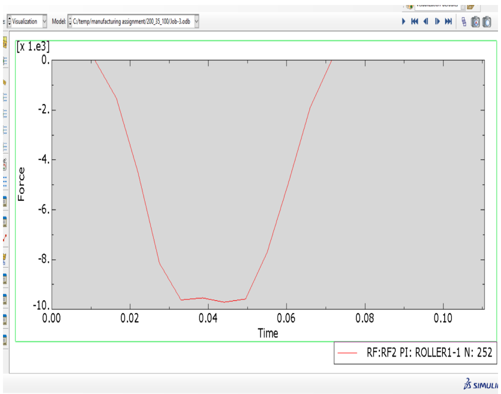

FIG. 11. Rolling force vs time graph for 35%

IV.4. Case 3:20%reduction

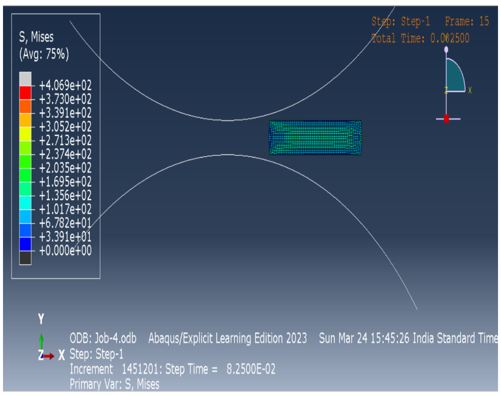

FIG. 12.

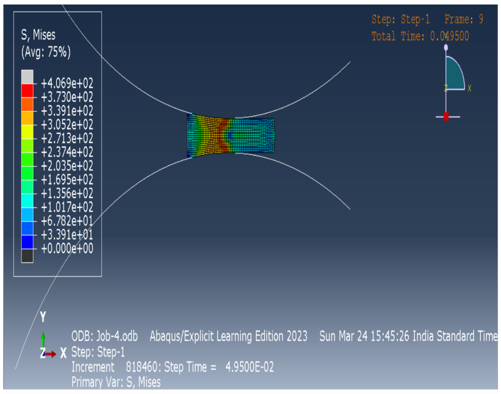

FIG. 13.

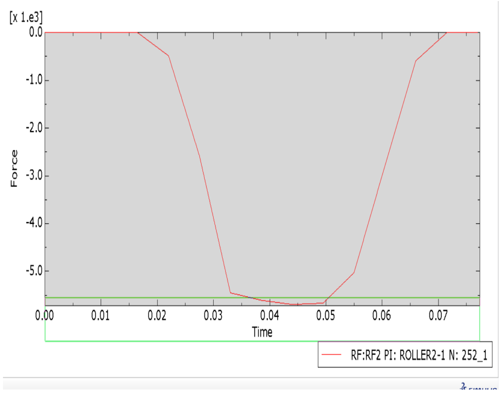

FIG. 14. Rolling force vs time

IV.5. Comparison

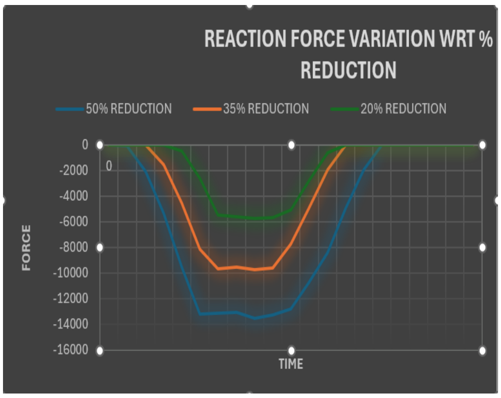

FIG. 15.

IV.6. Conclusion

Based on the data, it appears that as the percentage reduction in the cold rolling process increases, the average rolling force also increases.
Conclusion: The average rolling force in the cold rolling process tends to increase with higher percentages of reduction applied to the workpiece.
Reason may be following:

- **Material Deformation:** As the percentage reduction increases, the amount of deformation imparted to the workpiece during cold rolling also increases. This results in greater resistance to deformation, leading to higher rolling forces required to achieve the desired reduction in thickness.

- **Increased Contact Pressure:** With higher reductions, the contact area between the workpiece and the rollers decreases. This leads to an increase in contact pressure, causing more intense plastic deformation of the material and consequently requiring higher rolling forces to overcome this resistance.

- **Work Hardening:** As the material undergoes successive reductions, it experiences work hardening, where its strength and resistance to deformation increase. This phenomenon further contributes to the need for higher rolling forces to achieve the desired reduction in thickness.

- **Frictional Effects:** Increased reduction percentages can also lead to higher frictional forces between the workpiece and the rollers. These frictional forces add to the overall resistance encountered during the rolling process, necessitating higher rolling forces to maintain the desired reduction rate.

V. ROLLER DIAMETER AND %REDUCTION IS CONSTANT

V.1. Inputs

- Time=0.11 seconds
- Workpiece velocity=550 mm/sec
- Roller Diameter=200mm
- %reduction=50%
- Young Modulus=69000 Mpa
- Poission Ratio=0.33
- Density=2660 kg/m^3
- Shear stress=117 Mpa
- Friction coffecient=0.25

V.2. Case 1:100 rpm

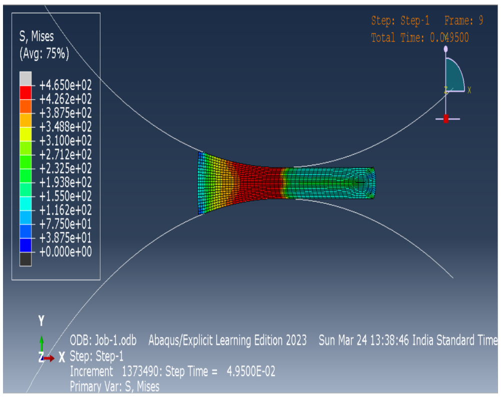

FIG. 16.

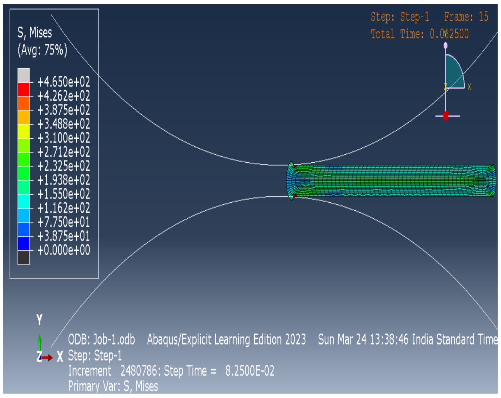

FIG. 17.

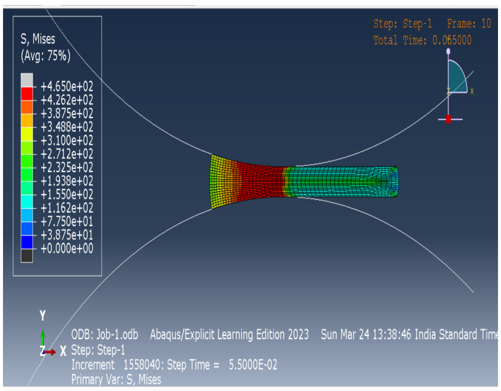

FIG. 18.

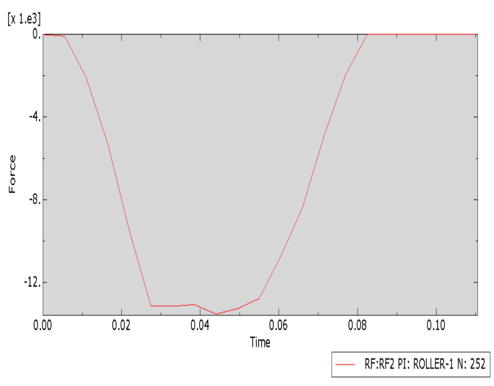

FIG. 19. Average rolling force vs time

V.3. Case 2: 140 rpm

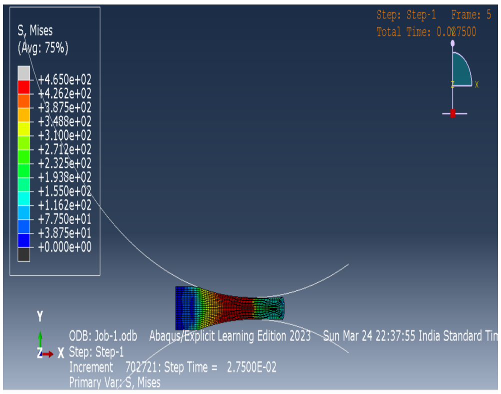

FIG. 20.

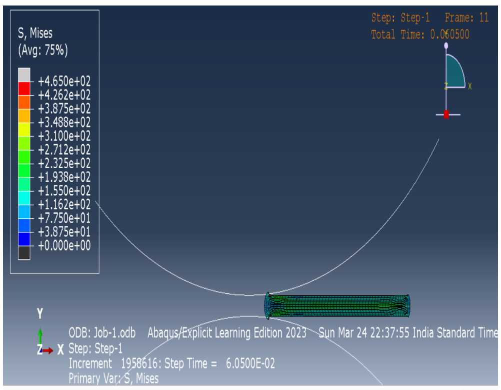

FIG. 21.

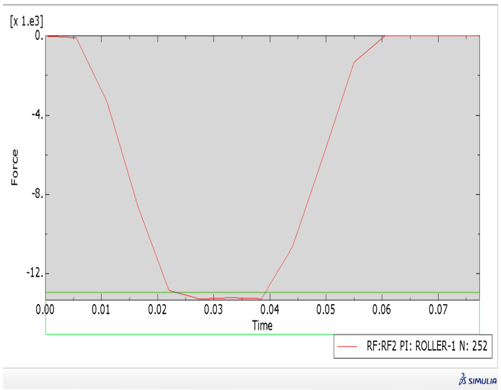

FIG. 22. Average rolling force vs time

V.4. Case 3:160 rpm

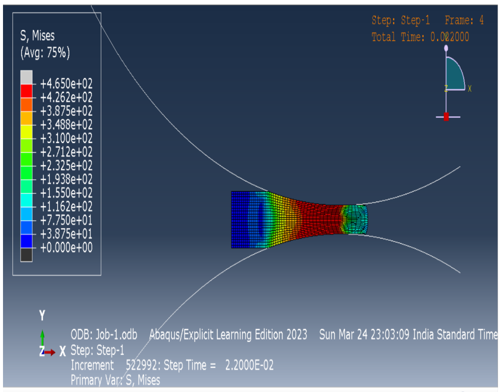

FIG. 23.

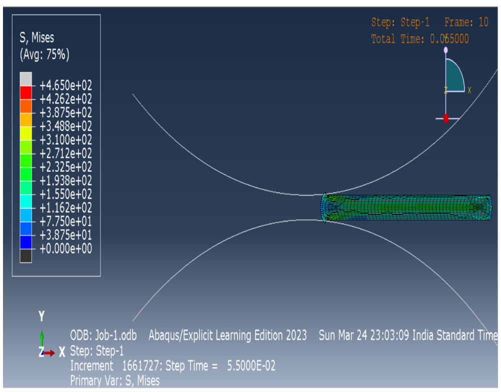

FIG. 24.

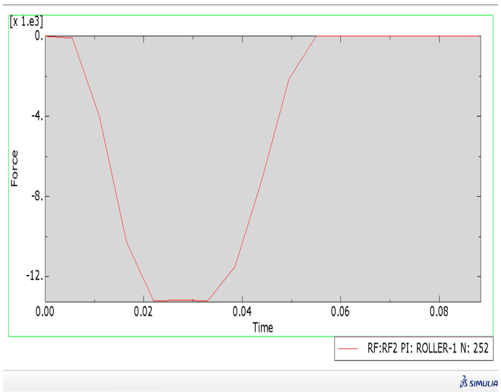

FIG. 25. Rolling force vs time

V.5. Comparison

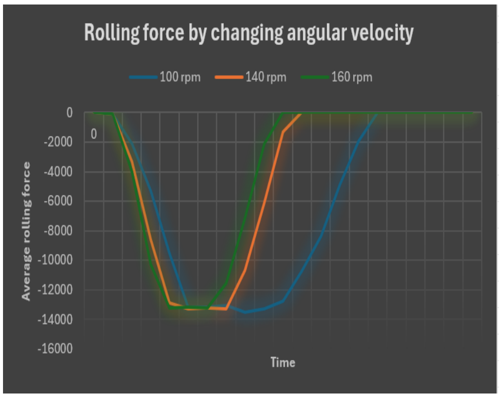

FIG. 26.

V.6. Conclusion

Based on the data, it appears that as the angular velocity of the roller increases in the cold rolling process, the average rolling force generally decreases.
Conclusion: In the cold rolling process, increasing the angular velocity of the roller tends to result in a decrease in the average rolling force required.
Reasons may be following:

- **Reduced Contact Time:**Higher angular velocities lead to faster rotation of the rollers, reducing the contact time between the workpiece and the rollers. This shorter contact time results in less deformation of the material per revolution, thereby reducing the overall rolling force required to achieve the desired reduction in thickness.

- **Decreased Frictional Effects:**With higher angular velocities, the relative motion between the workpiece and the rollers increases, potentially reducing the frictional forces acting on the material. Lower frictional forces contribute to lower resistance encountered during the rolling process, resulting in decreased rolling forces.

- **Dynamic Effects:** Higher angular velocities can induce dynamic effects such as centrifugal forces, which may help to reduce the effective contact pressure between the workpiece and the rollers. This reduction in contact pressure can lead to a decrease in the overall rolling force required.

- **Energy Considerations:**Higher angular velocities typically require more energy input to drive the rollers. However, the reduction in rolling force with increasing angular velocity suggests that the energy efficiency of the process may improve as the rollers operate at higher speeds.

VI. ANGULAR VELOCITY AND %REDUCTION IS CONSTANT

VI.1. Inputs

- Time=0.11 seconds
- Workpiece velocity=550 mm/sec
- Angular velocity=100 rpm
- %reduction=50%
- Young Modulus=69000 Mpa
- Poission Ratio=0.33
- Density=2660 kg/m^3
- Shear stress=117 Mpa
- Friction coffecient=0.25

VI.2. Case 1:D=200mm

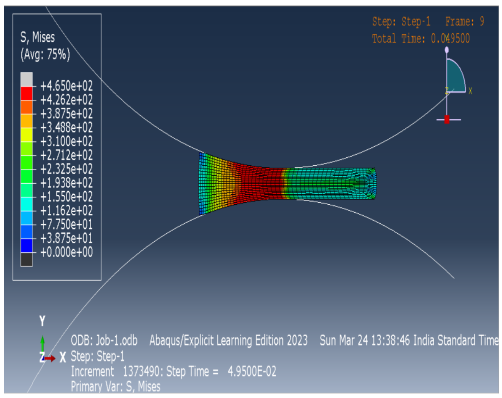

FIG. 27.

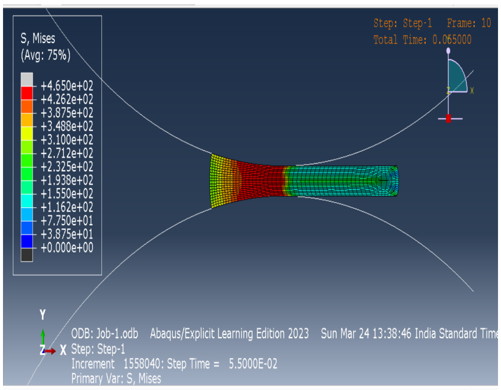

FIG. 28.

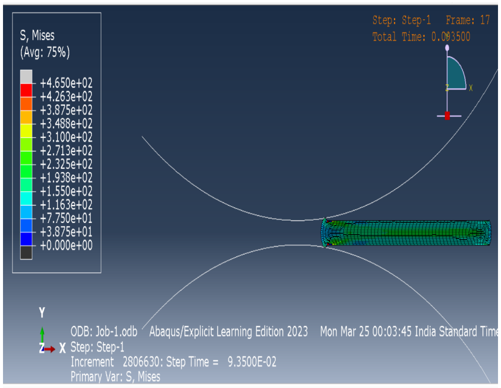

FIG. 31.

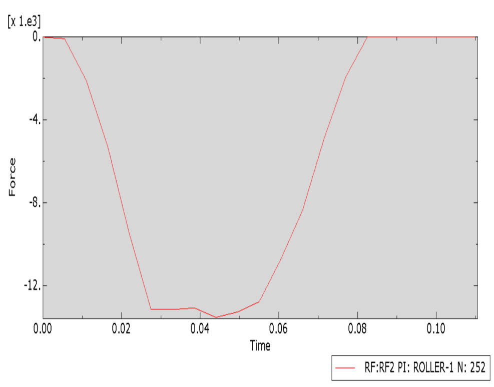

FIG. 29. Rolling force vs time

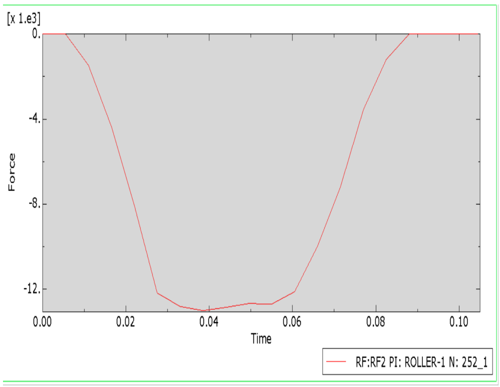

FIG. 32. Rolling force vs time

VI.3. Case 2:D=190mm

VI.4. Case 3:D=180mm

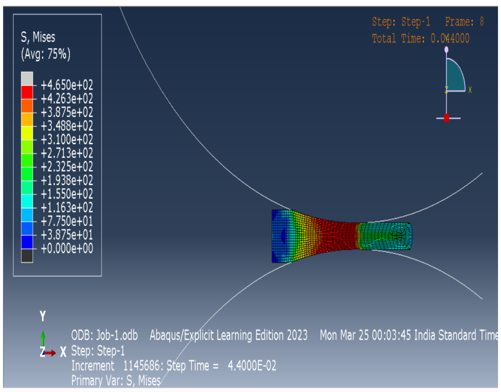

FIG. 30.

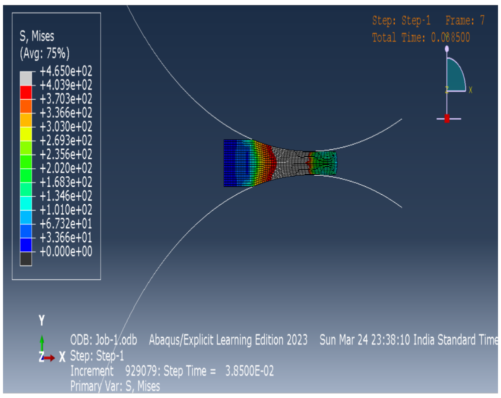

FIG. 33.

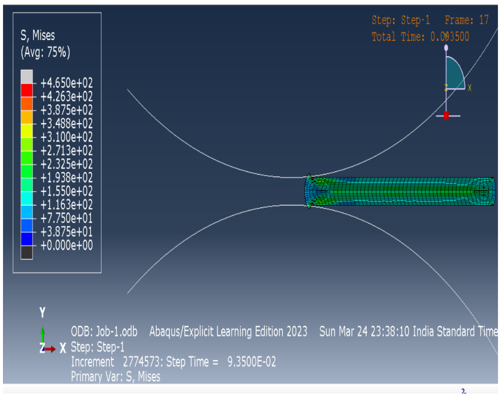

FIG. 34.

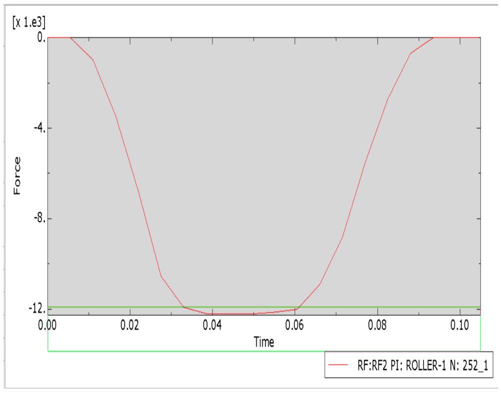

FIG. 35.

VI.5. Comparison

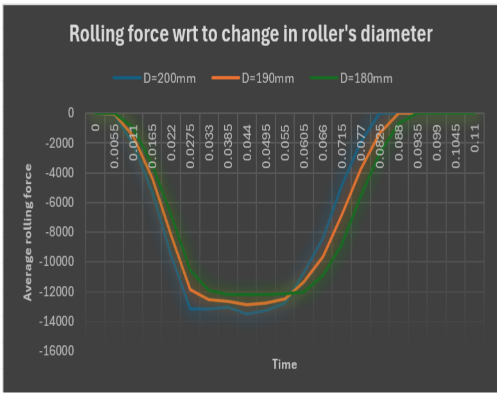

FIG. 36.

VI.6. Conclusion

Based on the data, it appears that as the roller diameter decreases in the cold rolling process, the average rolling force generally increases.
Conclusion: In the cold rolling process, decreasing the roller diameter tends to result in an increase in the average rolling force required.
Reason may be following:

- **Increased Contact Pressure:**As the roller diameter decreases, the contact area between the workpiece and the rollers also decreases. This leads to an increase in contact pressure, causing more intense deformation of the material and consequently requiring higher rolling forces to overcome this increased resistance.

- **Reduced Deformation Capacity:** With smaller roller diameters, the ability of the rollers to deform the material is reduced. This results in a higher degree of material hardness and resistance to deformation, necessitating higher rolling forces to achieve the desired reduction in thickness.

- **Increased Frictional Effects:**Smaller roller diameters may also lead to increased frictional forces between the workpiece and the rollers. These frictional forces add to the overall resistance encountered during the rolling process, contributing to the higher rolling forces observed.

- **Material Flow Considerations:**Smaller roller diameters may restrict the flow of material during the rolling process, leading to localized areas of higher stress and strain. This localized deformation requires higher rolling forces to achieve the desired reduction in thickness uniformly across the workpiece.

VII. TABLES

TABLE I. Rolling force vs time(changing % reduction)

Time	50%	35%	20%
0	0	0	0
0.0055	-80.2533	0	0
0.011	-2086.8	0	0
0.0165	-5301.56	-1524.42	0
0.022	-9511.61	-4493.01	-485.122
0.0275	-13146.5	-8145.46	-2583.61
0.033	-13145.3	-9618.36	-5451.95
0.0385	-13065.4	-9535.75	-5608.18
0.044	-13521.9	-9707.56	-5696.83
0.0495	-13261.8	-9579.45	-5668.42
0.055	-12768	-7707.92	-5029.19
0.0605	-10716.2	-4890.84	-2790.07
0.066	-8366.82	-1893.96	-588.849
0.0715	-4891.32	0	0
0.077	-1920.73	0	0
0.0825	0	0	0
0.088	0	0	0
0.0935	0	0	0
0.099	0	0	0
0.1045	0	0	0
0.11	0	0	0

TABLE II. Rolling force vs time(changing angular velocity)

Time	100	140	160
0	0	0	0
0.0055	-80.2533	-92.4082	-95.8784
0.011	-2086.8	-3339.49	-4003.5
0.0165	-5301.56	-8618.42	-10270.5
0.022	-9511.61	-12845.6	-13215.2
0.0275	-13146.5	-13284.5	-13175.6
0.033	-13145.3	-13221.9	-13211.1
0.0385	-13065.4	-13269.8	-11514.6
0.044	-13521.9	-10662	-7153.71
0.0495	-13261.8	-6077.87	-2131.88
0.055	-12768	-1326.61	0
0.0605	-10716.2	0	0
0.066	-8366.82	0	0
0.0715	-4891.32	0	0
0.077	-1920.73	0	0
0.0825	0	0	0
0.088	0	0	0
0.0935	0	0	0
0.099	0	0	0
0.1045	0	0	0
0.11	0	0	0

TABLE III. Rolling force vs time(changing Diameter)

Time	200	190	180
0	0	0	0
0.0055	-80.2533	-40.12665	0
0.011	-2086.8	-1533.1435	-979.487
0.0165	-5301.56	-4380.25	-3458.94
0.022	-9511.61	-8151.745	-6791.88
0.0275	-13146.5	-11849.65	-10552.8
0.033	-13145.3	-12535.65	-11926
0.0385	-13065.4	-12635.6	-12205.8
0.044	-13521.9	-12865.5	-12209.1
0.0495	-13261.8	-12739.95	-12218.1
0.055	-12768	-12454.25	-12140.5
0.0605	-10716.2	-11365.9	-12015.6
0.066	-8366.82	-9640.01	-10913.2
0.0715	-4891.32	-6856.925	-8822.53
0.077	-1920.73	-3726.255	-5531.78
0.0825	0	-1356.04	-2712.08
0.088	0	0	-691.504
0.0935	0	0	0
0.099	0	0	0
0.1045	0	0	0
0.11	0	0	0

VIII. OTHER INPUT PARAMETERS

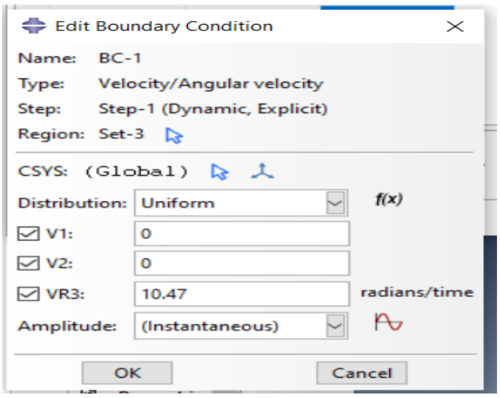

FIG. 37. Angular velocity of roller

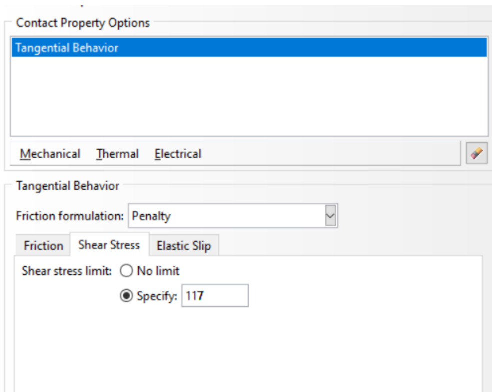

FIG. 38. Max shear stress(MPa)

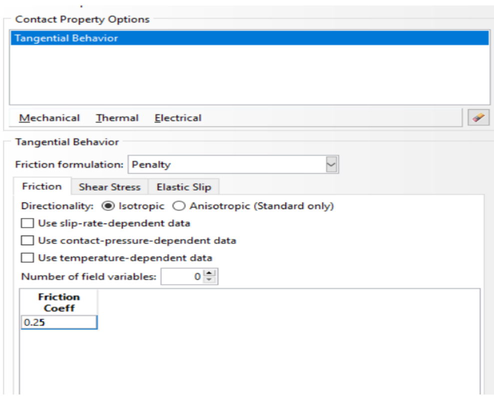

FIG. 39. Friction coefficient

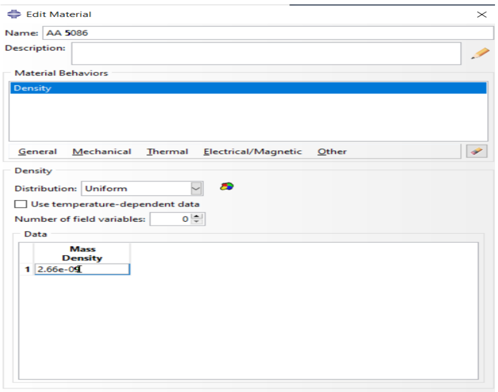

FIG. 40. Density of material

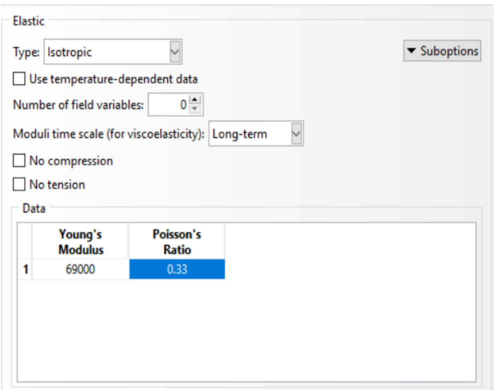

FIG. 41. Elastic properties of material

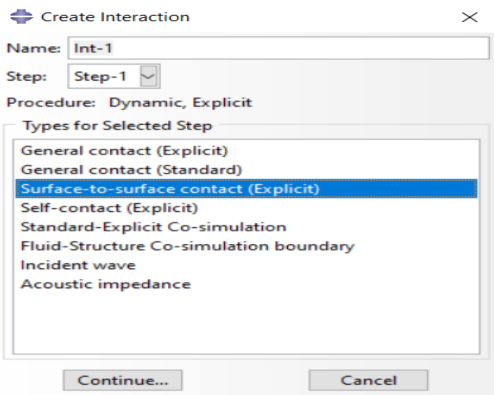

FIG. 42. Interaction type between workpiece and roller

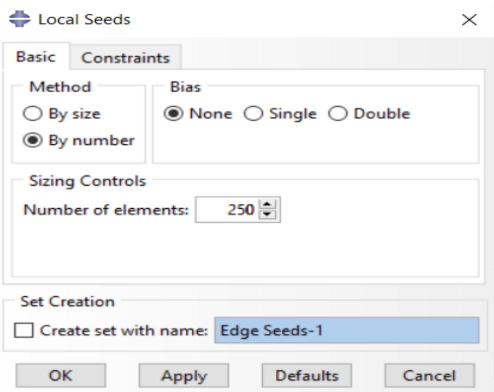

FIG. 43. Roller's meshing

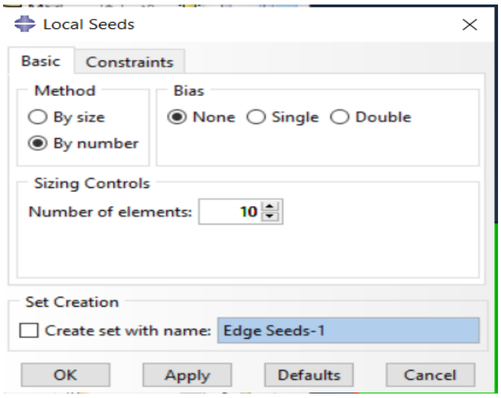

FIG. 44. Workpiece's width side meshing

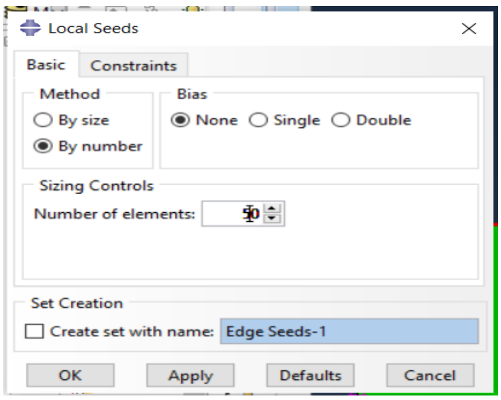

FIG. 45. Workpiece's length side meshing

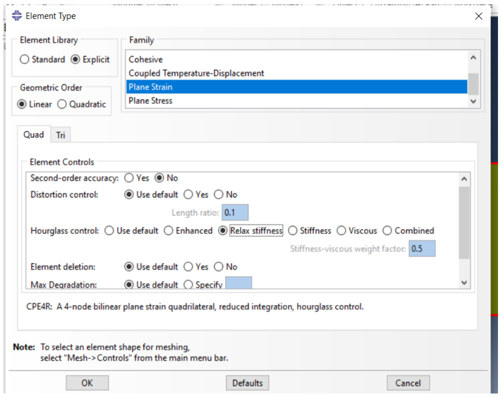

FIG. 46.

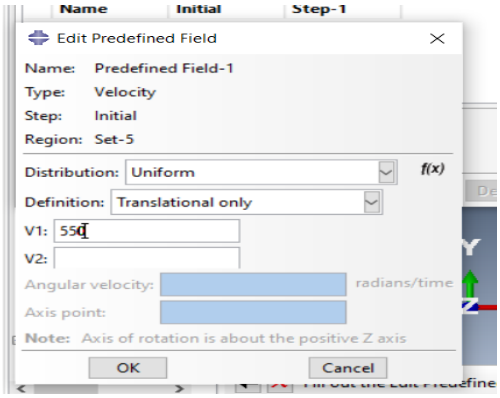

FIG. 48. Predefined velocity

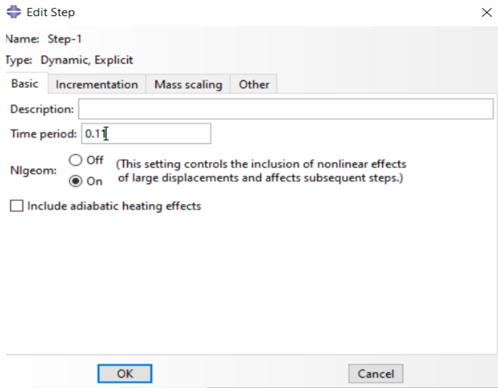

FIG. 49. Time Period

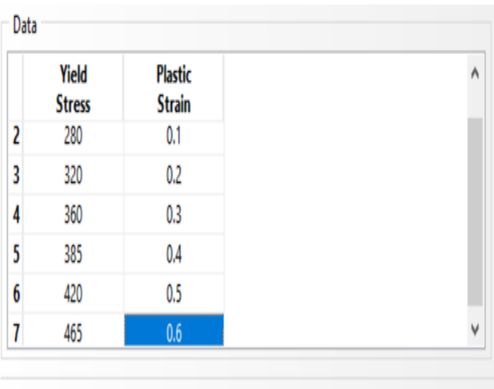

FIG. 47. Plastic properties

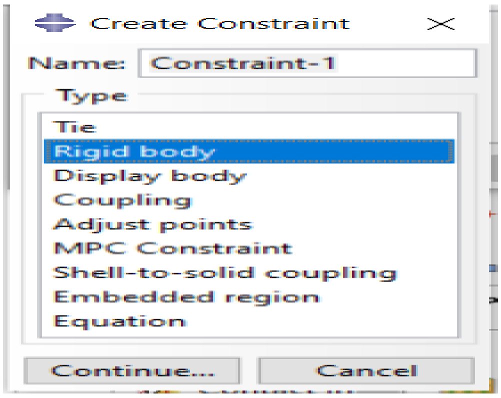

FIG. 50. Constrain