ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 7, Issue 5 , May 2020

Anomalies of ductility of iron in the temperature range of phase transformation

Nugmanov I., Boboyev Kh Kh., Toshtemirov K.Q

Candidate of Technical Sciences, Almalyk branch of Tashkent State TechnicalUniversity named after Islom Karimov.Uzbekistan, Tashkent region, Almalyk;

Senior Lecturer, Almalyk branch of Tashkent State Technical University named afterIslomKarimov, Uzbekistan, Tashkent region, Almalyk;

Assistant, Almalyk branch of Tashkent State Technical University named afterIslomKarimov,Uzbekistan, Tashkent region, Almalyk;

ABSTRACT: A nonmonotonic dependence of the ductility of technical pure iron on the strain temperature is established. In the region of the $\alpha \rightarrow \gamma$ phase transition, a sharp drop in plasticity is observed, apparently due to the shear nature of the $\alpha \rightarrow \gamma$ transformation.

I.INTRODUCTION

Typically, the ductility of metals increases monotonically with increasing temperature. However, in some cases, a deviation from this simple dependence was observed, which was called the "plasticity anomaly"

Especially the plasticity anomaly is manifested in steels and occurs in the temperature range close to Ac_1 – Ac_2 temperatures, and it is natural that it is associated with the presence of phase transformations in the steel.

The first who discovered an anomaly of ductility in steel, showing a deviation from a monotonic increase in ductility with increasing temperature was the famous English scientist V. Rosengain. He noted this simply as a fact. However, in subsequent studies, plasticity anomalies were associated with phase transformations in steel [1].

In the following years, experimental data accumulated, many publications were published, many researchers claimed that an increase in ductility was observed in the phase transition interval from Ac_1 to Ac_2 (the point of magnetic transformation of iron at 768° C), and plasticity decreased in the range of Ac_1 - Ac_2 (2).

It is very interesting to recall that the statement made many years ago by the famous Japanese scientist K. Honda that plasticity decreases above the Ac_3 temperature of the single-phase austenitic region (2). It should be noted that in the following years many publications appeared that claimed that in the interval of phase transformations from Ac_1 to Ac_2 an increase in plasticity is observed (3,4). Another opposite point of view was approved and experimentally proved (5.6); in the region of phase transformations in the Ac_1 - Ac_2 interval, plasticity does not increase, but decreases. This contradiction is largely due to the fact that it is difficult to systematically study the mechanical properties, especially the microstructure at the time of the phase transformation of iron. Of interest is the study of ductility in technically pure iron at various deformation temperatures, and especially in the field of phase transformation. The chemical composition of the investigated material was as follows:

C	Si	Mn	S	Cи
0,003%	0,35%	0,30%	0,01-0,03%	0,30%

The mechanical properties were studied in the temperature range 500–950^0 C and the strain rate range 10^{-4}–10^{-2} s^{-1} on an Instron machine model TT11114. We used samples made with a diameter of the working part of 5 mm and a base of 25 mm. The samples were heated to the test temperature in a three-section resistance furnace, and the temperature gradient did not exceed ± 50° C over a length of 300 mm.

Before deformation, the samples were kept in the furnace for 20 min in order to ensure heating of the samples and stabilization at a given temperature. To reduce the oxidation of samples at high temperatures (T 600 - 700^{0}C), a protective glass enamel ЭВТ13 was applied, which was applied to the working part of the sample before heating.

II. SIGNIFICANCE OF THE SYSTEM

Metallographic studies were performed using a Neofot-2 microscope. Microstructure of technical iron in a state of delivery (Fig. 1).

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 5 , May 2020

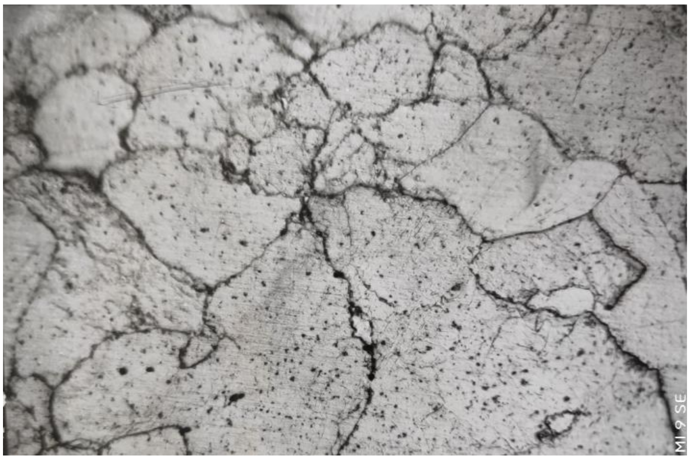


Fig. 1. The microstructure of technical iron is in a state of delivery. x500.

The temperature of the phase $\alpha \rightarrow \gamma$ transformation in technically pure iron of the reduced composition was determined by differential dilatometric analysis on CHEVEHARD units when heated at a speed of 4^0C / min (Fig.2), it was found that the polymorphic transformation occurs in the temperature range 900-920^0 C.

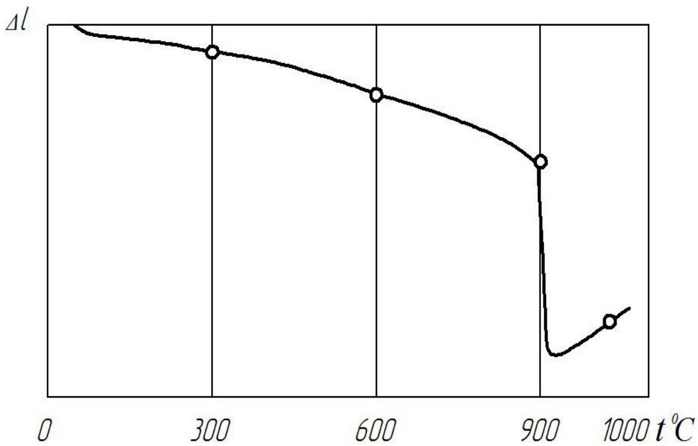


Fig. 2. Dilatometric heating curve of technically pure iron.

The presence of the conversion interval noted in this question is explained by the influence of impurities mainly of silicon, which extends the range of polymorphic transformation of iron.

Thus, below 900^0C in technically pure iron there is - α phase is higher - 920^0Cγ - phase.

Tensile tests were carried out on an Instron dynamometer in the temperature range from room temperature to 1000^0 C. mainly in the α - and partially γ - region. The heating temperature was controlled by a chromel-alumel thermocouple with an accuracy of $\pm 3^0$ C. The heating rate was 40^0 C / min. Sample heating time 10 min. The strain rate is $\dot{\varepsilon} = 6.6 \cdot 10^{-4}$ c^{-1}. In fig. Figure 3 shows the dependence of the relative elongation δ on the deformation temperature of technical iron in the delivery state, there is a continuous increase in δ with increasing temperature (from 44% at 500^0 C to 64% at 870^0 C), and with a further increase in temperature, its sharp decrease in the phase transition region , then again a noticeable increase in elongation in the γ - region.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 5 , May 2020

III. LITERATURE SURVEY

The temperature dependence of the flow stress is also nonmonotonic in Fig. 3. it can be seen that an increase in the test temperature sharply reduces the flow stress, but near the temperature region $\alpha \to \gamma$ of the σ transformation, it again increases markedly.

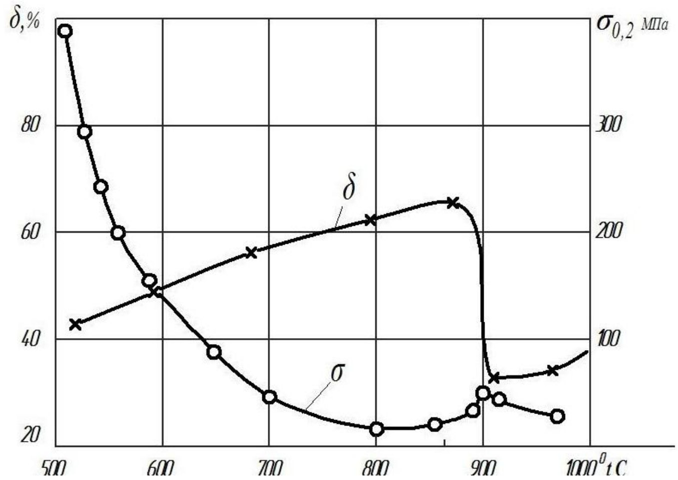
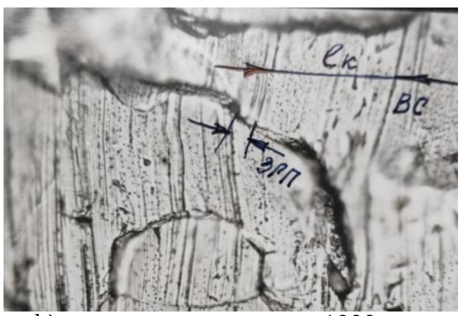


Fig. 3. Dependence of the relative elongation δ of technical iron o on temperature at $\dot{\varepsilon} = 6.6 \cdot 10^{-4}$ c^{-1}.

However, it is most interesting to elucidate the causes of a sharp drop in ductility when the temperature of phase transformation is reached. The microstructure, as well as the deformation relief arising from deformation, were studied from this. From Fig. 4. it can be seen that the deformation relief, and therefore the mechanism of deformation of technical iron, is noticeably different at these temperatures. Slip bands during deformation are not detected. However, at a temperature of 870° C, intragranular slip is the main mechanism of deformation.

The contribution of intragrain glide was assessed by changing the distance between two risks lying within the same grain (Fig. 4.a, b). The contribution of intragranular slip amounted to $\gamma_{в.с} = (\varepsilon_{в.с}/\varepsilon_{общ.}) \cdot 100\% = 50\%$. In addition, at 870^0C another characteristic effect was revealed - the development of grain fragmentation in Fig. 4.c.

a) x1000



b) x1000

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 5 , May 2020

c) x500
Fig. 4. The deformation relief arising at a temperature of 870^0 C.
(ЗГП - grain boundary slippage. BC - intragranular slip)

IV. METHODOLOGY

On the methodology for assessing the contribution of intragranular dislocation slip. The extension axis is horizontal, ἐ = 10% at 870°C in vacuum.

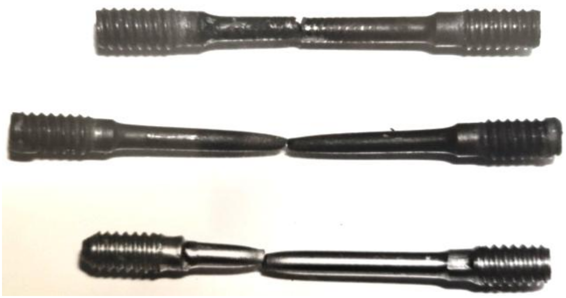


Fig.5. Type of samples of the state of delivery after stretching at different temperatures.
a) 20 ° C, b) 700 ° C, c) 910 ° C.

A different deformation relief is observed at a deformation temperature of 910°C (Fig. 5.a). Under these conditions, slippage increases sharply, a characteristic relief in the microcrack and the development of transcrystalline fracture are observed within individual grains, and their development, apparently, leads to the destruction and decrease in the ductility of technical iron (Fig. 5.b).

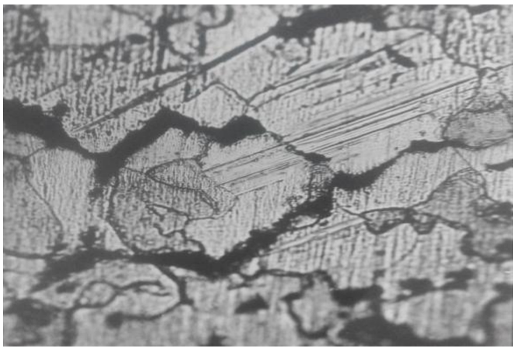


Fig. 5.a. Deformation relief at temperatures of 910^{0}C.

The deformation is localized in the border regions, which leads to the formation of microcracks and a decrease in the ductility of iron (Fig. 5.b).

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 7, Issue 5 , May 2020

Fig.5.b. The deformation relief at a temperature of 910^{0}C detected in vacuum by the method oxidation of metallographic thin section. x1500

V. EXPERIMENTAL RESULTS

The deformation relief at 940^{0}C is complicated due to changes in microstructures during reverse phase transformation. The obtained results allow us to make assumptions about the reason for the sharp drop in the ductility of technical iron near the phase transition point. The formation of plates during deformation is probably associated with the shear nature of the $\alpha \rightarrow \gamma$ transformation (3.8)

FINDINGS. A nonmonotonic dependence of the ductility of technical pure iron on the strain temperature is established. In the region of the $\alpha \rightarrow \gamma$ phase transition, a sharp drop in plasticity is observed, apparently due to the shear nature of the $\alpha \rightarrow \gamma$ transformation. This is an obstacle to the movement of the dislocation and leads to transcristalide destruction.

REFERENCES

1. Gulyaev A.P. Superplasticity of steel. M.: Metallurgy, 1982 56 p. forces.
2. Superplasticity of metallic materials. M., "Science." 1973.220 s. forces. Auth: M.Kh. Sharmarov, A.S. Tikhanov, S.I. Damask steel and others
3. Novikov I.I., Tailor V.K. Superplasticity of ultrafine grain floats. M. Metallurgy. 1981. 167 p.
4. Volynova T.F., Gulyaev A.P. - M and TOM. 1981. No. 3. with. 24 - 27.
5. Pribylov B.P., Katsev P.P., Eskin V.L. The methodology for assessing the ductility of high-speed tool steels. - Technology of mechanical engineering. 1967. No. 11-12. S.26-31.
6. Kaybyshev O.A. Plasticity and superplasticity of metals - M: Metallurgy. 1975.280 s.
7. Vasilieva A.G., Pogodin - Alexeyev G.I. Anomalies of strength and ductility and ductility in the intercritical interval. M and TOM. 1982. No. 1. with. 23 - 29.
8. Nugmanov I.N., Boboev Kh.Kh., Toshtemirov K.Q., THE EFFECT OF SUPERPLASTIC DEFORMATION ON THE OPERATIONAL PROPORTIES OF STEELS// Universum: Texnicheskiye nauki: electron.nauchn.jurn. 2020. № 3(72). URL: *http://7universum.com/ru/tech/archive/item/9153*

AUTHOR'S BIOGRAPHY

№	Full name place of work, position, academic degree and rank	Photo
1	Candidate of Technical Sciences, Almalyk branch of Tashkent State TechnicalUniversity named after Islom Karimov.Uzbekistan, Tashkent region, Almalyk;	

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 7, Issue 5 , May 2020

2	Senior Lecturer, Almalyk branch of Tashkent State Technical University named after Islom Karimov, Uzbekistan, Tashkent region, Almalyk;	
3	Assistant, Almalyk branch of Tashkent State Technical University named after IslomKarimov,Uzbekistan, Tashkent region, Almalyk;