The Technology of Manufacturing Sleeves

In previous articles for *Engine Professional*, I have discussed the evolution of irons used to create sleeves and the process of sleeving various types of engines. In this article, I am going to return to the how Darton creates a sleeve from the beginning to end, starting with the foundry process.

In this publication, Darton currently is running an ad titled “The life of a sleeve from raw earth to perfection”. This concept is not a sales slogan but a truism for all manufactured items we use in our daily lives. ALL products we consume or utilize are based on a life cycle originating from Mother Earth. Metals, electronics, are all based on minerals mined from the ground. Plastics are possible because of oil. Our food comes from the process of seeds utilizing the minerals in the soil.

In the case of metals, each metal material is a composition of various minerals mixed and melted to form a usable structure. This process occurs in a foundry by starting with a melt and then being processed in various ways such as casting, forging, continuous casting, pressure die casting and so on.

To begin, the process requires an engineering analysis to determine the final usage of the finished product. In the case of performance engines, we have a block from aluminum, a crankshaft from steel, rods from steel or aluminum, cams, pistons and yes, sleeves.

The analysis starts with intended use; street engines producing 6-800 horsepower do not necessarily require the most expensive components as a 10,000 HP Top Fuel engine running on Nitromethane. Part of what I will discuss here deals with the sleeves we make for the NHRA professional racers in Top Fuel and Funny Car. Darton considers these sleeves as the pinnacle of technology in chemistry, founding and manufacture. Darton currently supplies most if not all of the professional race teams in these categories and we enjoy this success because of the quality and durability of our product.

In previous articles, I have pointed out that ductile iron (nodular iron) is one of the few metals which with an ASTM spec (536-84), does not have a specific chemistry to attain the mechanical properties outlined in the spec. To attain superb operational results as we expect in the Top Fuel category, the material must be extremely hard on the surface (expressed as hardness Bhn), have elasticity (expressed as elongation), and have unusually high strength (expressed as Tensile and yield). To achieve these results begins with the chemistry.

Every material by every foundry starts with a chemical spec. This spec is derived by selecting certain compounds and minerals described in the “Periodic Table”. This table lists most all minerals known to man, expresses them in a two letter designator and assigns them a “specific gravity”. Specific gravity is defined by the ratio of the density (mass) to volume of a reference substance, usually water. For instance, Titanium “Ti” is 47.867 SG and Lead “Pb” is 207.2.

In the case of our sleeve material, the following list is generally considered as necessary to make a dense, durable product: iron, carbon, sulfur, phosphorus, silicon, chromium, nickel, manganese, copper, tin, titanium, tungsten and many more.

Each of these minerals starts in pure form as an ingot or powder and introduced into a molten mass in the ladle in extremely precise amounts to attain an exact relational percentage to the specified amount of each pour. Also to make excellent ductile iron, the molten mass must be inoculated prior to pouring by magnesium (Mg). This process turns cast iron into nodular iron and in an exam by microscope changes from a flake type of structure to one appearing to be comprised of many small circular balls of material. Not only is the...
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proper chemistry essential, the time of introduction into the molten ladle is critical. As shown in Figure 1, a microscopic view of our DDI-2007 reveals a density of more than 600 nodules per sq. MM. This value is an essential by product of the chemistry, the foundry process and the proper rotational speed of centrifugal dies to assure the proper distribution of the solidified minerals.

I always like to use the analogy of apple pie to describe chemistry. Apple pie is an American staple dessert, but trying to find two alike at any restaurant is impossible. The reason is the chemistry (ingredients), how they were added, how it was baked, etc. Personally, I never found a substitute for my Mom’s apple pie and I’m sure many of you have the same opinions about taste and origin.

In the case of metals, the determining factor and arbiter of the quality is laboratory testing and specific reports. Usually the reports are segregated by chemistry, mechanical evaluation and microscopic analysis of density. The chemistry is determined by use of a “Spectrographic Analysis machine” (see Figure 2) which presents in actual terms the chemistry AND the percentages of each mineral which confirms or denies the original compound as designed by the engineer. Spectrographic machines work by defining each mineral using light waves and specific gravity
measurements. In this way the analysis is assured in percentages to the second and third decimal point.

Once we have confirmed that the raw material is according to the engineering spec, the next steps is to actually design the sleeve with all the necessary machining features specified by the customer. Darton uses “Solid Works” as a design suite and in companion with “Auto Cad”. (See Figure 3, page 67.) Solid Works is multi-dimensional on our computer systems and allows us to 3D model parts before we commit to an engineering blue print. As soon as the blue print is approved by the customer, we return to our Solid Works platform to create to necessary programs for our CNC machines with tool paths and tools required to machine the parts. The next steps are to manufacture the work holding and tooling to make a high quality part.

At Darton, prior to committing to production on any part(s) we evaluate first articles of production in the atmosphere that exists in our shop at the time. The US atmospheric standard for materials evaluation is Sea Level, barometric pressure of 29.92 and temperature of 59°F (15°c). Cast or ductile iron is very susceptible to dimensional variations based on temperature. Our testing laboratory is to the national standard and to actually determine compensation of machining due to atmospheric differences from the standard, we employ a Computer controlled CMM machine to measure first articles. In this way we incorporate the necessary machine compensation to assure the production parts are made to spec. (Figure 4, page 67.)

It is virtually impossible to measure parts with conventional tools like micrometers and such, with the necessary accuracy as required by blueprints which depict tolerances to the fourth decimal point.

Darton uses various machines and equipment on a daily basis to make perfect parts, 100% of the time to keep our customers happy.

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