Abstract :

Cold forming processes are the common processes in sheet metal forming, especially in the final stages of production processes. In this thesis, cold rolling process was selected to study the effect of the different reduction ratios on the mechanical properties and the residual stresses state in aluminum alloy (2024). Force, pressure, and required roll torque were calculated for each reduction ratio using the mathematical equations, also the true mean flow stress (σ_{tm}) was calculated for material during cold rolling process.

In the experimental study, sheets of aluminum alloy (2024-T3) were prepared with dimensions (400 X 80 X 3.15 mm), and the annealing process was conducted for these sheets to get the temper condition (2024-O). The cold rolling process was performed with different reduction ratios (10%, 20%, 30%, 40%, 50%, 60%), by a rolling machine composed of two rolls having (50 mm) diameter each.

To investigate the effect of reduction ratio on the mechanical properties of the alloy, tensile and hardness tests were carried out for rolled and unrolled specimens. The tensile tests were performed in three directions with respect to the rolling direction (rolling direction RD, transverse direction TD, oblique direction at 45°), to find out the directionality effect. The strain hardening parameters (strain-hardening exponent *n*, and strength coefficient K) were determined.

The residual stresses of AL 2024 alloy (due to reduction by cold rolling) were measured using the X-ray diffraction techniques (XRD) in two directions (rolling direction RD, and transverse direction TD).

It was found that the 50 % reduction ratio is the maximum reduction of AA 2024, edge crack observed at 60 % reduction. The hardness tests showed a significant increase in hardness of the alloy, reached 52% at 60%

reduction ratio. The reduction by cold rolling affected the mechanical properties of AA 2024 and their directionality. Ultimate and yield stresses were increased together with a severe drop in the ductility of rolled specimens. The 10% reduction ratio was found most influential on these properties. The tested specimens in transverse direction achieved the highest tensile stress followed by the specimens tested in rolling direction, while the specimens tested at angle 45° had the lowest.

The results of X-ray diffraction showed the presence of residual stresses at the surface of rolled specimens, and these were compressive stresses in the two tested directions (RD, and TD) at 10% reduction ratio. When the reduction ratio exceeded 10%, these stresses transformed to tensile stresses for specimens tested in rolling direction, while these stresses remained compressive type for all reduction ratios in transverse direction.

Computer simulation was carried out using finite element method (FEM) by (ANSYS-LSDYNA 12.1) software to investigate the residual stresses behavior and to determine the maximum reduction ratio of AA 2024. The numerical results showed a good agreement with the experimental results.