THE INFLUENCE OF STRUCTURAL MATERIALS SELECTION ON THE PROPER OPERATION OF THE VEHICLE CHASSIS

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Abstract

The article presents a review of the most new structure materials that currently are being applied to production of different vehicle elements. The main purpose of the article is to draw attention to the materials applied to fabricate this kind of elements. The authors have made a comparison of the materials and strength properties of these materials. Furtemore, they have considered the influence of those properties on the operation of the vehicle chassis elements. The article contains also useful information about the currents towards the application of composite materials in production of vehicle elements.

Keywords: Vehicle chassis, fatigue strength, modern materials

1. INTRODUCTION

Significant development in the scientific researches into new materials, without doubt has an influence on human life. The progress of such investigations has made a contribution to create over 100 000 engineering materials. It gives great possibilities for different constructors but on the other hand it may causes problems to select proper materials both for the construction and machinery. In order to select these materials, some technological, construction and exploitation requirements must be achieved. Great significance for the processes has also economic and ecological criteria. A variety of new materials often enables the constructor to fulfil the different and opposite criteria, i.e. high resistance and lightness of the construction. Despite the great advantages of the modern materials in terms of technology, they often do not satisfy the economic criterion [1].

The standards for the modern materials applied in vehicles are very high. It results from the fact that these materials have immense influence on drive safety and useful properties of vehicle, i.e. comfort, corrosion-resistance and fastness. The important issue is also a diminution in the mass of vehicle. It may be achieved by using the lightest materials. Increasingly, plastics are used in the construction of vehicles. It is estimated by different literature sources that plastics amounts about several percent of the mass of vehicle.

2. A REVIEW OF THE CONSTRUCTION MATERIALS USED IN THE AUTOMOTIVE TECHNOLOGY

Development of material engineering and automotive technology during the last decade enables the constructors to apply lots of quite new materials for modern vehicles [2, 3]. It is obvious that depend on application, the construction materials must meet some criteria. For example, main criterion for many elements of vehicle is material resistance. It is important issue, mainly because the vehicle chassis elements are the most important system that determines the safety and driving comfort. The main subject covered in this article is a proper selection of materials for different elements of chassis according to the suitable requirements. The largest part of all materials used in vehicles is steel (about 60 %) [4]. Plastics (about 16%) take the second place. Other materials that are applied in vehicles are light metals, rubber, glass and the others. The elements of chassis made of steel are usually heavier than the same elements made of aluminium alloys or composites. Another material used in automotive manufacturing technology is grey cast iron, ductile iron, ADI, and less ductile alloy that is used according to the nature of work of the given vehicle element [5, 6].

The basic advantages of cast iron are relatively low costs of its production in comparison to steel, good mechanical properties, good technology properties, low sensitivity to notch, good fatigue strength and abrasion resistance, and high vibration damping factor [7]. The last material quality, namely the high vibration damping factor is especially important for those elements of chassis which are part of the unsprung masses. The main disadvantages of cast iron are its fragility, poor weldability and the presence of cementite. It takes place because cementite worsens considerably workability of cast iron [5].

The material which is becoming widely applied in automotive technology is isothermally hardened ductile iron (ADI). Ductile iron is submitted to the process of isothermal hardening and as a result is converted into iron ausferritic which has good fatigue resistance and toughness. This material is resistant to destruction more and less in the same way like steel but is more resistant from aluminium alloys.

A suitable conducted heat treatment gives a field point and tensile strength of material about twice higher in comparison to standard ductile iron. Shot peening and rolling of roundings may increase a fatigue resistance of material even about 50 % [8]. Products made of cast iron ADI replace increasingly castings and cast steel forgings also elements made from aluminium and carbon steel. The products of this type are used in automotive technology to produce the mounting elements, transmission systems, etc.

Aluminium alloys are this kind of construction materials which are increasingly have being applied in construction of vehicles. The main advantage of aluminium alloys is facility for forming the exact shape of elements during the car production process because of its high plasticity. In addition, aluminium alloys are kind of materials which also may be easily given to plastic heat and cold working. Aluminium alloys are characterized as having good weldability and mechanical treatment and additionally they are totally resistant to atmospheric corrosion. Aluminium alloys are used as casting alloys and as alloys to plastic working.

Elements and sub-assembles made of magnesium alloys are a viable alternative to traditional materials used in the automotive technology. The most important physical property of magnesium alloy is a very low density of about 1800 kg / m^3. This is the lowest value of technical alloys, which permits to significantly reduce the weight of vehicle.

Casting alloys of magnesium usually contain more than 10% of alloying additives. Magnesium may form alloys with various metal except for chromium and iron. One of the main alloying additives is calcium. It is used in small amounts by some manufacturers in automotive industry. Calcium as additive reduces oxidation process of alloy, particularly in the liquid state and also later during heat treatment. It also improves rolling process of sheets made from magnesium alloy [3].

All materials which have been listed in section 2 have being applied in automotive technology in the chassis of vehicles. It is important to notice that this article doesn’t raise the issue of the very important group of construction materials, mainly plastics. It results from the fact that plastics are still the limited construction material in the chassis of vehicle. However, lots of elements in vehicle such as for example connecting link of stabilizer are just made of plastics [9]. One of the toughest elements of the breaking system (which are a part of unsprung masses) is the brake clamps made of cast-iron and light alloys. The light alloys have the lower weight specific gravity. It means that clamps made of this kind of alloys significantly reduce the unsprung masses.

3. THE FATIGUE STRENGTH OF MATERIALS APPLIED TO PRODUCTION THE SWINGARMS

The studies were carried out using an experimenal machine for scientific experiments (**Figure 1**). A characteristic feature of fatigue failure of materials is that it occurs at the maximum stress, considerably lower from the extemporary strength Rm and even from yield point Re or R0.2. The cracks fatigue may have some fragile fractures. They are very dangerous, because a gap fatigue may often remains unnoticed. It means that destruction of elements may occur suddenly and unexpectedly and it usually leads to the dangerous damages.

The researches have shown that about 80 % of all fractures are caused because of materials fatigue and only 20 % by the static overload.

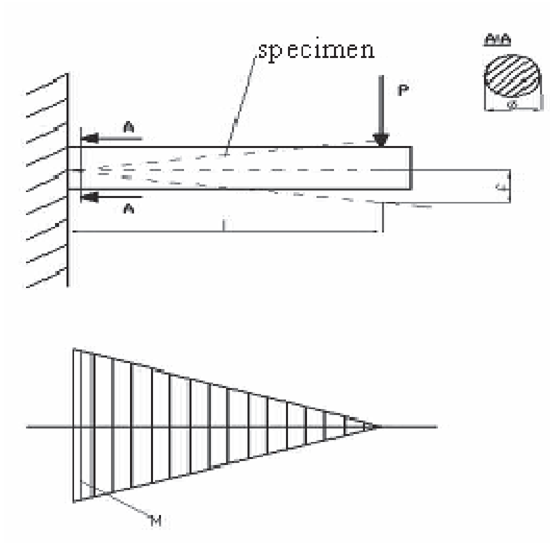

Figure 1 A scheme of the measured system and a diagram of bending moments: P - load, f - deflection

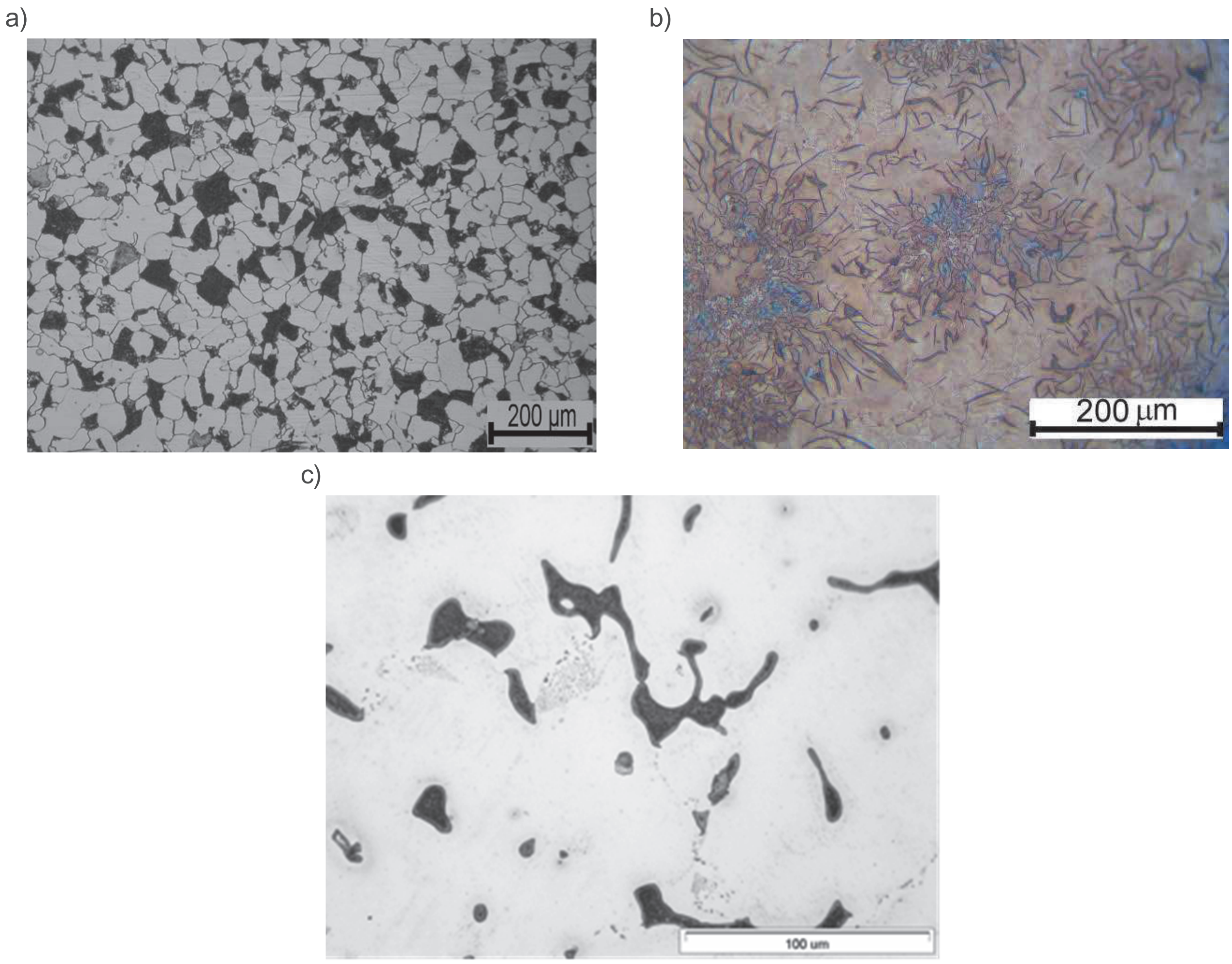

Figure 2 The structures of alloys in this study: a) steel with ferritic-pearlitic structure, b) a flake cast iron, c) an aluminum magnesium alloy

The study of fatigue strength was made using especially prepared samples (**Figure 2**). The samples were in geometric shape, in the form of bar that was 2 mm in diameter and 50 mm in length. Material for the studies was taken from the swingarms of vehicle, i.e. steel, cast iron and aluminum alloy.

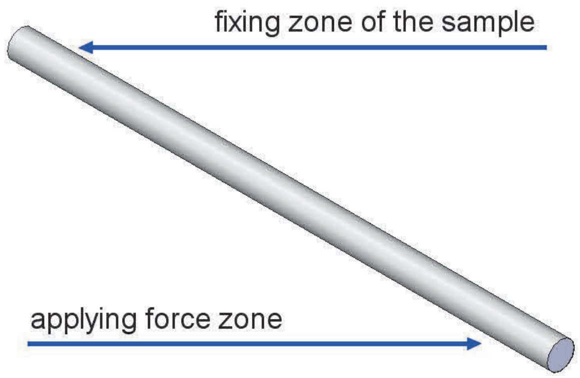

Figure 3 Form of material sample taken from the swingarm

The aim of the study described below was to determine the fatigue strength of materials that are being applied to production the swingarms of vehicle. The samples were cut out from the swingarms, made of cast iron, steel and lightweight aluminum alloy. The length of the samples was 50 mm, circular cross-section 2 mm (**Figure 3**).

Based on the fatigue researches there was set a diagram of the fatigue strength (**Figure 4**) where the zones of permissible stresses (which permit the proper exploitation) were defined.

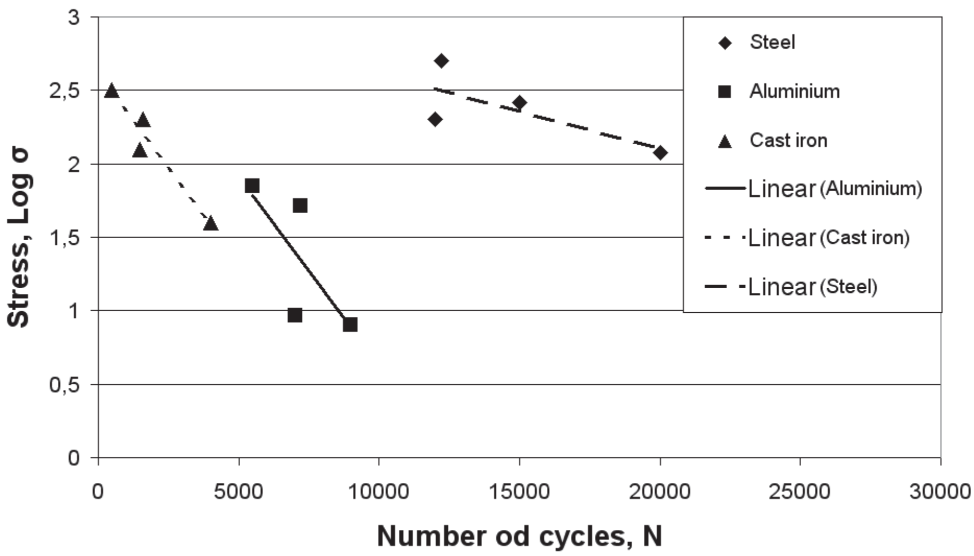

Figure 4 A diagram of the fatigue strength as a function of the number of cycles

There were also carried out metallographic researches of the macro scale using a stereoscope microscope (**Figure 5**). The brittle fracture because of propagation velocity of the crack is the most dangerous for safety of the structure. It may be observed in **Figure 2b**. It also has the lowest fatigue strength (**Figure 5b** - cast iron) but despite it is often used as material for the swingarms due to low manufacturing costs. A steel sample has the greatest strength, despite the fact that it’s density is above 2.5 times bigger then a sample of aluminium alloy (**Figure 5a**). The plastic fracture was noticeable on the surface of the fracture of aluminium alloy.

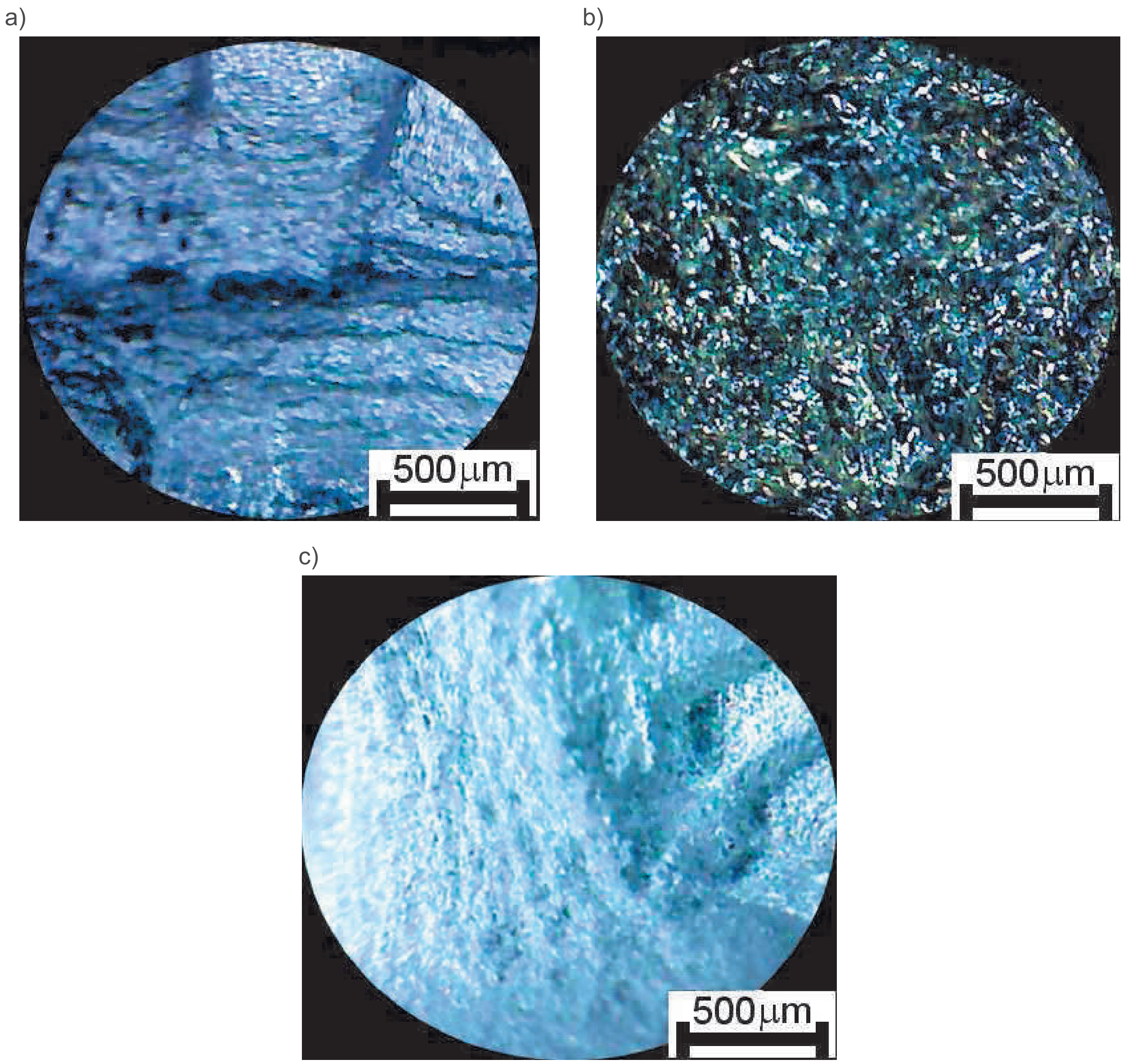

Figure 5 The surface of fatigue fracture: a) a sample from steel, b) samples of cast iron, c) samples of aluminium alloy

4. CONCLUSION

The proper selection of construction materials enables to reduce the size of the unsprung masses, which significantly affects driving comfort. The actions in these directions are clearly visible and are held by the increase in the share use of modern materials by manufacturers in automotive engineering. It should be also noted that due to the application of modern plastic vehicle user benefits often go hand in hand with the reduction of energy consumption in the production process, and thus the manufacturing costs for the manufacturer. However it is rarely reflected in the price of the final product. The comparative have shown that the best solution would be applying an aluminium alloy to the swing arms of vehicle. The aluminium alloy has a low weight and additionally it has a tendency to strength during the variable pulsate stresses and fatigue strength is also higher.

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