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Business, Industries

IntroductionThe automotive industry consists of organisations that design, develop, manufacture, market and cell motor vehicles. Reduced weight, better fuel economy and less pollution are goals that the automotive industry continuously tries to achieve with tight cost and time parameters and one way of doing that is to change materials. The challenging conditions experienced by automotive vehicles mean the materials used need to be both strong and dependable. Ceramics can be non-metallic or metallic and are inorganic solids. They are known for the ability to withstand high temperatures and hardness, it is highly brittle in nature, thus making it suitable for use in the automotive industryLT1 .

Compared to metals and polymers, ceramics have lower thermal expansion, higher dimensional stability and it has a better machinability than metalsLT2 which is very useful for components in vehicles. It is these factors that make ceramic have a wide range of applications from small components to the construction of engines. There are two categories of ceramics:·   Traditional ceramics – consisting of tiles and bricks·   Industrial ceramics – also known as engineering, high-tech or fine ceramics. Used in automotive, turbine, structural and aerospace components.

The strength of ceramics comes from its structure and its grain size; its crystalline (single-crystal or polycrystalline) structure contains many atoms that are bonded by covalent or ionic bonds. Smaller the grain size, the stronger the ceramic is. LT3 Below are two case studies where the automotive industry has used ceramics in place of another material. Both advantages and disadvantages of the material will be covered and what I think will happen in the next few years. The manufacturing processes involved to make these components will be discussed as well. Carbon Ceramic BrakesBrake disks are used on every form of automobile.

Along with the brake callipers, which squeeze a pair of brake pads, they slow down or stop the vehicle. It does this by converting kinetic energy into heat energy – since the brake disc is connected to the rotating axle of the car, the two brake pads squeeze the disk causing the rotation to slow down and eventually stop. The friction creates heat and overtime both the pads and discs will wear out.

Material Disk brakes are commonly made out of grey iron for normal cars and light trucks but initially, copper was used as the braking medium on the disks. The reason to use this is primarily due to its low cost of production tribological properties. LT4 However, carbon ceramic brakes have now come into the picture; it is now an option to fit this on cars such as the Mercedes AMG series and it is on supercars as well as heavy duty vehicles Carbon ceramic materials are used for the brake pads and the rotors are a combination of carbon (Short carbon fibres, carbon powder), silicon and a resin.

LT5 Due to the change of the material, the rotors offer better braking performance during extreme use such as track days. However, these brakes come at a high price. LT6 The disk brake consists of a disk body and friction layers on either side of the disk body.

There are also cooling LT7 vanes within the disc body. The material used is a carbon fibre reinforced silicon carbide. The silicon carbide gives the hardness of the disk. Carbon fibres give it a high mechanical strength and provides fracture toughness. With these two together, the composite made will be resistant to high temperatures and heavy loads. Having this as the material for brake disks is useful as it reduces the weight significantly but still providing the strength. Compared to its grey iron compatriot, it can reduce the weight by 50% – this means roughly 30 pounds is shaved of with all four disc brakes.

One key benefit that carbon ceramic brakes offer, is the ability to maintain its functionality at high temperatures. When the rotor is spinning at high speeds and the brake pads squeeze the rotor, the rotor begins to heat up due to friction. For a grey iron disk, the temperatures reached when the brakes are applied are over 1000 degrees FahrenheitLT8 , which is more than what the brake fluid can cope with. With the carbon ceramic brakes, the heat can disperse before it reaches the fluid and therefore frequent and heavy braking can be achieved for longer – there will be less brake fade and therefore the brakes will last longer, almost six times longer than the iron brakes. Manufacturing It takes quite a long time to make these ceramic brake discs. It includes preparation of material, production of the disc body and then the bell mounting.

Numerous tests are followed by this to ensure it's a good quality LT9 disk. There are many manufacturing methods used but the most popular ones are metal casting, cutting, forming and shaping and fabrication and welding. The LT10 main process used is the permanent mould casting process.

Using this method, complex shapesLT11 can be made with a finer LT12 grain structure. First, short carbon fibres, carbon powder and a resin will be mixed together. This is transferred to the mould via an automated machine. Once it is half full, aluminium cores are inserted into the mould which will form ventilation cavities – this stops the disc from overheating. The material mixture is then poured again to fill the mould. A roller levels the mixture in the mould before it is lightly pressed to make the contents inside compact.

The mould is then sent to a large press where huge amounts of pressure is applied along with a temperature of 400 degrees Fahrenheit. This causes the resin and carbon fibre to become plastic. The mould is cooled down and the cores are pulled out. Rough edges are smoothed out using computer guided machines. Ventilations holes are also drilled in at this point. The disc ring is then put into an oven where it is heated for over two days gradually to a heat of 1800 degrees Fahrenheit.

This causes carbon to be formed via a chemical change. The next stage involves silicon and high temperature. A crucible is taken and five mounts are placed to hold the disc. A funnel is placed in the ring and is filled with a fine silicon powder. This crucible is then heated in a furnace for a day with temperatures reaching around 3000 degrees Fahrenheit. This melts the silicon completely. The liquid silicon is drawn into the disc ring using a suction method to form silicon carbide which is very hard.

This is the liquid-state process. This forms the main shape of the disc however it isn't ready. A protective coating is applied. This paint protects the carbon and the disc from oxygen.

It is essential this is done because carbon and oxygen will react together at high temperatures. This will help enhance the lifespan of the disc ring. A machine is used to polish the final disc to smoothen out the surface.

Computer guided machines inspect the surface to examine its " molecular and crystal structure" to see if there are any defects.   The two main manufacturing processes used is permanent mould casting and the liquid silicon infiltration (LSI). Compared to die casting, permanent mould casting will give a stronger product as die casts can contain voids caused by entrapped gas or air during injectionLT13 . Another benefit is that there is little scrap produced from this process.

However, this is an expensive process so a high production volume is needed to counteract the tooling cost. Permanent mould casting isn't known for its intricate shapes – it will be too hard to remove the piece from its mould, having said that it isn't a problem when making brake discs since it's a circular shape. It isn't the good at making big pieces either. Dimensional accuracy is also very good with a permanent mould cast – it produces consistent parts every time. With regards to LSI, it is a cheap way to strengthen an already strong material. Any shape can be fabricated using this method. It has a high thermal conductivity however the high temperature may damage its fibres. DesignThe carbon ceramic brake discs shape is very similar to the shape of a cast iron disc.

It is a circular shape with numerous holes on the friction layer. These holes allow heat to be dissipated when it exceeds very high temperatures during braking. The cores that were made during the manufacturing process is there for the same purpose.

The design also caters to wet conditions where what can leave the brake disk if it enters the disc. Spark PlugA spark plug is a small component within an internal combustion engine. It provides a spark that is hot enough to ignite the air fuel mixture inside the combustion chamber of the engine – this is done by having a high voltage arcing across a gap on the spark plug. The spark plug has an electrodeLT14 , an insulator a shell and a ground electrode. MaterialOne key part of the spark plug is the insulator. This is there for mechanical support and electrical insulation Manufacturing Design Porcelain insulator