CONTROL VALVES – Material of Construction

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Many control valve specifications call for valve body made of brass, gunmetal or bronze for sizes 50mm diameter and below, and cast iron for sizes 65mm diameter and above. These specifications seem to have been in use for over half-a-century and show a bias towards copper alloys over cast iron for small sized valves.

The reasons for this bias could be many, the easiest being the better corrosion resistance of copper alloys, but that seems unlikely in HVAC systems where most of the piping itself is of mild-steel, prone to corrosion.

The intent of this article is to go through the characteristics and physical properties of some of the copper and iron alloys to find out other reasons for this bias and its relevance today.

Copper Alloys

Copper was the first metal used by man and it was soon found that its properties could be improved by alloying. Brass, gunmetal and bronze are all alloys of copper with different percentages of zinc, tin and lead as alloying elements.

Bronze – Bronze was the first copper alloy used by man. Early bronze was an alloy of copper and arsenic that occurs together naturally. Later on, arsenic fell out of favour for its toxicity and was replaced by tin. Addition of tin makes the alloy harder and more corrosion resistant then the virgin metal, thus more useful.

Bronze was widely used until iron became cheaper and more plentiful. Bronze is harder and tougher than any other copper alloy. In HVAC context bronze is more suitable for valves for high-pressure hot water and steam applications.

Brass – Brasses are copper alloys in which the principal alloying element is zinc. Their properties depend primarily upon the proportion of zinc present. Most commonly used brasses contain 30% - 40% of zinc. These brasses are characterized by their ductility at room temperature, and can be extensively deformed by rolling, drawing, bending, spinning, deep-drawing and forging.

The combination of ductility, machinability and strength makes this material most suitable for small valve bodies, with thin wall sections, which are either forged or die-casted.

Gunmetal – It is a copper alloy containing both zinc and tin as alloying elements. It was developed by British admiralty for ordnance parts by adding zinc to bronze, to improve casting characteristics.

Gunmetal has good casting characteristics, particularly as a sand casting. It is most suited for sand casted valve bodies where high strength, pressure tightness and corrosion resistance are important.

Iron Alloys

Cast Iron – The terms 'cast iron' generally refers to 'grey iron', but actually it is not a single material, it is a family of materials whose major constituent is iron with varying amounts of carbon and silicon. Cast irons are natural composite materials whose properties are determined by their microstructures.

Grey Iron – Grey iron is an iron alloy characterized by its relatively high carbon content, usually 2% to 4%. When molten iron solidifies some of the carbon precipitates as graphite, forming tiny, irregular flakes within the crystal structure of the metal. The presence of graphite flakes give grey iron excellent casting, machining and self-lubricating properties, but distrupt the crystal structure providing a nucleation point for cracks, leading to grey iron's characteristic brittleness.

Ductile Iron – In ductile iron the graphite is in the form of spherical nodules rather than flakes, thus inhibiting the creation of cracks and providing enhanced ductility. It is also known as S.G. iron or nodular iron. It was invented around 1948.

Its high tensile strength, ductility and ease of casting makes it material of choice for applications where use of steel is expensive. It has replaced many components in the automotive industry.

In HVAC context, ductile iron can replace copper alloy valve bodies without increasing the wall thickness and component weight. It can also be used to replace the grey iron valve bodies with increased strength and pressure rating.

To summarise, all copper alloys have excellent resistance to corrosion but each has its distinct advantages. Brass is most suitable for forged and die-casted valve bodies, gunmetal is more suitable for sand casting and bronze is more suitable for high pressure and temperature applications.

Grey iron can be used for casting all kinds of valve bodies, except of very small sizes with thin sections, whereas Ductile/ Nodular/S.G. iron overcomes this weakness and can be used to produce components from less than 20 grams to more than 200 tons of section sizes as small as 2mm to more than 500mm.

Going back to the specifications, the other most likely reasons for bias favoring copper alloys could have been the ease of manufacturing, possibility of using thin wall sections, thus reducing component weight, and not very high price differential.

But in today's scenario when, copper alloys have become much more expensive, improved foundry practices have made it possible and easier to cast small components of grey iron, and development of ductile iron has made it possible to cast components with thin sections, it is time to rewrite these specifications and remove the unnecessary bias towards copper alloys.

Small valves of forged brass are likely to remain popular for the ease of manufacturing, thus low overall cost. ❖