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OPTIMIZATION AND PREVENTION OF FAULTS IN AUTOMOTIVE WHEEL MANUFACTURING

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ABSTRACT: *Automotive wheels can be classified into 3 segments according to the material used in their manufacture: there are those made of light alloy (basically aluminum), those made of steel (can be extra mild steel, low carbon steel, HSLA or dual phase steels). However, we will only look at steel and alloy wheels, whereas both types of wheels (made of steel and made of alloy (aluminum alloys) have characteristics that together would yield a part with a balance of excellent mechanical properties, a cost not so different from the general presented by the market and a satisfactory aesthetic quality, it was decided to make a study with the purpose of making possible the production of a part that presents improvements in the manufacture of the two analyzed wheels. (Fe-C) and light alloy (aluminum), in addition to studying possible failures and simulating s concerning wheels with the aid of solidworks software.*

Keywords: *Wheels, failures, welding*

1. INTRODUCION

The wheel is one of the old et instruments invented by man, since the beginning of time man felt the need to invent things, it was in front of this concept that the first wheels appeared, with the purpose of facilitating and streamlining the trajectory and the course of being human.

The wheel is a safety item that must meet the high design and manufacturing standards to provide, in addition to a esthetics, greater driving comfort and lower fuel consumption. Its function is structural, since the set formed by wheel and tire has the function of keeping the vehicle in contact with the track and transmit from the vehicle to the track. All efforts arising from the weight of the vehicle, ie, the traction, braking and steering systems and, conversely, transmit to the vehicle all effort arising from the Irregularities and obstacle of the run way during taxiing (Barros Neto, 2009).

2. METHODOLOGY

For the production of this article, a study was made of several articles on steel and aluminum wheels, with the purpose of obtaining as many data as possible and information about the structures and forms of manufacture as well as the materials used in order to know the various types of failures and ways of prevention.

Another feature that proved to be very use full forth is study was the use of some videos with respect to the

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manufacturing process, for both steel and aluminum. And as a last resort was made the consultation of books, primarily the book of "science of materials" since it sought to analyze the microstructure of the materials used in the manufacture of wheels and the possible flaws and various forms of optimization in the manufacture of steel wheels and aluminum.

3. RESULTS AND DISCUSSION

3.1 Application of steel in wheel manufacturing in the automotive industry



Figure 1. Steel wheels. Available from: <https://quatorrodas.abril.com.br/auto-servico/mitos-e-verdades-sobre-as-rodas-de-liga-leve/>

The steel wheels have, a characteristic difference, the high weight, when compared to the alloy wheels, due to the microstructure of the material used. Steel wheels are forged from three types of materials: they are sweet stray steels, dual phase steels and ARBL or BLAR (or HSLA steels) steels. Extra-sweet steels have a low carbon content, less than 0.15%, therefore they have a yield point between 170 and 180 (MPa) and a tensile strength limit (LRT) of 305 to 325 (MPa). Due to these values the extra sweet steels have a good machinability and formability, yet offer considerable ductility, however, does not present desirable values with respect to the weight, since it has a density superior to 7 gcm^3 . (High Resistance Steels And Low Leather).

3.2 Manufacturing process and microstructure of steel wheels

The wheels are structurally rim and disc, and can be made of aluminum, steel and other alloys. Many metal elements can be combined with aluminum to form their alloys, the most commonly used being copper, magnesium, manganese, silicon and zinc. Depending on the product, aluminum alloys can be classified as plastic or cast alloys. Within these categories, the alloys are grouped in series according to the main alloying elements (Moreira, 2011; Furlan, 2008) we can analyze the manufacturing process according to figure 2:



Figure 2. Schematic representation of the steel wheels manufacturing process. Available from: <http://wheelrimmaking.com/profile/wheel-manufacturing/199771/0/>

3.3 Application of aluminum in the manufacture of wheels of the automotive industry

The automotive industry has replaced cast iron and steel with aluminum alloys, with the ratio of mechanical strength to weight being the main motivation. This specific tensile strength is strongly influenced by the poly phase microstructure of the aluminum alloys (Warmizek, 2004).

3.4 Manufacturing process and microstructure of aluminum wheels

There are basically three types of aluminum wheel manufacturing process, the melt in which molten aluminum is cast into low pressure molds, the one injected into which the molten aluminum is compressed under pressure into molds and the most used forgings in trucks and bus. "But there are other less usual processes, but the main and most used are those cited. The majority of aluminum wheels are cast in one piece, but there are also.

Models where the face is welded in the part where the tire goes (such as the original wheels of the 2G eclipse 1994-1999). a process widely used to manufacture custom wheels. "(History of the leather wheels).

The most commonly used aluminum alloys in the manufacturing process of light alloy wheels are magnesium, silicon, titanium and strontium, each with its own particularities. For example, Al-Ti alloys have high strength, and Al-Sr alloys have good malleability, which facilitates the manufacturing process and is a positive point in the application itself. Al-Ti alloys (titanium at 0.05 to 0.2) are high tensile strength and good ductility alloys. Al-Si alloys increase fluidity, reduce shrinkage and improve weldability, but at high Si levels, machining is difficult. These alloys have excellent corrosion resistance, good tensile strength and excellent ductility. Regardless of which element is used in the alloy, with aluminum, the result will be a highly resistant alloy with low energy absorption and / or tensions (inverse of tenacity). (Bibliographical Study).

3.5 Failures and Optimization for Steel and Aluminum Wheels

3.5.1 Wheel model used

For this study, a steel wheel was modeled:

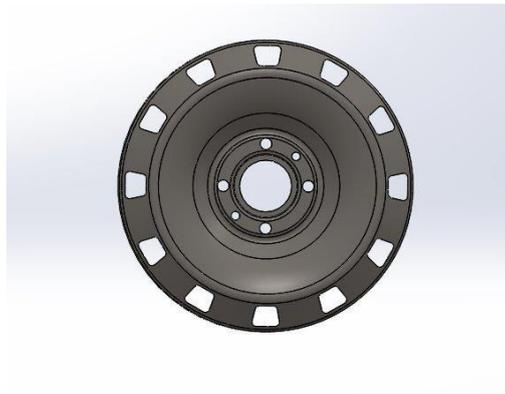


Figure 3: Steel wheel disk (author, 2019)



Figure 4: Final model of steel wheel used in simulations (author, 2019)

Modeling was performed using SolidWorks software, a 3-D modeling program. In Figure 3 some images of the steel wheel disc modeling process will be presented, showing very briefly some profile steps for revolution surface generation, edge rounding, Boolean operations, holes, etc.

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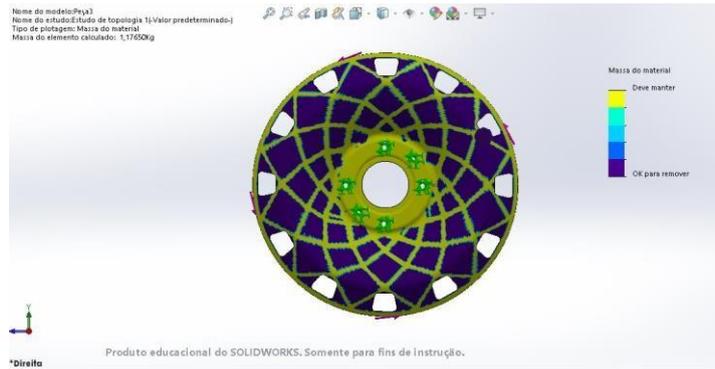


Figure 5: Topology Study 1 (author, 2019)

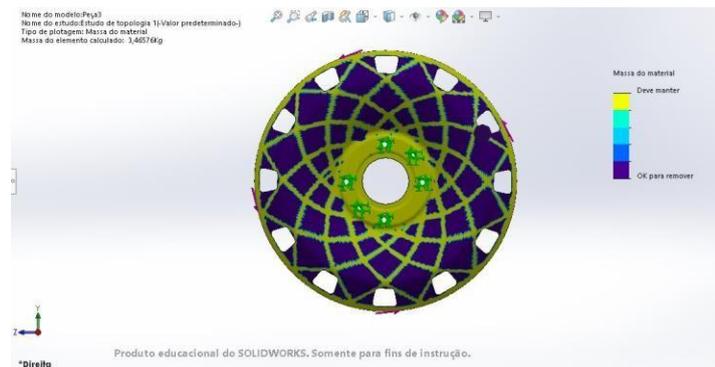


Figure 6: Topology Study 2 (author, 2019)

According to the topological analysis of the steel and aluminum wheels, and the analyzes are the same, the excess materials of the wheel were removed, as illustrated in figures 5 and 6, therefore, with the reduction of the wheel material, it was noticed that the diameter, the width and strength do not vary. Thus, the manufacturer gets lower wheel weight, better cost benefit without changing the resistance.

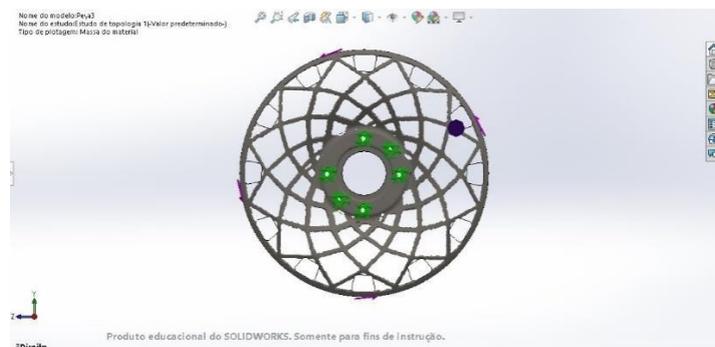


Figure 7 (author, 2019)

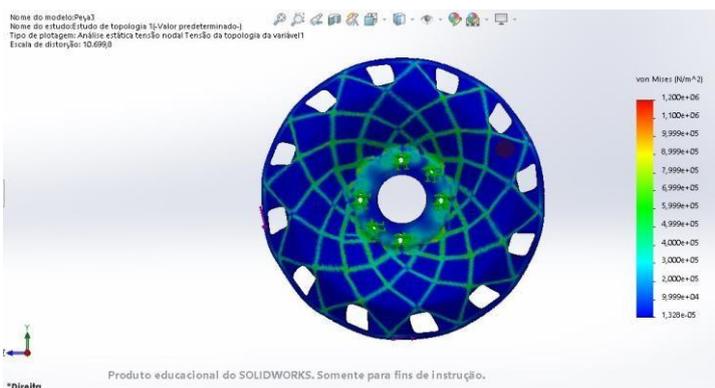


Figure 8: Static analysis nodal tension 1 (author, 2019)

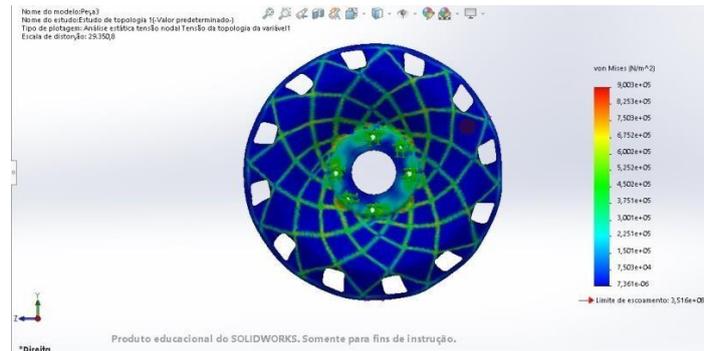


Figure 9: Static analysis nodal tension 2 (author, 2019)

As can be seen from these analyzes, regions with higher equivalent stresses appear within the flange as seen above. It is also noted that in the region of the wheel disc the stresses can then be considered a safe region as to the intensity of the stresses acting on it. A region that has considerable equivalent stress values is at the rim flange end, but in this region, the stress gradient is smaller than in the flange foot region due to the sudden variation in geometry in this region.

The presence of defects inside the parts is an item that affects the performance of the product. For (Reilly et al 2013), the size, quantity and location of pores: macro and micro, inclusions or oxide films, can have a significant impact on the mechanical properties and fatigue of the material. In this scenario, the wheels can tolerate a finite number of defects and still meet customer specifications. The permissible quantity depends on the defect, its type and its location.

The presence of defects such as porosity has great influence on the formation process and crack initiation. The occurrence of these defects has a significant influence on mechanical properties such as ductility and fatigue (AsmInternacional,1998).

Fatigue is a process of progressive, localized and permanent structural change, in which a component is subject to cyclic loading at some point or points, thus determining the occurrence of cracks or complete fractures after a number of cycles (Asm Internacional, 1998).

To optimize the process it is possible to add some components that improves the performance of the wheel helping in its microstructure and avoiding future errors such as the processes mentioned below.

ARBLs, also known as micro liged steels, have been designed for the purpose of providing better mechanical properties, have a yield stress of more than 275 MPa and / or better resistance to atmospheric corrosion than conventional carbon steels. Its chemical composition may vary depending on the thickness of the final product in order to meet the requirements of the mechanical properties. The plates and plates in ARBL steels have excellent weldability and formability guaranteed by the low carbon content, between 0.05 and 0.25% C (Davis, 2001). It allows the obtaining of a microstructure composed of refined grains in the condition of laminate, with benefits for both strength and toughness (Skobir, 2011).

Application requirements such as corrosion resistance, formability, weldability, fatigue strength, thickness reduction and strength-to-weight ratio are decisive factors in the process of choosing a specific ARBL steel. This set of characteristics of ARBL steels has led to their increasing use in automotive components (Skobir, 2011).

Perlytic ferritic micro alloyed steels may contain V, Nb and Ti as single alloy elements or in combination. The main role of these elements is to promote the refining of the ferritic grain size, however, they can develop the additional function of increasing the resistance of the ferritic - pearlitic steels by means of precipitation hardening (Kim, 1983).

The level of precipitation hardening depends on the size and distribution of the precipitates. Precipitates formed in the austenite want them to be undissolved particles retained during the reheating process or particles formed by deformation induced precipitation, contribute very little to the hardening because they are coarse and widely spaced. On the other hand, the precipitates formed at the interface between austenite / ferrite during the phase transformation, and the precipitates for measuring the cooling of the ferrite are small and finely distributed, resulting in considerable hardening. Therefore, it is necessary to maintain a certain amount of alloy element in solution in the austenite for subsequent precipitation in the ferrite (Kim,1983).

For the manufacture of wheels, it is possible to use 4XXX Al-Si alloys as soon as these aluminum alloys are widely used in casting processes for the manufacture of parts with complex geometries such as wheels, as increased fluidity favors filling of the mold cavity, main lying thin-walled parts. In this way, the components of the alloy play an extremely important role in the solidification process (Asm Internacional,1998).

Manganese has a solubility of 1.8% at 657° with aluminum and less than 0.2% at room temperature. The addition of manganese in the injected alloys occurs between 0.2% and 0.55%, in order to act as a grain refiner to reduce contraction. The great function of this element is to neutralize the iron, avoiding the precipitation of primary compounds and consequent embrittlement of the alloy. Together with their on forms the written Chinese compound (Asm Internacional, 1998).

Magnesium, which increases strength and hardness by the formation of an intermetallic compound, Mg₂Si (Asm Internacional, 1998). In the study by (Santos et al., 2006), the fatigue strength of two Al-Si alloys used in the manufacture

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of motor blocks was compared. The alloys with higher Mg contents present greater resistance to fatigue.

4. CONCLUSION

After the study carried out with the aforementioned wheels (namely wheels made of steel and wheels made of aluminum alloys), the need to improve them and optimize them in terms of their weight, their cost and of course their mechanical properties. For this, we propose and / or suggest changes in its structure and its material (material used for manufacturing). The more detailed study is fundamental for the application of these proposals and / or suggestions. Tests on the final product are also essential to ensure safety and efficiency. If the test results are favorable, the wheel obtained will present incredible characteristics and properties (for example: weight value below the value presented by steel wheels currently on the market and greater capacity to absorb impacts and stresses, which consequently and respectively results in fuel economy and safety), with an affordable price, which would be a huge breakthrough in the development of this element so primordial.

5. ACKNOWLEDGMENTS

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7. DECLARATION OF LIABILITY

The authors Lucas Santos de Oliveira, Rafael Lemos Diniz, Israel Conceição Rocha, Paulo Henrique Pereira Araujo and Alexandre Serpa Aguiar are solely responsible for the printed material contained in this article.