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MECHANICAL BEHAVIOUR OF NODULAR CAST IRONS AFTER PROLONGED HIGH TEMPERATURE EXPOSURE

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Ductile cast irons (DI) are widely used in industrial applications for their good castability, low cost and high range of mechanical properties that can be tailored for specific applications by changing matrix microstructure. However their use is limited to components working at room temperature, since prolonged exposure at high temperature can lead to decomposition of both ausferrite and perlite, with a consequent strength reduction [1-3]. To date most of the research activity on this topic was mainly focused on investigating microstructural evolution of DIs, rather than establishing relationships among time and temperature of exposure, and final mechanical properties.

The aim of the present paper was to correlate the effects of prolonged high temperature exposure on microstructure and residual strength of ductile cast irons with different matrix microstructures, after an isothermal high temperature exposure (degradation).

1. Materials and Methods

The following materials were investigated: the ferritic ductile iron EN GJS/400-18 (FDI), the pearlitic ductile iron EN GJS/800-2 (PDI), the austempered ductile iron ISO 17804/JS/1050-5 (ADI), the perferritic isothermed ductile iron - Zanardi internal Standard 101:2007 (IDI). In order to evaluate the thermal stability of these cast irons, high temperature exposure tests were carried out by isothermal soaking at temperatures between 200 and 600°C and time up to 300 hours, in a muffle furnace.. Microstructural characterization was carried out with optical microscope (OM). Mechanical properties of degraded samples were evaluated by means of Brinell hardness measurements and tensile tests, both at room and 500°C, according to ASTM E8.

2. Results

Microstructural analyses confirm that the prolonged high temperature exposure leads to the decomposition of the ausferrite and pearlite, while it has no appreciable effects on ferrite. The microstructure of PDI is stable up to 500°C, regardless of time(?), while at higher temperatures pearlite spheroidization firstly occurs (Fig. 1) and then, with prolonged exposure, it decomposes into ferrite and graphite.

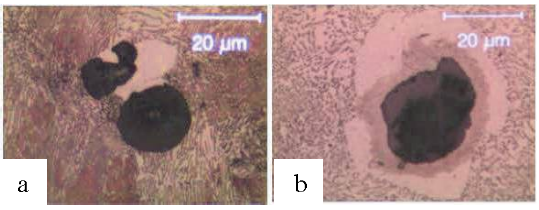

Fig. 1. Microstructure of PDI samples. before (a) and after (b) thermal exposure at 550°C for 120 hours

A similar evolution of the pearlite present in the perferritic microstructure of IDI cast irons has been observed. However they are stable only up to 400°C, since perferritic microstructure has a finer pearlite respect to PDI [4] and is therefore more prone to spheroidization.

In ADI cast irons, decomposition of ausferrite is not appreciable up to 400°C and only samples exposed at 500°C clearly show the decomposition of the carbon-rich austenite into carbides and ferrite (Fig. 2). Mantaining the ADI at high temperature the complete decomposition of the ausferrite leads to a fully ferritic microstructure.

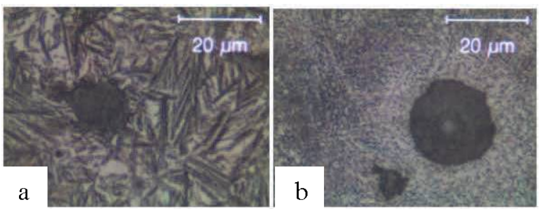

Fig. 2. Microstructure of ADI samples, before (a) and after (b) thermal exposure at 500°C for 72h.

Decomposition of both pearlite and ausferrite is a diffusion controlled process, clearly dependent on both time and temperature exposure.

In order to relate microstructural evolution to mechanical properties after thermal exposure, several samples of the studied ductile cast irons were subjected to prolonged high temperature soaking, and the corresponding hardness variations were evaluated. The results are reported in the hardness-time-temperature curves (HTT) of Fig. 3.

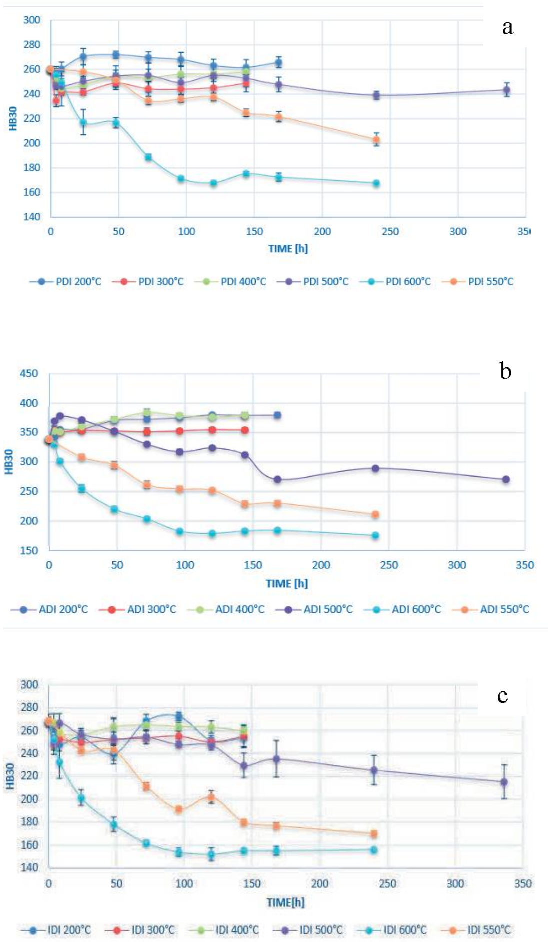

Fig. 3. Hardness-time-temperature curves (HTT) of PDI (a), ADI (b) and IDI (c)

Figure 3 clearly shows that while PDI hardness is substantially unaffected by high temperature exposure up to 500°C, IDI and ADI are stable only up to 400°C and at 500°C, after 240 hours, their hardness decrease is of about 15%.

Results of the tensile tests carried out at both room and 500°C, after thermal exposure at 500°C up to 240h (Fig. 4), highlight a reduction of both yield (YS) and ultimate tensile strength (UTS) at 500°C of about 60% respect to UTS and YS at room temperature, regardless of the matrix microstructure and of the high temperature exposition time the samples have been subjected.

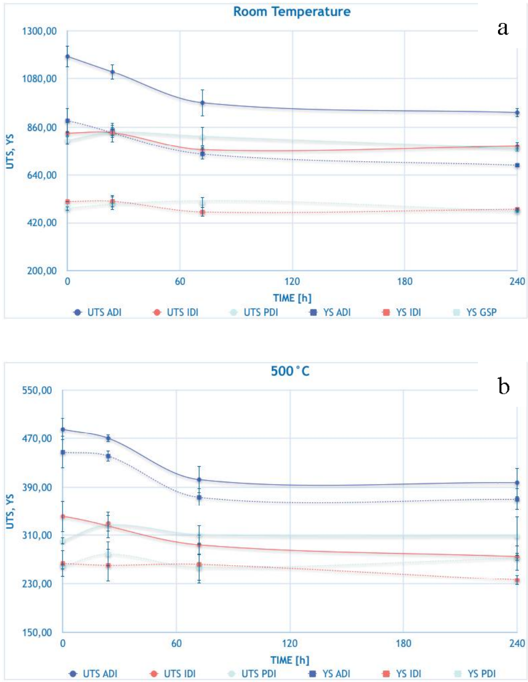

Fig. 4. Results of tensile tests carried out on DIs exposed at 500°C for time up to 240h. Tests at room temperature (a), tests at 500°C (b).

3. Conclusions

Several ductile cast irons with different matrix microstructures (perlitic, ausferritic…..) were compared in terms of their microstructural evolution, residual hardness and tensile properties, after prolonged high temperature exposure.

PDI The highest thermal stability among the tested ductile cast irons was observed in the PDI

Even if ADI displayed the most evident strength reduction after exposure at 500°C, they always showed UTS and YS higher than the others DIs.

Acknowledgments

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