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A study of the microstructure and properties of continuous casting rare earth ductile iron pipes

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Abstract

Continuous casting procedures are simpler than centrifugal casting. Continuous casting rare earth ductile iron can be obtained by adding REMgSiFe. This paper researches the effect of elements on structures and properties of rare earth ductile iron pipes. Methods for improving the properties of rare earth ductile iron pipes are discussed. The strength and elongation of the pipe are 515–485 MPa and 2.5–2.7% without heat treatment or 440–425MPa and 7–16% with heat treatment. The microstructure of the matrix of continuous casting rare earth ductile iron pipes are ferrite or pearlite or ferrite plus pearlite. In China, continuous casting rare earth ductile iron pipes have been produced successfully and used in different fields.

1. Introduction

Cast iron piping affects many industrial and agricultural production processes. There are three methods of producing cast iron pipes: centrifugal casting, continuous casting and manual casting [1–3]. At present, ductile pipe is produced by the centrifugal casting procedure in many countries, but it requires heavy investment. The procedure of continuous casting ductile iron pipe is simpler and its investment is less than that for centrifugal casting ductile iron pipe. The strength and elongation of continuous casting rare earth ductile iron pipe without and with heat treatment are more than 420 MPa and 1–3% or more than 420 MPa and 7–16%, respectively. However, the latter properties are very difficult to obtain. In China, DN_{300}–DN_{1500} continuous casting rare earth ductile iron pipes have been produced successfully and used in different fields.

2. Experimental details

Experimental research has been carried out in the laboratory and in some workshops. Base iron was melted in a middle or industrial frequency furnace. The composition of the base iron was follows: C, 3.6–4.0%; Si, 2–2.5%; Mn, 0.6–0.8%; P, 0.05–0.07%; S, 0.04–0.06%. The spheroiditic agent was REMgSiFe which contains Mg (9–10%) and RE (8-9%). Added REMgSiFe was 0.8–1.0%. The melt was treated at 1480–1500 °C with spheroiditic agent, then inoculated with 75 FeSi. The treated melt must be poured into the casting pipe within 15–20 min. Samples were taken from the treated melt and the body of the pipes for mechanical properties and metallographic tests.

3. Results and discussion

The experimental results demonstrate that suitable rare earth ductile iron pipe can be obtained by the continuous casting procedure. The strength and elongation of the body of the pipes without and with heat treatment are more than 515–486 MPa and 2.5–2.7% or more than 440–425 MPa and 7–16%, respectively. Rate of spherical graphite is at the 1–3 level. The matrix of the body of the pipes may be ferrite or pearlite or ferrite plus pearlite. These results are summarized in Table 1 and Figs. 1 and 2.

Some samples which were taken from the body of the rare earth ductile iron pipes were used to analyse defect types. The samples were examined serially by planing 2 mm once from the outer surface layer to the inner surface layer. The rate of defects in continuous casting rare earth ductile iron pipe is more than that of centrifugal casting rare earth ductile (87.5%). Slag inclusion and gas holes are the main defect types in continuous casting rare earth ductile iron pipe, which decrease the mechanical properties of the pipe, especially elongation. To improve the quality of continuous casting rare earth ductile iron pipe, the amount of slag inclusions and gas holes must be reduced. Because slag inclusions consist of Mg, Al, Si, Ca, Ti, Ce, Mn and oxygen (see Figs. 3 and 4), an important method of

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TABLE 1. Compositions and properties of DN_{800} continuous casting ductile iron pipe

Sample[a]	Composition (%)							Mechanical properties		Matrix structure
	C	Si	Mn	P	S	RE	Mg	σ_b (MPa)	δ (%)	
S_{801}								435	2.5	
TS_{801}								425	8.7	
S_{802}								515		See Fig. 1
TS_{802}	3.67	2.79	0.52	0.031	0.016	0.021	0.012	440	16	See Fig. 2
S_{803}								503	2.7	
TS_{803}								435	7.0	

[a]S, pipe without heat treatment; TS, pipe with heat treatment.

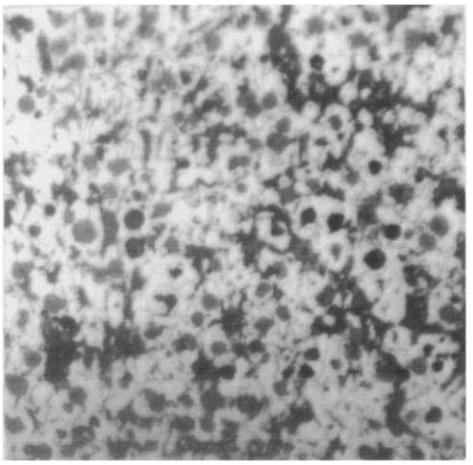

Fig. 1. Metallographic structure of DN_{800} rare earth ductile iron pipe without heat treatment (×100).

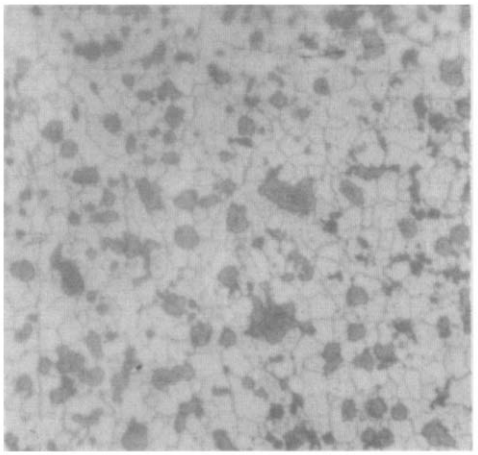

Fig. 2. Metallographic structure of DN_{800} rare earth ductile iron pipe with heat treatment (×100).

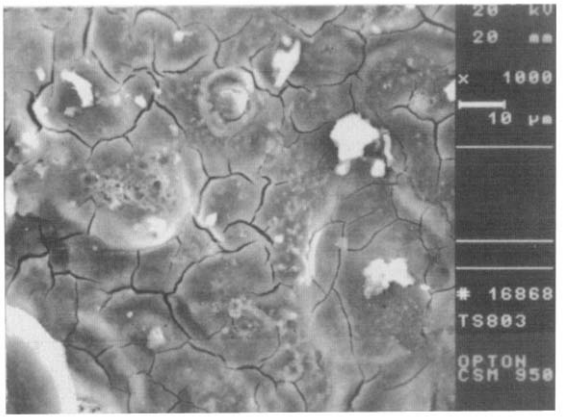

Fig. 3. Slag inclusion in rare earth ductile iron pipe.

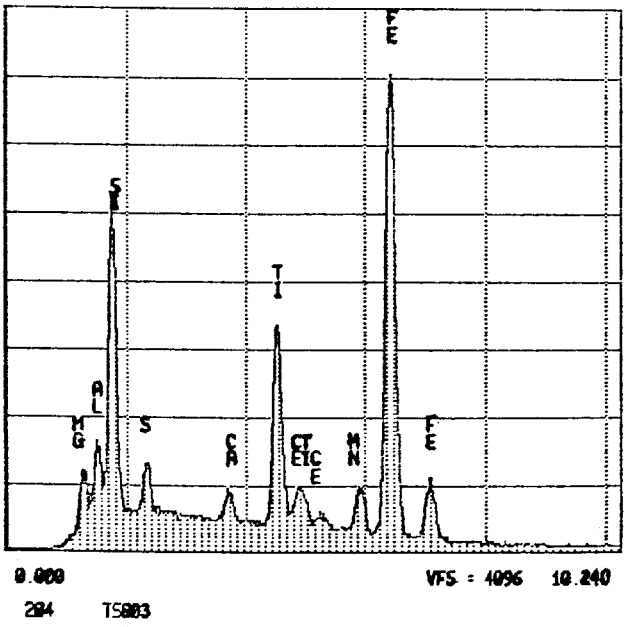

Fig. 4. Composition of slag inclusion in rare earth ductile iron pipe.

increasing the quality of rare earth ductile iron pipes is to control the metallurgical quality of the melt and additional spheroiditic agent. The content of Mg, Al, Si, Ca, Ti, Ce, Mn, S and O must be kept at low levels in order to obtain suitable ductile iron. Thereafter, slag inclusions and gas holes are decreased and the mechanical properties of the body of the pipes are improved.

Another important defect in continuous casting rare earth ductile iron pipe is shrink marks on the inner

surface, where the effective thickness of the pipe is decreased; this also lowers the mechanical properties of the pipe. This kind of defect can be decreased when by increasing the cooling strength of the inner crystallizer in the continuous casting machine.

4. Conclusions

The continuous casting process is a good method of obtaining casting rare earth ductile iron pipe. Its strength and elongation can be 515–484 MPa and 2.5–2.7% without heat treatment or 400–425 Mpa and 7–16% with heat treatment. The cost of continuous casting rare earth ductile iron pipe is less than that of centrifugal casting rare earth ductile iron pipe. The main defects in continuous casting rare earth ductile iron pipe are slag inclusions, gas holes and shrink marks. Strict control of the metallurgical quality of the liquid cast iron and decrease in the addition of spheroiditic agent are effective methods of decreasing slag inclusions. Elevated cooling strength of the inner crystallizer of the continuous casting machine can decrease shrink marks. Slag inclusions in continuous casting rare earth ductile iron pipe consist of Mg, Ce, S, O, Al, Ca, Si, Ti, Mn and so on. Controlling the content of Mg, Ce, S, O, Al, Ca, Si, Ti, Mn and so on is important to decrease slag inclusions.

References

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