

VALVES OF HIGH-NICKEL ALLOYS

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Abstract

The practical difficulties encountered in the manufacture of high-nickel alloys have been enumerated. Some properties of the core sand, facing and backing sands used for moulding have been given. Suitable fluxes are mentioned, but only the proprietary flux acted as a degassing agent and for deoxidation. It has been noticed that despite adoption of all precautions, porosity could not be entirely eliminated. Author has invited remedial suggestions to solve difficulties.

Introduction

HIGH-NICKEL alloys are corrosion-resistant alloys meant for handling acids, alkalis, brines, water and food products; they are also resistant to exposures in dry and moist atmospheres. They are, however, particularly used where corrosion resistance along with strength and ductility is required. Many practical difficulties are, however, encountered in the manufacture of valves of high-nickel alloys and these are¹: (a) the fairly high solidification (shrinkage — 0.25 in. per ft.), (b) the increasing tendency towards the absorption of C, H and S thereby giving rise to unsound castings, (c) the narrower range of freezing (50°C.), (d) their high melting and pouring temperatures (1400°-1650°C., depending on nickel content).

The principal requisites in the standard methods so far used in the making of these alloys are that the sand used in moulding must be refractory and permeable². Moulds must be dried in order to ensure greater permeability and facing sands should be of finer mesh to produce good finish and also of refractory nature to resist the penetrative

action of the metal, particularly at high temperatures. As the solid contraction of copper-nickel alloys is associated with a tendency towards hot-shortness, any undue resistance on the part of the moulds or cores may give rise to cracks and tears in the castings; to counteract this tendency, moulding sands, cores, methods of feeding, etc., should be standardized.

Cores should be of silica sands¹ mixed with linseed oil and molasses or cowdung and be baked at a temperature high enough to ensure complete oxidation of the oil binder in order to prevent undue formation of any gas when the alloy will lie quietly against the same.

(a) The high-nickel alloys having considerable solidification shrinkage, the most practical way is to cast the metal through the risers, as the metal in the risers, being last to freeze, will adequately feed the casting; moreover, where the ingates pass directly through the feeders, the efficacy of heads and risers can be much improved by stopping the pouring as soon as the metal rises in them and then filling up by pouring hot metal directly into them.

(b) Also, since these alloys have a tendency for absorption of hydrogen, carbon and sulphur, which are the products of combustion in an oil-fired furnace, the time of melting these alloys should be considerably shortened; otherwise, hydrogen will cause porosity, carbon weakness through the formation of flakes and sulphur brittleness. The standard procedure is to melt 80-90 lb. in 1½ hr. Moreover, in order to reduce the pick-up of these three elements to the minimum, the standard procedure is to surround the melting zone with free oxygen^{1,2,3,4},

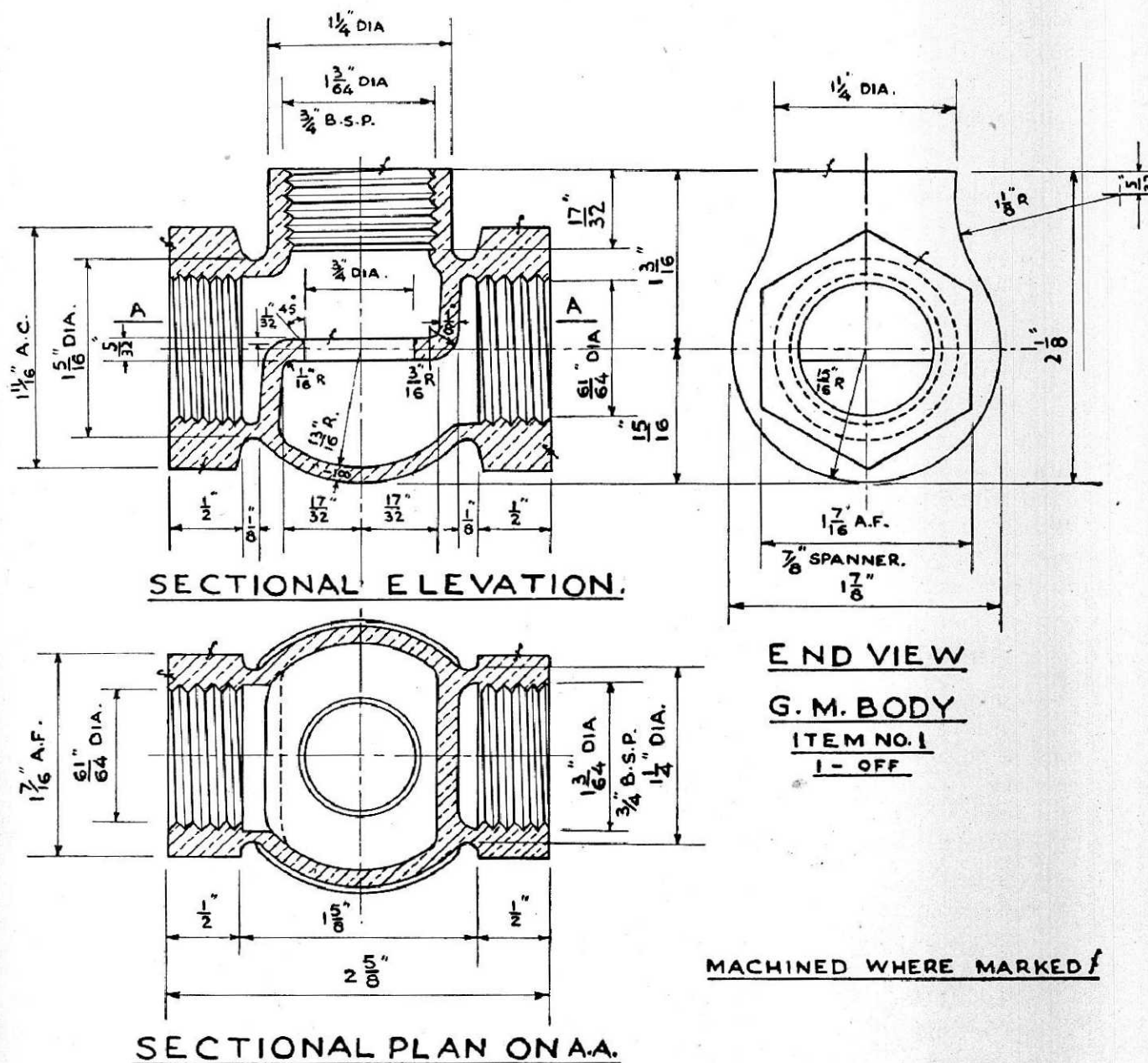


FIG. 1 — GUNMETAL VALVE

any absorbed oxygen being, however, removed by a deoxidizing treatment.

(c) & (d) Because of the narrower range of freezing, the crucible containing the melt⁴ should be quickly handled and pouring should be done as quickly as possible. Speed of working at this stage is of vital importance,

as otherwise thin-sectioned castings may tend to misrun.

More or less the same standard procedures as discussed above were adopted in our works to produce pressure-tight valves of high-nickel alloys for use in chemical plants. But the majority of the valves so far produced

were found to leak under the pressure of 300 lb./sq. in.

Required Specifications of the Alloy and the Valve

The composition of the alloy is as follows:

Copper	...	41.0-42.0
Zinc	...	0.5-1.0
Manganese	...	1.75-2.25
Silicon	...	1.25-1.75
Tin	...	1.5-2.0
Iron	...	2.0-2.5
Nickel	...	50.0-52.0

The valve is to resist the action of particular chemicals and to be of globe-valve type with cast iron hand wheel, as per British Standard Specification. A general view of the valve with necessary dimensions is shown in Fig. 1.

Experimental Procedures

To prepare the cores, pure silica sand of 60-80 mesh (B.S.S.) mixed with 3 per cent linseed oil and cowdung according to consistency was made in a sand-mixer. No water was added. The mixture had the following properties:

A.F.A. Green permeability	...	60-70
Green compression	...	1.8-2.0 lb./sq. in.
Green hardness (as per test-piece)	...	19.5
Moisture	...	11.0-11.8 per cent
Dry hardness	...	95
Clay contents	...	2-3 per cent

Cores were baked at 450°F. for 40 to 50 minutes, painted with plumbago to ensure better inner surface and clean stripping, and again baked at about 450°F. for 25 to 30 minutes. Cores were found too hard to be broken and also to possess good venting properties. Excessive baking, which spoils the cores, was, however, avoided.

In moulding, the facing sand was prepared with pure silica sand of 80-90 mesh (B.S.S.) bonded with 2 per cent linseed oil and cowdung according to consistency. This mixture

was found to maintain the strength after being properly dried at the surface without losing the binding properties and also to have more or less the same properties as above. In a mould, the amount of facing sand was almost half, i.e. 50 per cent.

The backing sand was obtained from our cast iron foundry and had the following properties (naturally-bonded sand):

Green compression	9.9.5 lb./sq. in.
A.F.A. Green permeability	... 8-10
Green hardness (as per test-piece)	70
Mould hardness	... 50
Moisture	... 9.0 to 9.5 per cent
Clay contents	... 9-10 per cent

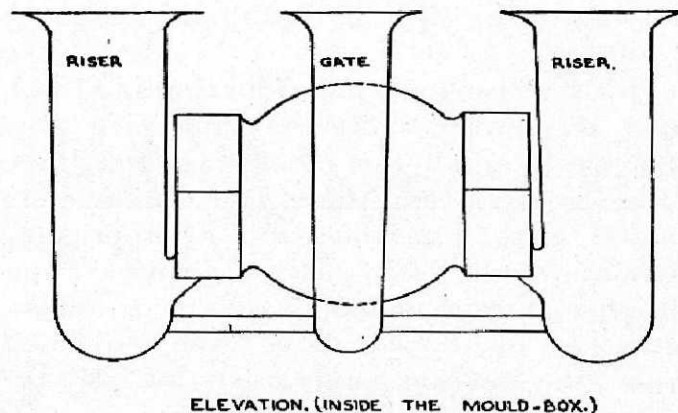
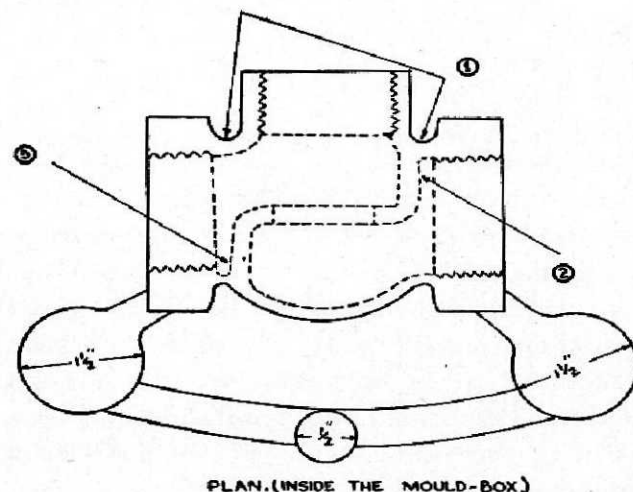


FIG. 2 — MOULDING-BOX ARRANGEMENT FOR CASTING GUNMETAL VALVE. BOXES CAST HORIZONTALLY

Position 1 — (a) Melt No. 1: 2 leaked; (b) Melt No. 3: 1 leaked; (c) Melt No. 4: 1 leaked. Position 2 — Melt No. 2: 1 leaked. Position 3 — (a) Melt No. 3: 1 leaked; (b) Melt No. 4: 1 leaked

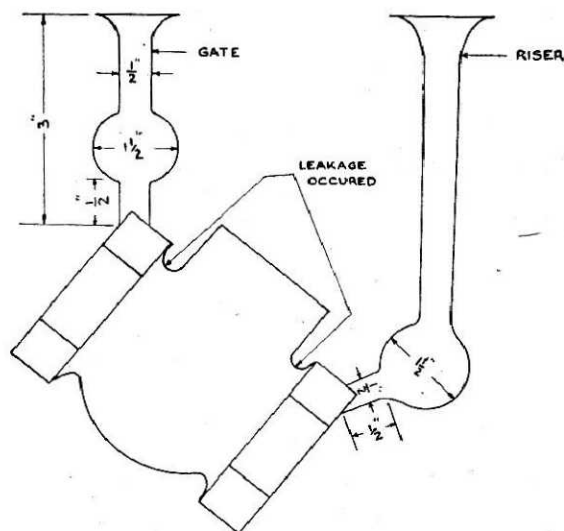


FIG. 3 — POSITION OF THE PATTERN IN THE MOULD-BOX. BOXES CAST VERTICALLY AT AN ANGLE OF 70°

All the moulds were air-dried for 24 hr. followed by heating for 25 minutes over a coke-fired furnace. Air-drying was, however, indispensable, otherwise cracks would have occurred during subsequent heating. Moulds were then painted with a proprietary paint, terracoat No. 14, supplied by M/s. Fosco Foundry Services Ltd., England, and again baked in the same way over the furnace for about 40 minutes.

Three methods of moulding were adopted as shown in Figs. 2 (standard method), 3 and 4.

In all, melting was done four times and each melt containing a different flux each time was used for all the moulds by the three different methods; these four fluxes were borax, glass, limestone and a proprietary flux and were used under identical conditions. Virgin ingots of specified composition as mentioned above were purchased from the market and used for all the four meltings. The furnace used for melting was a Morgan's Crucible furnace (oil-fired) of the lift-out type with an air pressure of 30 w.g.

The crucible was heated up to a dull red heat. Two per cent by weight of the fluxing

agent was first introduced into the crucible; then the ingot metal was partially charged and the lid placed over the crucible. The crucible was slowly heated for the first 5 minutes. In order to raise the temperature, full air pressure up to 25 w.g. was then applied with the flow of oil so adjusted as to give an oxidizing flame and melting was carried out as quickly as possible. As melting proceeded, the remaining amount of ingot metal was charged removing the lid of the crucible so as to make the total melt weigh about 80 to 90 lb. During the second charging, the air supply and the oil flow were, however, temporarily suspended. Before pouring into the moulds, the melt was superheated for 5 minutes.

(The degassing operation was done only when the proprietary flux had been used. The packet containing the degasser supplied by the same concern was dropped on to the surface of the melt and immediately immersed with a suitable tool. In view of the

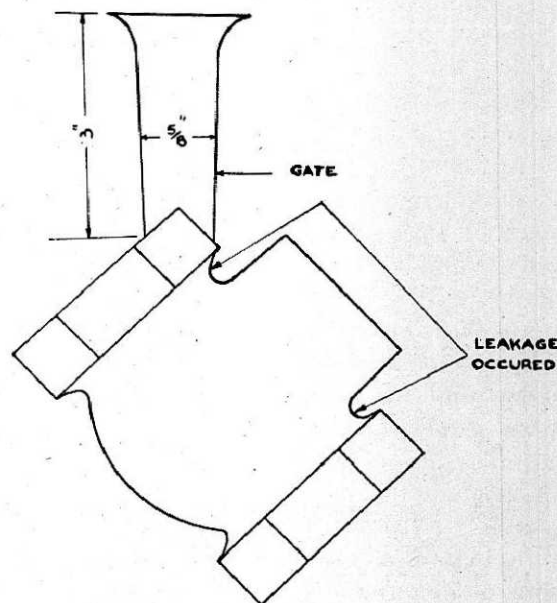


FIG. 4 — POSITION OF THE PATTERN IN THE MOULD-BOX. BOXES CAST VERTICALLY AT AN ANGLE OF 70°

TABLE 1—RESULTS

SL. No.	NATURE OF FLUX USED IN DIFFERENT MELTINGS	NUMBER OF CASTINGS BY MOULDS AS IN FIG. 2				
		Total Nos.	Good casting	Bad casting	Stood 300/lb. sq. in.	Leaked
1	Borax and Mg-tubes	6	2	4	nil	2
2	Glass and Mg-tubes	7	3	4	2	1
3	Limestone and Mg-tubes	6	3	3	1	2
4	Proprietary flux and Mg-tubes	6	2	4	nil	2

TABLE 2—RESULTS

SL. No.	NATURE OF FLUX USED IN DIFFERENT MELTINGS	NUMBER OF CASTINGS BY MOULDS AS IN FIG. 3					NUMBER OF CASTINGS BY MOULDS AS IN FIG. 4				
		Total	Good	Bad	Stood 300 lb./sq. in.	Leaked	Total	Good	Bad	Stood 300 lb./sq. in.	Leaked
1	Borax and Mg-tubes	4	4	nil	nil	4	4	3	1	nil	3
2	Glass and Mg-tubes	5	5	nil	1	4	4	4	nil	nil	4
3	Limestone and Mg-tubes	4	3	1	nil	3	4	4	nil	nil	4
4	Proprietary flux and Mg-tubes	4	4	nil	1	3	4	4	nil	nil	4

high temperatures involved with resultant danger of iron pick-up with steel tools, a graphite combination plunger was employed.)

The deoxidation treatment was next carried out by Mg-tubes as recommended in amounts by the supplier, i.e. 2 tubes per 80 lb. of metal. The appropriate numbers of deoxidizing tubes were wedged in the holes of the graphite combination plunger and taken right to the bottom of the charge.

The crucible was then withdrawn. The slag, after being thickened by the addition of dry sand, was skimmed off and the pouring made as quickly as possible.

Discussions

In Fig. 2, as the casting had been done horizontally, the flow of the metal to fill up the mould was a bit slow as a result of which the thin-sectioned castings were misrun involving high percentage of rejections; but

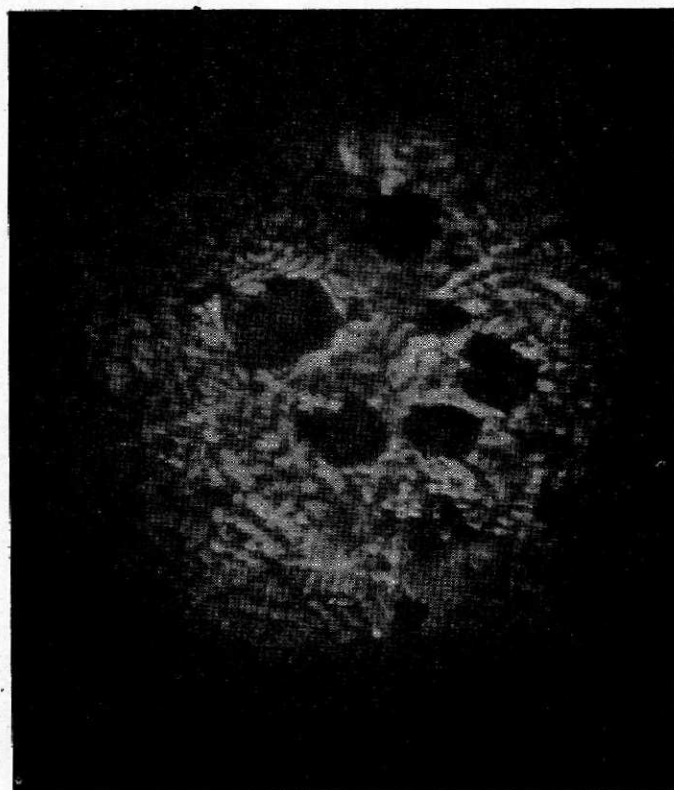


FIG. 5 — POROSITY IN HIGH-NICKEL VALVES. MAGNIFICATION ($\times 100$)

the few good castings that were obtained in this method yielded a bit better results so far as leakage was concerned. Amongst all the melts, melt No. 3 with glass as the flux gave satisfactory results.

In Figs. 3 and 4, as the casting had been done vertically, most of the castings were perfect, but they yielded poor results so far as leakage was concerned.

The positions where leakage occurred have been distinctly marked in all the figures. No particular process gave us satisfactory results. Fig. 5 shows a photomicrograph of a sample cast from melt No. 4, etching reagent being Carapella's reagent (ferric chloride, conc. HCl, ethyl alcohol), magnification 100. Some entrapped globular-like formations are clearly visible. Macro-examinations also show porosity.

Acknowledgements

My thanks are due to Sri K. Ray, B.E., C.E., M.I.E., Proprietor, Annapurna Metal Works, Calcutta, for giving me all the facilities to carry out these experiments, and to Dr. S. R. Sen Gupta, Ph.D. (Glas.), M.I.E., Principal, Bengal Engineering College, for allowing me to work in the college.

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2. *Foundry Service, Foseco, Information Sheet 46*, (February 1950).
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Discussions

Mr. A. T. Pal (Author) invited suggestions to remedy some of the defects enumerated in his paper.

MR. S. S. GILL (Metallurgist, Hindustan Motors Ltd., Calcutta)

Chills may be used at some suitable spots to avoid hot tears.

MR. F. C. GOLDSMITH [Foundry Services (Overseas) Ltd.]

It has been found that an addition of lithium in the region of about 0.005-0.01 per cent by weight to high-nickel alloys has a marked degassing effect and should help if the trouble is due to gas porosity.

Lithium also dissolves the scum formed by magnesium when the latter is used as a deoxidizer. Particles of this scum, if carried into the casting, may be a contributory factor to the porosity experienced in high-nickel castings by the author.

MR. D. K. COUTTS (Mond Nickel Co. Ltd., Bombay)

Could you give a rather more detailed description of porosity experienced, as otherwise it would be difficult to decide which of the many possible causes of porosity was responsible in this particular case?

MR. E. H. BUCKNALL (Director, National Metallurgical Laboratory, Jamshedpur)

The use of calcium silicide instead of magnesium-tubes as deoxidizing agents can be tried. A change of design can also be effected. I would like to know whether you would obtain different results, mechanical and metallographical, by using different fluxes in one particular type of moulding.

MR. ASUTOSH PAL (Annapurna Metal Works: Author)

By changing the design, perfect castings were obtained, but it would not be permitted for various reasons — machining difficulties for intricate bodies and higher metal contents. In all cases, porosity was observed and it was a question of degree only.

Lithium could not be tried as it was not available in India at the time of experiment.