Static and dynamic testing of Al alloys and effect of measurement uncertainty

B. Podgornik[1], B. Žužek[1], V. Kevorkijan[2], B. Hostej[2]

[1]Institute of Metals and Technology, Lepi pot 11, 1000 Ljubljana, Slovenia
[2]IMPOL R&R d.o.o., Partizanska 38, 2310 Slovenska Bistrica, Slovenia

Abstract

The growing demand for the reduction of pollution, more sever control of the emissions and better fuel-efficiency constitutes the driving force behind weight reduction in the automotive industry. The characteristic properties of aluminium and aluminium alloys make them one of the most important non-ferrous metals today and the ideal candidates to replace heavier materials like steel in cars to respond to the weight reduction demands. When compared to structural steels, Al alloys have much better strength to weight ratio, good formability, good corrosion resistance, as well as a good recycling potential, thus giving them a very broad field of application.

In order to properly use materials in design, especially when it comes to light alloys a complete understanding and information on their mechanical properties, such as hardness, elastic modulus, yield and ultimate strength, and elongation must be obtained. It is also vital to know how the properties are affected by the conditions of a specific application of the material. Thus, design of critical automotive components also requires knowledge of the material fatigue behavior, where relatively small fluctuations in stress or presence of small surface and subsurface defects may lead to fatigue crack initiation and failure under otherwise innocuous loading conditions. Factors such as the size of the part, surface condition, loading direction and loading rate may all result in changes in static and dynamic properties and must be considered in design. Furthermore, as the design of automotive parts is constantly pushed toward the limits of the material deviations from the defined material properties and excessive measuring uncertainty can lead to unexpected premature failure of the component. Therefore, reliable determination of material strength, especially yield and ultimate tensile strength, and fatigue resistance with low uncertainty is crucial when selecting material for dynamically stressed automotive components.

There are many different contributions to the uncertainty of measured results. The major contribution normally comes from the tested material and test equipment. However, variations in testing parameters, like temperature, strain rate, etc., have been found to have a large effect on uncertainty contribution not related to test equipment. Other contributions relate to sample's design, manufacturing, preparation and surface quality as well as to eventual human errors.

In this talk different methods of static and dynamic testing of Al alloys aimed for highly stressed automotive components will be reviewed and correlations between very simple hardness measurement, and tensile and high cycle fatigue test results discussed. However, the main focus will be on evaluating the effect of different material and metrology factors, including material inhomogeneity and type of Al alloy, number of measurements or samples, specimens design, sampling, preparation, machining and surface quality, specimen size, type of testing machine and environment as well as human error on hardness, tensile and high cycle fatigue test results and measurement uncertainty when performed on Al alloys.

Keywords: Al alloys, measurement uncertainty, hardness, tensile test, high cycle fatigue