Accumulative roll bonding (ARB) is a severe plastic deformation process that is applied to achieve metallic materials with very fine grains (submicron) without changing sample dimensions. In this study, aluminum metal matrix nanocomposite with ٥٪ volume titanium aluminide reinforcement was obtained by rolling, annealing and accumulative roll bonding processes on Al-١١٠٠ sheets containing pure titanium powder. For reducing the size and increasing the adhesion of Ti powders, mechanical alloying was used before cold roll bonding. Aluminum-aluminum sandwiches containing ٠٫٥٪ wt. Ti were rolled under ٥٠٪ thickness reduction. Then, annealing was performed at different temperatures and times to establish aluminide titanium intermetallics. Finally, the specimens were subjected to ARB process. For comparisons, the same conditions of cold roll bonding, annealing, and ARB were applied on aluminum sheets without reinforcing particles. In addition, aluminum metal matrix composite with reinforcement titanium aluminide was also made using the conventional cold rolling, ARB and annealing method, and the results were compared. The effect of time and temperature parameters on the formation of titanium aluminide during annealing was studied by scanning electron microscopy (SEM), Energy dispersive x-ray spectroscopy (EDS) and X-ray diffraction (XRD). Microstructural evaluations and chemical analysis of the samples were investigated using scanning electron microscopy, field emission scanning electron microscope (FESEM), transmission electron microscopy (TEM) and electron backscatter diffraction)EBSD(.

Apart from this, nanohardness and Young's modulus were calculated from the nanoindentation test and their mean values were obtained. In order to study the mechanical behavior of the samples, single-axis tensile tests were used. Fracture surfaces of samples after the tensile test evaluated with scanning electron microscopy. Moreover, the microstructure’s texture was calculated by EBSD, then obtained polar figures and orientation distribution functions (ODF) were evaluated. The results showed that the annealing after the initial cold roll bonding at the temperature of ٥٩٠°C for ٢ hours led to completely consume of Ti and the formation of a $\text{TiAl}_{٣}$ intermetallic compound with a hardness of ٦ GPa. Finally, ARB was performed on Al-$\text{TiAl}_{٣}$ composite up to five cycles. The results of elemental analysis revealed that no phase change was observed during ARB, and in the long run a composite containing a uniform distribution of the $\text{TiAl}_{٣}$ intermetallic reinforcement particles with a size of about ٢٠٠ nm in the aluminum matrix.

The results showed that in the early stages, the main grains were separated by the boundaries due to the deformation and then, with increasing ARB cycles, a layer structure consisting of parallel layers with a rolling direction was created. The boundary space was reduced by progressing of ARB process and eventually by increasing of strain and the occurrence of continuous dynamic recrystallization, the microstructure with grain size less than ٥٠٠ nm was established. The grain size of monolithic aluminum specimens without Ti powders was ٧٠٠ nm under the same conditions. The reason for this difference is the effect of particles of intermetallic compound on grain reduction. The results of mechanical tests showed that the strength of the final composite increased by increasing the ARB cycles. By applying the ARB process, the strength and hardness of the sheets increased ٢٫٥ and ٣٫٥ times compared to the initial value. The final strength obtained from this composite was ٤٠٠ MPa. The results showed that mechanical property changes during the ARB process is consistent with microstructure evolution. The activated strengthening mechanisms for this composite are including grain boundary, strain hardening and orowan mechanisms.

Therefore, the major contribution to strengthening of the Al-$TiAl_3$ composite is due to the fine grain size of the aluminum substrate and the presence of fine $TiAl_3$ particles in matrix. Also, by examining the fractured surfaces, it was found that the fracture in the final sample was ductile with the mechanism of shear dimple formation. In addition, texture studies indicated a decrease in the cubic component intensity due to the formation of nano shear bands by the reinforcing particles in the fifth cycle of the ARB, while for the aluminum sample without reinforcing particles, the cubic component was more intense.

The microstructure evaluation of composite that fabricated by cold roll bonding, ARB and then annealed also showed that after five cycles of ARB and annealing, the $TiAl_3$ intermetallic compound was formed.