An Overview of the CGI Market Potential
"*The Five Waves*"

SinterCast first introduced the concept of "*The Five Waves*" during the Annual Shareholder Meeting of 24 May 2002. The concept of five individual waves provides a convenient breakdown for addressing the different sectors of SinterCast's core automotive cylinder block and head market in terms of engine size, type, market location and possible launch timing. The purpose of this overview is to indicate the approximate size of each of the five individual waves, with more emphasis being placed on the near term waves which, at this time, are more tangible. No attempt is made to forecast the SinterCast share of these sectors. Rather, the size indications presented in this overview simply indicate the overall size of the potential CGI market.

In order to compare the potential of the different market sectors, SinterCast's internal calculations are made in terms of "engine equivalents". Each "equivalent" is defined as one 50 kg cylinder block. Thus, a relatively small 1.6 litre engine with a 35 kg cylinder block would provide 0.7 engine equivalents while a 75 kg V-8 cylinder block would correspond to 1.5 engine equivalents and each 350 kg truck block would represent seven engine equivalents. The use of engine equivalents allows the different sectors to be compiled into a single common market potential. The five waves presented in this overview are therefore addressed in terms of the absolute number of engines, the total tonnes, and the number of engine equivalents.

The First Wave : V-Diesels in Europe

The first wave is for V-type diesel engines in Europe. The need for stronger materials occurs first in V-type engines because of the complex 'tug-of-war' mechanical loading patterns and the consumer demand for higher performance from this family of engines. The V-type engines also command a higher price premium and are therefore more able to accommodate the increased cost of CGI. The start occurs in Europe because of the popularity of diesel engines in the European market, particularly in the luxury sector.

The first wave actually began in 1999 with the start of production of the Audi 3.3 litre V8 diesel engine at the Halberg foundry in Germany. This wave has recently been reinforced by the announcement of the high volume Ford-PSA 2.7 litre V6 engine that will begin series production at the Tupy foundry in Brazil this summer. Other V-engine commitments, including an upgrade of the Audi V8 to 4.0 litres, have also been announced. The market size is summarised as follows:-

Annual passenger car sales in Europe : ***15 million***
At 40% diesel penetration, number of diesels : ***6 million***
Assume 15% of diesels are V-type : ***0.9 million***

There are approximately 900,000 V-type diesel engines sold in Europe each year. If we assume that one-third of these are currently produced in aluminium there are approximately 600,000 V-type cast iron diesel engines. For SinterCast, however, we approach the aluminium and cast iron programs equally with the objective of converting these to CGI or committing the next generation to CGI. We must also consider the future possibility of compound or bi-metallic engines which incorporate a CGI load-bearing 'skeleton' and a lightmetal exterior. In either case, the CGI potential extends to the entire sector. At an average weight of approximately 65 kg per CGI V-block, the first wave opportunity represents approximately 60,000 tonnes per year or 1.2 million engine equivalents.

The Second Wave : Commercial Vehicles

The second wave relates to commercial vehicles, principally trucks with engine displacement larger than 9 litres. As a result of corporate consolidation in the commercial vehicle sector, engine strategies are becoming more global. Therefore, in contrast to the first wave, the commercial vehicle wave applies equally to Europe, Asia and the Americas. This wave will begin to ramp-up during the period 2004-2006. In the commercial vehicle sector, CGI can find application for both in-line and V-type blocks and also for cylinder heads. The market size calculation is therefore summarised as follows:-

*Annual global commercial vehicle sales : **1 million***
*Assume 20% of commercial engines are V-type : **0.2 million***
*Number of commercial vehicle blocks : **1 million***
*Number of commercial vehicle heads : **1.2 million***

At an average cylinder block weight of 300 kg and an average cylinder head weight of 125 kg (both values typical of 12 litre engines), the second wave represents approximately 450,000 tonnes per year or 9 million engine equivalents.

The Third Wave : In-line Diesels in Europe

The third wave relates to in-line passenger car diesel engines. Similar to the first wave, this wave is primarily focused on Europe, due to the popularity of diesel engines in the European market. In-line engines provide the highest volume for European passenger cars, with displacement ranging from approximately 1.2-2.2 litres. CGI can be used in this sector to achieve improved performance from an existing engine, weight reduction, or downsizing. While much of the current CGI attention in the passenger vehicle sector is focused on V-engines, the larger opportunity for CGI is to produce a heavily loaded small engine - a 1.2 or 1.4 litre engine - with the performance of a 1.8 or 2.0 litre engine. This can become CGI's contribution to the continuous trend of achieving more power from smaller and lighter packages. The market size calculation is summarised as follows:-

*Annual passenger car sales in Europe : **15 million***
*At 40% diesel penetration, number of diesels : **6 million***
*Assume 85% of diesels are in-line : **5.1 million***

The CGI breakdown in the in-line sector is more difficult than in the V-diesel sector. The demand for performance is lower and the price pressure is higher. For this reason, there will be a split between conventional grey iron, aluminium and CGI. While the initial production decisions for CGI will likely be applied to higher performance versions in the 2004-2007 time frame, the continued drive toward higher peak firing pressures and downsizing will increase the longer-term CGI market potential. At an average weight of approximately 40 kg per in-line CGI diesel engine cylinder block, the total European in-line diesel market currently represents approximately 200,000 tonnes per year or 4 million engine equivalents. The European diesel market share is expected to continue to increase to approximately 50%. This continued diesel penetration will affect the ultimate size of this wave.

The Fourth Wave : Diesels in America

The fourth wave relates to the application of passenger vehicle diesel engines in America. Although the large scale implementation of this wave must await the introduction of low-sulphur fuels in America in 2006, several sources are predicting a rapid increase in diesel popularity, as evidenced by the quotes that were presented in SinterCast's Annual Report for 2002. For the purposes of this calculation, we will assume a 15% diesel penetration in 2010, primarily for the SUV and pick-up truck sectors, which currently account for 50% of all passenger vehicle sales in America.

*Annual passenger vehicle sales in USA : **17 million***
*At 15% diesel penetration, number of diesels : **2.6 million***

Assuming that two-thirds of the American diesel engines will be V-type (typical block weight 80 kg) and one-third will be in-line (typical block weight 60 kg), the fourth wave represents approximately 190,000 tonnes per year or 3.8 million engine equivalents. This market can be expected to grow during the 2010-2020 timeframe, with some sources predicting parity with Europe (50% diesel penetration) by 2020.

The Fifth Wave : Petrol Engines

The fifth wave relates to the possible application of CGI to petrol engines. This wave will be motivated by the need to support special design objectives such as increased displacement through increased cylinder bore diameters (reducing bore-wall thickness) or by cost-effective downsizing and weight reduction in comparison to aluminium. CGI may also be used for gasoline direct injection engines as these powerplants become more popular in the future. Although SinterCast is currently supporting some CGI petrol engine development programs, the onset of this wave will likely be after 2008. The total annual sales of petrol engine vehicles is approximately 40 million units, worldwide. At present, it is not possible to anticipate the long term split between grey iron, CGI and aluminium. Nonetheless, the initial positive CGI experiences in the diesel sector will increase the industry awareness and confidence in CGI and facilitate future CGI product commitments in the petrol sector. Assuming an average petrol engine cylinder block weight of 30 kg, the entire fifth wave equates to 1.2 million tonnes per year or 24 million engine equivalents.

Potential Step : CGI Cylinder Heads

Historically, the limiting factor in engine design and performance has been the durability of the cylinder block. However, the mechanical properties of CGI provide new levels of robustness which, in turn, allow designers to push toward even higher engine loading. As the peak firing pressure of modern passenger vehicle diesel engines exceeds approximately 180 bar, the aluminium cylinder heads approach their durability limit. The continuing trend toward higher peak firing pressures may therefore present a new opportunity for CGI in passenger vehicle diesel engine cylinder heads. This would likely begin in the mid-to-upper size range for luxury vehicles or SUV applications, but could ultimately be applicable to high performance in-line diesel engines. This wave must wait for engine development to exceed the durability limit of current materials, but could begin in the 2007-2010 timeframe. The potential market size can be summarised as follows:-

Annual world passenger vehicle diesel sales in 2010 : ***10 million***
USA-Europe product mix : ***20% V-type***
Total passenger vehicle diesel cylinder heads : ***12 million***

Assuming that the typical cylinder head weight will be approximately 25 kg, the total diesel engine cylinder head market represents 300,000 tonnes or 6 million engine equivalents.

Summary

The total world market for passenger cars and commercial vehicles is approximately 50 million units per year. In consideration of the market opportunity for cylinder heads in commercial vehicles and diesel engine passenger vehicles, the total number of block and head castings is approximately 63 million units or 2.4 million tonnes. According to the individual cylinder block and head weight values presented in this overview, these block and head castings correspond to a total market of approximately 48 million engine equivalents.

Beyond the near-term waves, CGI may also find application in future engine concepts, particularly in the relatively new discussion of the convergence of diesel and petrol combustion systems. These future concepts, known either as CCS (Combined Combustion Systems) or HCCI (Homogeneous Charge Compression Ignition), would use spark ignition under extreme operating conditions such as full acceleration or when the engine is very cold and would operate on the diesel cycle as often as possible. This new concept, and other innovations that will surely come, will provide new CGI waves and opportunities. Strong materials, with relatively low cost, high availability and good environmental profiles, will always be in demand.

While the five waves define SinterCast's core market for automotive cylinder blocks and heads, the SinterCast technology will also be used for the production of other CGI components, both within and beyond the automotive arena. This may include large marine diesel engine components as produced at the DAROS and VDP foundries, off-road diesel engines, or products such as cylinder liners, clutch plates, brake components and others. The revenue from these production activities, plus the revenues from new installations, annual software licences, engineering services and spare parts provide a large market with continuous growth opportunities for SinterCast. We will continue to work together with the world foundry and automotive industries to secure new production commitments for CGI in each of the five waves.

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