Metal and Its Hardness

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As a college student, I had the privilege of working as a metallurgical lab tech in a foundry that produced grey and ductile iron for products ranging from engine blocks to I-Beams. Engine blocks were made from the softer grey iron, up to I-Beams made from that harder ductile iron. I would like to try and explain how casting metal is made (grey iron), in a very low key and non-scientific format so every can get just an idea hoe common metals are manufactured and hardness is obtained for specific products

To begin, most metals start off by being made in a foundry. A foundry contains a furnace, which is nothing more than a kettle that melts variations of iron. Once melted, this iron is poured into molds that cool down and become castings. These castings produce products like engine blocks, which are lightly machined, and possibly clipper blades which are highly machined. Machining, is taking the poured casting(s) and grinding it into a product per a specific specification. Specifications include type of iron, iron hardness, and a blueprint of the finished product.

What determines hardness and how is it adjusted in the metal?

Iron is made by melting pig iron in the furnace. Pig iron is just a basic raw material for the manufacture of iron products. Once melted, the pig iron is adjusted to a specification by the addition of carbon, silicon, and possibly alloys.

Alloy – a solid combination or mixture of two or more metals in which the atoms of one metal occupy the spaces between the atoms of another metal.

Hardness relates to the temperature in which the metal has melted, this is called the liquidous. If the liquidous is low, the metal is softer; if it is high the metal is harder. For example, some grey iron used in engine blocks will melt at around 2300 deg F, while steel melts at over 4000 deg F. Steel is very hard and can sometimes be used as an alloy in iron to make it harder.

Other method of controlling liquidous temperatures is the use of silica and carbon in the mixture. Silica will increase the liquidous, and carbon will decrease it. The compounds are used sparingly as fine tuning because overuse can cause stress fractures in some metals in certain applications. You wouldn't want the engine block of your car to start breaking up because the metal stressed.

How does the foundry make the iron to a certain specification?

When the furnace operator fills the furnace, there is still some of the last batch in there to melt the new charge. Molten metal will melt metal faster than anything. The first addition to any furnace is pig iron and any unusable castings or scrap from previous pours. Next the alloys or steel products are introduced to give the mixture some hardness. Many foundries buy crushed cars to add because of the high steel content. After a couple hours of high heat in the furnace, the molten metal is then tested for its liquidous. Remember, liquidous is the temperature that the mixture melts, the higher the harder. The furnace operator will then take a small ladle on a long pole and dip about a quart of molten metal out of the furnace, the operator will then four this liquid as fast as possible into a ceramic cup that has a probe in it that detects the exact temperature the metal solidifies. Using this temperature and a small calculation, the liquidous can be determined. If it's too high carbon or more pig iron can be added to soften the mix. If it's too low, silica or more steel can be added to harden the mix. This is a basic foundry furnace operation, and most experienced furnace operators can get the mix close the first time.

How is hardness tested?

Hardness of metals is tested by two different applications yielding the same result with different scales. One is Rockwell, the other is Brunel. Both execute the test almost the same way, but have different specification scales.

To do a hardness test, a test bar is poured for the test, or a casting is taken after it has been machined. The test bar is the better way to perform the test, others may disagree. The test bar is 12 inches long and one inch in diameter. A diamond saw is used the cut the bar in one inch segments for the test because it's done three times. The hardness tester is nothing more than a precisely controlled hydraulic plunger that pushes a small bead that's on the end of a tool into the piece of test bar. The piece of test bar is placed in the machine, the plunger is positioned to the surface of the metal, and the button is pushed. The plunger will make a mark on the surface of the metal. The test metal is then placed under a scope that measure the distance across the mark. If the mark is not so wide across, the metal is hard; if it is wide across this means the metal is softer. The number given by this reading is called its "hardness"

Many products made today from iron have their own hardness number as part of the specification. For example, a transmission casing for an automobile will have a higher hardness number than let's say an iron table leg. Two different applications requiring two different metal hardness.

This was just a brief non-technical overview of how some iron products are manufactured, their hardness controlled, and finally how the hardness is tested.