Summary

The twenty-first century manufacturing deals with a great range of structural materials which allow to create lighter constructions, more durable devices, more efficient machines, and the applicability condition is strictly connected with material thigh strength-to-weight ratio. This is important, particularly in the automotive industry, the aviation, in load-bearing structures - where previously aluminum alloys were the prevalent material and currently the various composites are. That is why modern aluminum alloys when competing with polymeric materials and composites must offer not only similar functional properties, but a relatively low price too.

Significant improvement of multi-component alloys mechanical properties can be obtained due the solution heat treatment provided by modern methods of cold working based on SPD (Severe Plastic Deformation) with multi-step heat treatment or by combination of various plastic-heat treatments. Moreover, a significant advantage of aluminum usage is the easy recycling. This is especially important for the environment protection and creates an enormous advantage over composite materials based on polymers.

Modern methods of SPD treatment allow to obtain nanostructure under conditions of heavy plastic deformation. On top of it, comparatively high properties for some series of aluminum alloys can be achieved by using multi-step heat treatment, in particular by multi-aging (T6I6 temper or T6I4 temper). This type of alloy properties improving method seems to be especially perspective, as it is relatively energy efficient.

Microscopic structure examinations conducted on several laboratory aluminum alloys for which a relatively high mechanical properties has been obtained, revealed the existence of dispersion and multiphase strengthening precipitates, crystallizing in cell structure $L1_2$ with a complex structure of core / single or double shell in size range of 10-20nm. The literature does not provide any previously published researches, which would document the possibility of obtaining the commercial multiphase precipitations with core / shell structure in alloys. However, the T6I6 temper of the commercial system Al-Cu-Mg (EN-2024) alloy leads to obtain a similar structure of multiphase precipitate, as in the laboratory alloy, but with a much larger size (around. 1-2 microns.). It is formed according to the second mechanism of kinetics precipitate based on the exchange of atoms in the cell structure. The chemical analysis did not reveal the exact phase components of the shell nor the core. Although the study has confirmed that the base phase is the Al_3 (Cu_x, Fe_y, Mn_{1-xy}).

The test material in T6I6 temper did obtain the fatigue strength approx. Z_{go} = 200 MPa, which is comparable to the value which has been obtained in T351 temper. Axial tensile studies have revealed the anisotropy of properties and significant differences in obtained values R_{02}, R_m, R_b and A in the transverse and longitudinal directions. The tensile strength Rm = 513 MPa has been obtained. In the same research, in T6I6 temper the elongation has been 58% higher than in the treatment T3 and 25% higher comparing to the treatment T6 temper. Improvement of the plastic properties have been confirmed by the results of the ECAP pushing researches as well.

The shell of the core / shell precipitation is particularly important for the dispersion strengthening. It becomes a buffer between the hard and tough core and the matrix with much lower strength properties. With such a structure, a relatively hard precipitation (the core especially) does not behave like a standard hard, brittle strengthen phase and it is not being destroyed.

Incoherent core / shell precipitation, which are not being cut down as a result of the acting load, provide dispersion strengthening and have a significant impact on improving the properties of alloy 2024 in the T6I6 temper . In comparison to the conventional treatments T3 temper and T6 temper the improvement of strength, plastic, and fatigue properties was obtained.