Towards the Optimum Alloy Selection for Column Pipe and Riser Main Assemblies:
Pushing the case for Aluminium Bronze

Mark Dougan
Director of Metallurgy, Spunalloys Ltd, UK
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Spunalloys is one of Europe's leading producers of ferrous and non-ferrous centrifugal castings, producing castings from an extensive range of plain, flanged and bespoke shaped dies up to 12 tonnes poured weight, 2.2 metres in diameter and 3 metres in length. It has its own specialised finish machine shop, fabrication facility and test house.

The full integration of casting, machining, and fabrication allows it to specialise in bespoke assemblies produced from centrifugal castings. Spunalloys produce one-off as well as volume fabricated assemblies for a wide range of process applications and industries, in particular column pipe assemblies and water lubricated bearings. Column pipes are routinely machined, assembled, third party inspected and packed for onward shipment to the customer's client.

The centrifugal process is used to cast cylindrical items through a vertical or horizontal plane. The very high centrifugal forces generated during casting apply significant g-force to the molten metal that is encased in the spinning, permanent die. The less dense material, which will include the impurities present in the molten metal, will be forced to the bore of the casting, to be subsequently removed during the machining operation. The pressure created by the g-force and the chill effect from the die leads to casting solidification occurring directionally under pressure. The centrifugal method therefore produces castings with a close grain and high integrity through elimination of shrinkage porosity and other casting defects, resulting in items comparable to forged products.

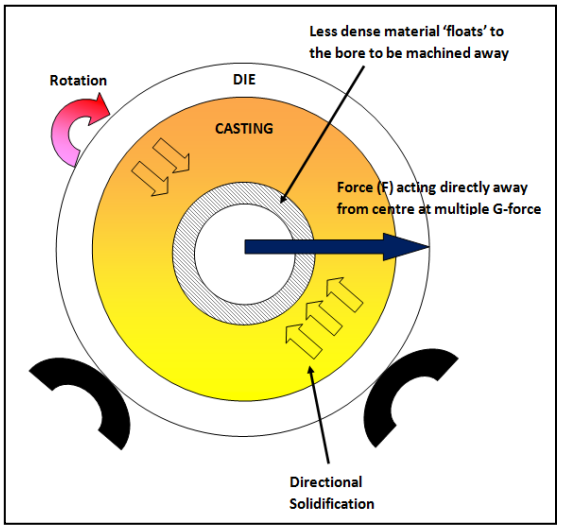

Figure 1: Schematic of centrifugal casting method

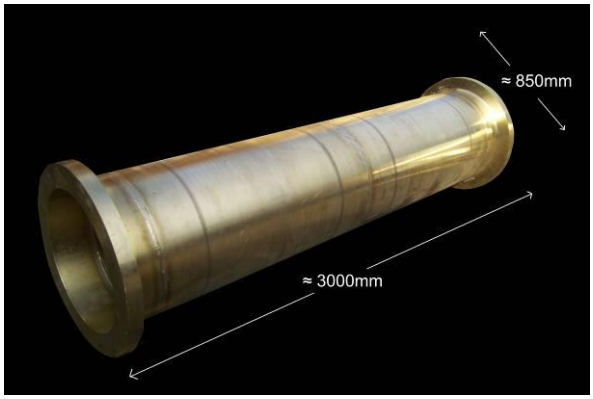

Figure 2: Large centrifugally cast column pipe assembly in nickel aluminium bronze, heat treated

Spunalloys is an approved supplier to the UK MoD, Rolls Royce, Tata Steels, Agusta Westland Helicopters, BAE Systems and Siemens. It holds quality assurance approval to ISO 9001:2008, and manufacturing approval to Det Norske Veritas, Bureau Veritas, Korean Register of Shipping, Germanischer Lloyd, American Bureau of Shipping and Lloyds Register of Shipping.

Materials are manufactured to UK, European and Worldwide standards. 250 alloys are routinely produced encompassing all the short freezing alloys from nickel aluminium bronze, cupro nickel, Monel and duplex and super duplex steels, and all the long freezing alloys from phosphor bronze, tin bronze and gunmetal. Cast iron is produced on a regular basis for compressor liners.

Figure 3: Centrifugally cast, finish machined, weld assembled, heat treated, radiographed, dye penetrant and pressure tested column pipe assembly complete with sand cast spiders in Nickel Aluminium Bronze.

The on-going exploration for oil and gas around the world, and the location of industrial plants on the coast, has increased the need for column pipe and riser main assemblies that can be produced to cope with the corrosive conditions provided by seawater. Seawater is a highly conductive medium and therefore an understanding of the galvanic series of metals is necessary in determining the correct alloy to be used. Corrosion in vertical turbine pumps and the assembly that carries the water to them can be minimised and prevented by proper material selection.

High initial cost may prevent the use of the alloy that would eliminate the corrosion problem. However choosing a low cost alternative, due to the corrosive conditions presented by seawater, will lead to a higher total cost solution when you take into account the critical nature and the down time cost of the pump assembly. It may also, over time, reduce the performance effectiveness of the pump. This report provides a brief analysis of what alloy is most suitable in differing service conditions.

The mechanical properties of nickel aluminium bronze, compared to duplex and super duplex stainless steel, are summarised below. Nickel aluminium bronze meets and exceeds the strength requirements for column pipe assemblies; it is also a highly castable and weldable alloy.

Table 1: Strength Properties

Material:	**Aluminium Bronzes**	**Duplex Stainless Steels**	**Super Duplex Stainless Steels**
Tensile:	580-640 N/mm^2	620 min N/mm^2	700 min N/mm^2
Yield:	240-285 N/mm^2	415 min N/mm^2	450 min N/mm^2
Elongation:	13-15%	20%	25%
Hardness:	140 HB typ	185 HB typ	180-200 HB typ
Density:	7.6 g/cm^3	7.8 g/cm^3	7.8 g/cm^3

Each column pipe will be exposed to unique service parameters, and each case will have a unique, optimal alloy selection. It is normally the foundry metallurgist in conjunction with the client's design engineers who are best placed to make the optimum selection.

Irrespective of the alloy chosen it is essential that the assembly is exposed to stringent non-destructive and destructive testing. The following testing procedures are routinely carried out as requested by the end user.

- ✓ Chemical analysis
- ✓ Mechanical testing
- ✓ Hardness testing
- ✓ Ultrasonic testing
- ✓ Pressure testing
- ✓ Radiography testing
- ✓ Dye Penetrant Testing
- ✓ Positive Material Identification (PMI)

The application and service conditions will also affect the rate of corrosion. A vertical fire pump on an offshore fire installation that sits idle for long periods of time will experience a different rate of corrosion to a pump made from the same material, operated continuously. In the example given, the optimal alloy selection for an idle pump would be nickel aluminium bronze.

The duplex and super duplex alloys are normally more expensive than nickel aluminium bronze, and whilst they are often regarded as possessing slightly higher corrosion resistance in fast flowing seawater than nickel aluminium bronze, extensive studies have shown that in warmer waters aluminium bronze **(heat treated)** is less corrosive than the duplex and super duplex alloys.

The duplex and super duplexes are regarded as corrosion resistant in fast flowing water, but under stagnant conditions they are susceptible to pitting and crevice corrosion. Copper base alloys are very corrosion resistant in quiet, unpolluted, sulphide free water. Mechanical depolarisation, which is the loss of the protective film on the pipe assembly, is an important aspect of pump design and material selection, and occurs in the duplex and super duplex alloys when the velocity of the water is slowed, which in turn brings about a depolarisation of the hydrogen film which protects the material.

Stainless and nickel based materials, unlike aluminium bronze, corrode due to pitting in stagnant water. Bronzes however can be damaged by seawater with hydrogen sulphides so the seawater must be unpolluted and free of hydrogen sulphide.

In many service environments marine fouling can be a severe problem, where marine growth build-up can lead to a severe loss of performance or application failure. Marine growth build up can be solved by selecting an aluminium bronze alloy, which is significantly less susceptible to marine growth than the duplex and super duplex alloys.

Table 2: Corrosion and 'other' properties ranked by cost

(1=least expensive, 5 = most expensive)

	Cost	Wear & Galling	General Corrosion	Pitting Corrosion	Crevice Corrosion	Erosion Corrosion	Cavitation	Stress Corrosion	Polluted Seawater	Corrosion Fatigue	Fouling Resistance	Strength	Galvanic
Nickel Aluminium Bronze	**1**	10	9	10	8	8	8	10	4	9	8	5	7
Duplex Stainless Steel	**2**	4	10	5	4	10	8	9	5	9	1	8	8
Superaustenitic Stainless Steel	**3**	5	10	9	8	10	8	8	9	6	1	5	7
Superduplex Stainless Steel	**4**	3	10	9	8	10	8	9	9	9	1	9	10
Monel	**5**	5	10	5	2	10	8				4	4	8

Aluminium bronze and nickel aluminium bronze is considered to provide good corrosion resistance when handling flowing seawater, is less corrosive in warmer waters than duplex and super duplex, does not have a tendency to pit in stagnant waters, and is resistant to marine growth build up.

Spunalloys have supplied column pipes to the pump industry world-wide for over 25 years. Literally thousands of column pipes and riser main assemblies have been supplied to pump makers in Europe, USA, India and Australia and installed all over the world. In that time there have never been any rejected parts returned from any customer.

Figure 4: Centrifugally cast, weld-assembled and finish machined column pipes ready for despatch to the end client. Fully traceable to individual heat number cast, and certified to customer requirements.

References and Further Information

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For more information on this topic, contact the author at mark.dougan@spunalloys.co.uk