Development of Advanced High Modulus Steels for Automotive Applications

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Abstract

Steel is seen as a versatile alloy composed mainly of iron (Fe) and carbon (C), and it is capable of achieving desired mechanical properties through composite alteration. By introducing a new element or changing the weight percent, wt.%, of an element within steel, increases could be seen in the likes of yield strength for instance, a key mechanical property in the automotive industry. Some examples which highlight the use of steels in a traditionally made automobile are car body panels, chassis, engine and exhaust components. From these examples it can be determined that steel is an integral structural material and now has the potential to be become more lightweight (lower density) whilst retaining/improving strength. This is achieved by introducing particles of composites titanium diboride (TiB_2), niobium diboride (NbB_2) and vanadium diboride (VB_2) as powders during steel manufacturing. These three composites will be researched through the course of this project, with the main goal of accomplishing weight reduction whilst adhering to design criteria; the criteria will state variables for key mechanical properties, which can be tested and validified through tensile and impact experiments. Another aspect to consider when manufacturing steel is the thermomechanical process (using heat energy to perform mechanical work) used, as this greatly affects microstructure and hence, mechanical properties.

Though there is not a defined problem with current steels used for car components, an objective set by many automotive companies was to reduce the total dry weight of vehicles in order to improve fuel consumption, handling and rigidity. Because of this, there is great activity in the research on advanced high strength steels (AHSS). This project aims to conduct research and testing on steel composites via two routes; which are named ‘vacuum-induction melting’ (VIM) and ‘field-assisted sintering technology’ (FAST). VIM is the melting of a metal within a vacuum whilst utilising electric current whereas FAST uses a direct current (DC) coupled with compressive force to consolidate powders together. Both methods will allow the production of steel ingots with different compositions, which can then be put through hot-rolling (a thermomechanical process which will produce sheets of steel with improved microstructure). From mechanical testing and microstructural analysis, a number of suitable steel composites will be finalised as suitable for production at an industrial scale. It is important to make comparisons between current steel compositions used in automobiles and new steels compositions obtained through research as a justification needs to be presented to manufacturers in order for them to make new purchases or to change machinery on a production line (costly and impactful decisions). This project will also give manufacturers a good insight into both liquid casting (VIM) and powder consolidating (FAST) metal processing in order for them to make a decision on the production of new steel compositions. For instance, large components are suitable for forging and casting using VIM whereas smaller components would be better suited using a FAST approach.