PM Trends for the Automotive Industry

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ABSTRACT

Roughly 70% of the structural parts made by Powder Metallurgy (P/M) have been used by the Automotive Industry, and despite of the drop in consumption due to the recent global economic crisis, this sector produced 700 thousand tons with turn-over about US$ 5.0 billion in 2009. The average weight of P/M components per vehicle has consistently grown over time reaching 19 kg in North American and 10 kg in the European and Japanese models. But enormous challenges are foreseen for P/M in the future. The increasing need for reductions in fuel consumption and emissions is forcing the automakers to reduce the size and weight of cars, especially on the engines and transmissions that currently are the main destination of P/M components. On the other hand the P/M industry, recognized to present fewer environmental hazards when compared to other manufacturing processes, is seeking to adapt to this new reality working on new materials and processes that can advantageously replace traditional solutions such as casting, forging and machining. Powder forging is already a reality and the new engines are being designed with PF connecting rods, with considerable savings in weight and better performance. Main bearing caps, new systems for valve control and synchronizer components are also being redesigned to be manufactured by P/M. On the electrical field, the recent development of Somaloy®, a new patented material by Hoganas AB of Sweden, an alternative for armors and rotors of electric motors replacing the traditional packages of steel plates, offers advantages in volume, weight, packing factor of coils and in recycling. It should also be mentioned the huge potential of using nanostructured materials in energy conversion and storage, which can revolutionize the current systems for hybrid and electric vehicles, still in embryonic stage. Right now, ensure the growth of the market giving users a competitive advantage is undoubtedly the greatest challenge of P/M.
1. INTRODUCTION

Automotive industry is the main driving force for the P/M global development. Figure 1 shows the P/M market share, indicating that almost 70% of application is used for vehicles production. Unlike the stability or even shrinkage of the automotive market of developed countries in 2009, the production of vehicles in developing countries has shown strong and consistent growth. China has become the world's leader producer and analysts believe that Brazil will overtake Germany as the fourth largest market in a near future.

On the other hand a reduction of P/M kilograms per car was noticed in the USA. Few years ago the average was 22Kg but now this weight is around 18–19Kg according to Michael E. Lutheran, MPIF president, during the last PowderMet 2010 in the USA. The main reason for this change is undoubtedly the pressure for reducing fuel consumption and emissions, which are forcing the automakers to reduce the size and weight of cars, especially on the engines and transmissions for which most of P/M components are designed. Figure 2 shows these figures in terms of average consumption of sintered products per car.
Despite the projected drop of P/M usage per car in USA, recent information shows that the American automotive market is reacting and the introduction of new systems is pushing again the P/M industry. Mr. Lutheran informed during the PowderMet 2010 that the launching of new six-speed transmissions by GM and Ford have high P/M content, in the range of 13 kilos.

Another factor that contributes to the increasing use of P/M parts is its low environmental impact when compared with other processes such as forging, casting or machining. Companies have increasingly sought solutions that contribute to reducing energy consumption throughout the production chain as well as reducing the consumption of raw material. Powder metallurgy provides these benefits as shown in figure 3.

![Figure 3 – Energy consumption and raw material usage](image)

Moreover, P/M mechanical properties and dimensional tolerances can match or even exceed those of materials obtained by other processes, as shown in figure 4. To reach the desired results, it is very important a co-design work between the customer and the P/M manufacturer.

![Figure 4 – P/M properties can match or exceed other processes](image)
2. POTENTIAL MARKET FOR P/M IN SOUTH AMERICA

In 2008, 22,300 tons of sintered parts were sold in South America, 16,000 ton of them to the automotive industry. The forecast for the production of light vehicle and motorcycles in South America for the next years are very promising as shown in Figure 5. It is expected an annual growth rate of 6.1% for cars and 7.3% for motorcycles in the period, and such predictions are supported by important recent changes in the economy of the region [1]. In the last ten years, at least 20 million Brazilians have joined the middle class. From Argentina is also expected a vigorous growth of the automotive market for the near future.

![Figure 5 - Light vehicles and motorcycles production](HIS Global Insight, Forecast 2010 - 2014, June 2010)

For the P/M industry the growth can be even higher. Today, the South America's models use an average of 5.5 kg of P/M products per car, and this figure can easily reach 7.9 kg considering the conversion of components still manufactured by processes other than P/M. For engines, parts that could be converted in the near future, as they are already used extensively by USA, Europe and Japan automakers are: main bearing caps, connecting rods, camshaft lobes and components for variable camshaft. Synchronizer hubs and rings, shift forks and clutch hubs for transmissions also represents an excellent potential for P/M in South America. Figure 6 shows examples of these components.

![Figure 6 - Potential use of P/M in South America's models](image)

Also contribute for the P/M industry growth, the demand for comfort items like air conditioning, assisted steering, automatic transmission or automated gearbox that are becoming more frequent. New safety regulations will make compulsory the use of features like air-bags and anti-lock braking systems in the next four years.
3. TRENDS IN THE AUTOMOTIVE INDUSTRY

The main challenge for the automotive industry in the next few years will be to improve the efficiency of the internal combustion engines in order to lower the fuel consumption with a minimum impact to the environment. Another important challenge is increasing the active and passive safety for passengers and pedestrians. These new demands will require from the South American automakers the introduction of new control systems already used abroad, such as variable cam timing, variable valve timing and lift, direct fuel injection, electrically assisted steering systems and more efficient braking systems. With this perspective, the development of new components should include the use of lighter and better performance materials.

In fact the automotive industry is going to pass through a transition where internal combustion engines will not be completely substituted. Most of the green vehicles will be hybrid solutions where an internal combustion engine is combined with an electric motor. According to McKinsey Global Institute, it is expected that the electric vehicles and hybrid electric vehicles to surge by 18 – 20% per year from 2009 – 2012 and will account for an estimated 10% of all auto sales by 2015 [2].

4. CHALLENGES AND OPPORTUNITIES FOR THE P/M INDUSTRY

P/M is a versatile technology that can greatly contribute to the automotive industry in this new path. Valve metallization and high speed steel valve seats [3] are being used in flex-fuel engines with high compression rate. Efforts in order to get higher material densities with techniques as warm compaction, die wall lubrication, high compressibility powders and selective densification allows the production of high performance components such as transmission gears, synchronizer sleeves and rings, shift forks and clutch hubs. The surface densification technique is also a reality and several transmission gears are already under regular mass production. Single pressing and sintering connecting rods will lower P/M manufacturing costs opening excellent opportunities for this industry.

Electric vehicles have a potential of several kilograms in its traction motor system as well as others systems, and thanks to recent developments of new materials, the P/M industry can follow the market trends for electric and hybrid vehicles. Soft Magnetic Composites (SMC) is a special class of materials based on fine iron powder particles coated with a nanolayer of electrically insulating material. This powder can be compacted, using the traditional PM method, into a solid component structure with the ability to carry flux in 3D and present low conductivity in all directions. All these properties allow the SMC usage in a sort of new motor topologies and open the opportunity to new applications. Some of these applications are common rail diesel injector, ABS pump motor, electric power steering torque sensor and many others under development. There is no doubt that a good target for SMC materials are high performance traction motors on electric vehicles, with reduced iron mass, high efficiency and increased torque density [4]. The use of SMC for the electric motors can demand more than 15 kilos of P/M per vehicle.

It must be mentioned that P/M offer important environmental advantages when compared to competing processes: lower energy consumption and more efficient use of raw materials. Also the possibility to obtain net shape or near net shape parts reduce the use of cutting oil on final machining operation. Life cycle assessment analysis [5] proved that P/M is a manufacturing process with less environmental impact.

Metal Injection Molding (MIM) can play an interesting role in the automotive industry due to the net-shape capability for complex shape parts which can reduce machining costs to low levels. Larger and more precise parts are being developed and short production runs can be cost effective. Parts as ignition lock and turn signal lever [9] are already in normal production. Vanes for compressors can be a feasible alternative for forged and machined parts and can be potentially exploited.
P/M light alloys can offer substantial weight savings, contributing to improved efficiency of the vehicles. Parts such as oil pump rotors and housings, and camshafts bearing caps are already in normal production. Aluminum and titanium alloys must be considered as promising materials also for connecting rods, valve train and other power train components.

Aluminum foams are an interesting alternative for vehicles weight saving with the advantage to be a stiff and also a high impact energy and absorption material. Other properties are vibration reduction, sound absorption, low thermal conductivity and flame resistance [8]. Sandwiches with aluminum or steel sheets can offer stiffer materials with a great weight reduction.

Nanoscience and nanotechnology has a huge potential to contribute to the development of more efficient systems for storage and conversion of energy required by hybrid and electric cars. Research in the use of metal hydrides for hydrogen storage, more efficient batteries and solar cells, development of super capacitors and CO$_2$ carbon capture that can lead to cleaner energy are being extensively done and may contribute to a sustainable energy system, with better and more effective solutions for the use of the existing finite energy sources [6]. More efficient fuel cells using nanomaterials are each day being investigated and it is difficult to predict when and how nanoscience and nanotechnology will have the largest impact, but for sure they will be part of energy sustainable solutions.

**CONCLUSION**

The automotive industry is now experiencing a moment of great changes with the use of new materials, processes and technologies in order to produce greener and safer vehicles. P/M is a metal manufacturing process that can offer net shape or near net shape products with the advantage to use fewer raw materials, fewer transformation energy and fewer environmental impact compared to other processes. It is the right time to explore new opportunities through the partnership of engineering and research areas of automakers and supplier. This proactive and cooperative work has to be done from the beginning of new developments in order to achieve the best results. It is a responsibility of the leaders of these industries to promote and encourage this revolution.

**REFERENCES**


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