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# **Effect of Plastic Deformation on the Magnetic Parameters and Magnetostriction of the 20GN Steel**

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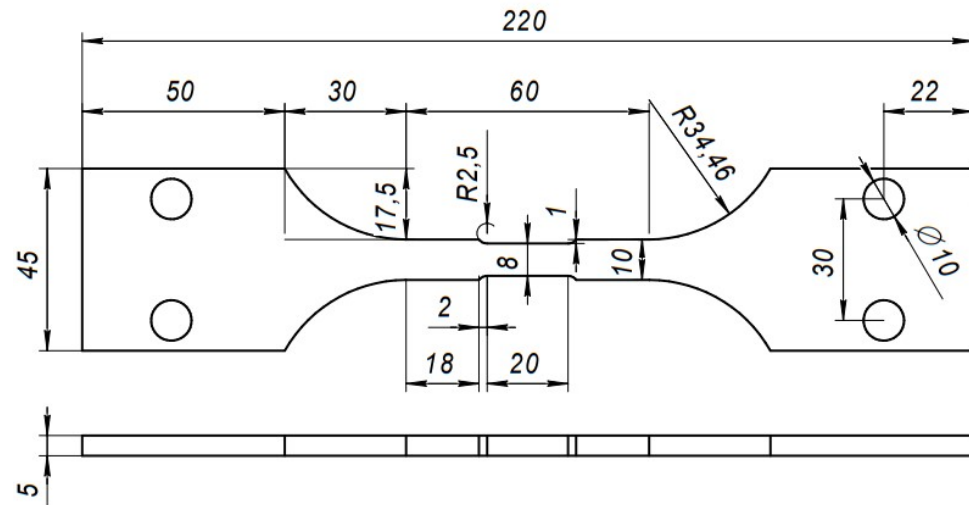
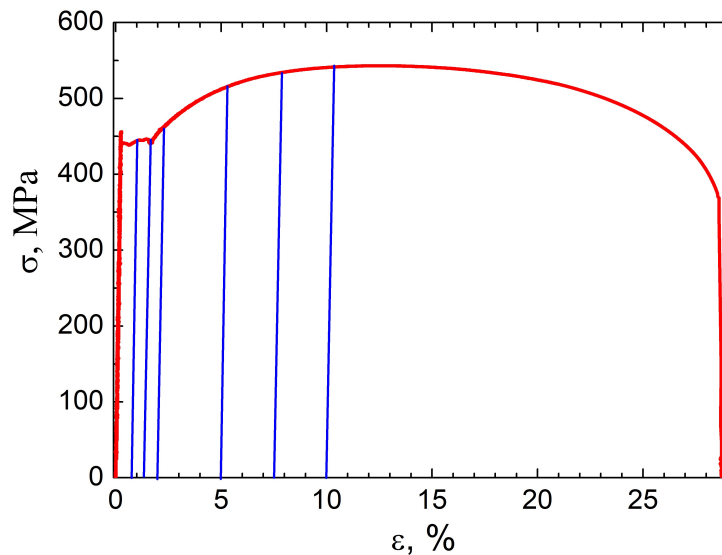
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## MATERIALS AND RESEARCH METHODS

Dog-bone-shaped flat specimens were cut out from the 20GN hull steel. Additional heat treatment of the specimens was not performed.

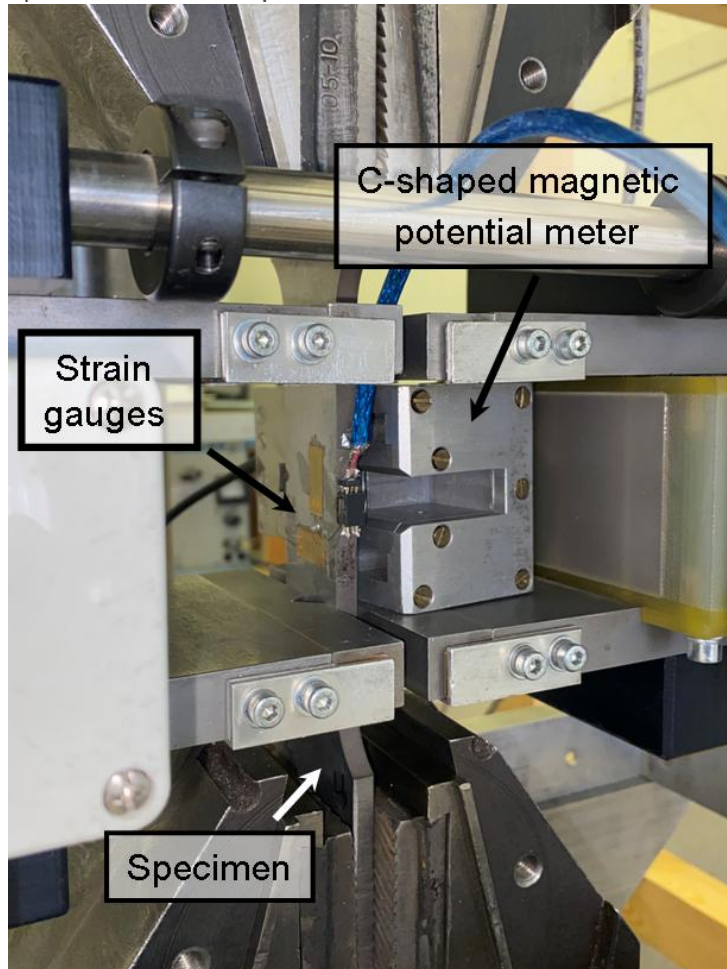
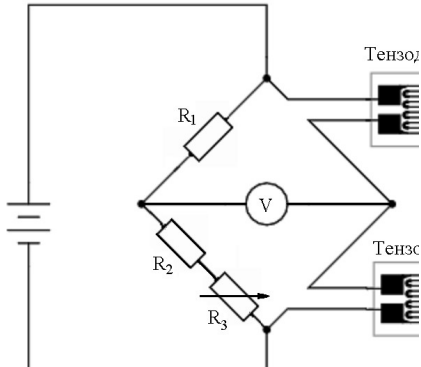
The chemical composition of the 20GN hull steel, wt%

C	Si	Mn	Ni	Nb	Mo	Cu
0.194	0.283	1.155	0.823	0.096	0.050	0.049



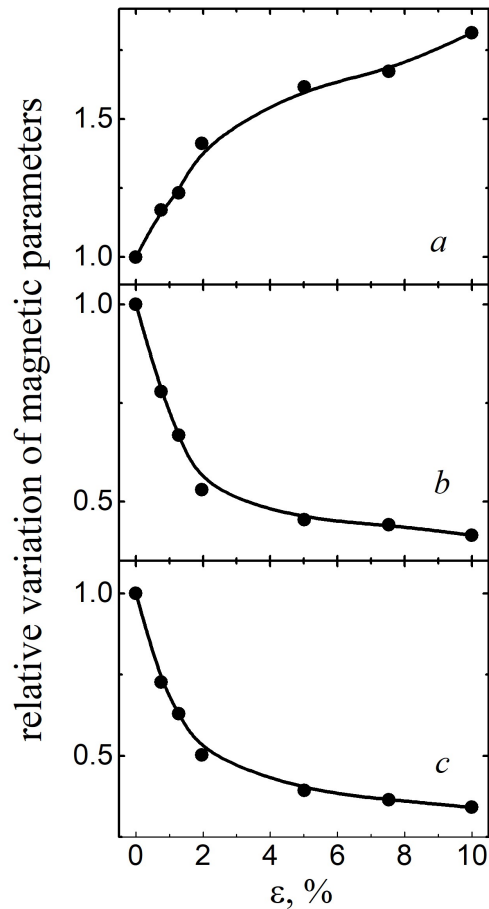
Preliminary mechanical testing performed in a Tinius Olsen Super L60 universal testing machine has shown that, for the material under study, offset yield strength is 440 MPa (yield drop is 450 MPa), tensile strength is 550 MPa, percentage permanent elongation after rupture is 25%.

## MATERIALS AND RESEARCH METHODS

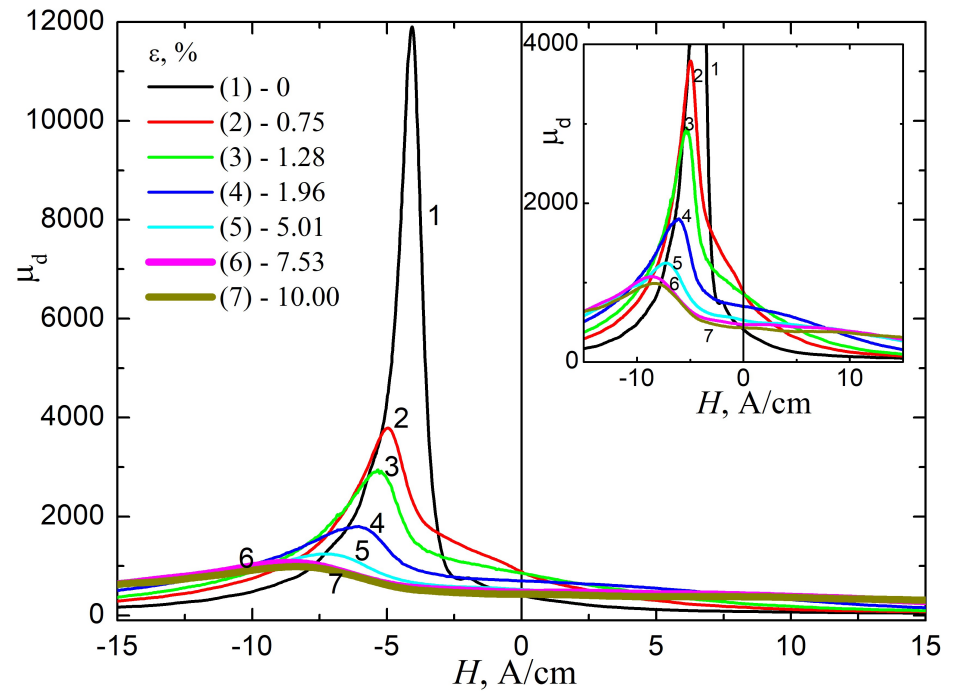


The magnetic characteristics were measured in a closed magnetic circuit along the loading axis by means of a Remagraph C-500 hysteresisgraph. The strength of the internal magnetic field  $H$  measured by a C-shaped magnetic potential meter reached 500 A/cm. The coercive force and residual magnetic induction were determined from the magnetic hysteresis loops. Maximum magnetic permeability  $\mu_{\max}$  was found from the basic magnetization curve. The measurement error for the field and induction did not exceed 3%. Longitudinal magnetostriction was measured by means of BF350-3AA foil strain gauges with a nominal resistance of 350  $\Omega$  and a base of 3 mm, connected according to the Wheatstone bridge circuit. The bridge was fed by stabilized direct current. Magnetization reversal and the measurement of the internal field for recording the field dependencies of magnetostriction were performed by Remagraph C-500 device.

## RESULTS

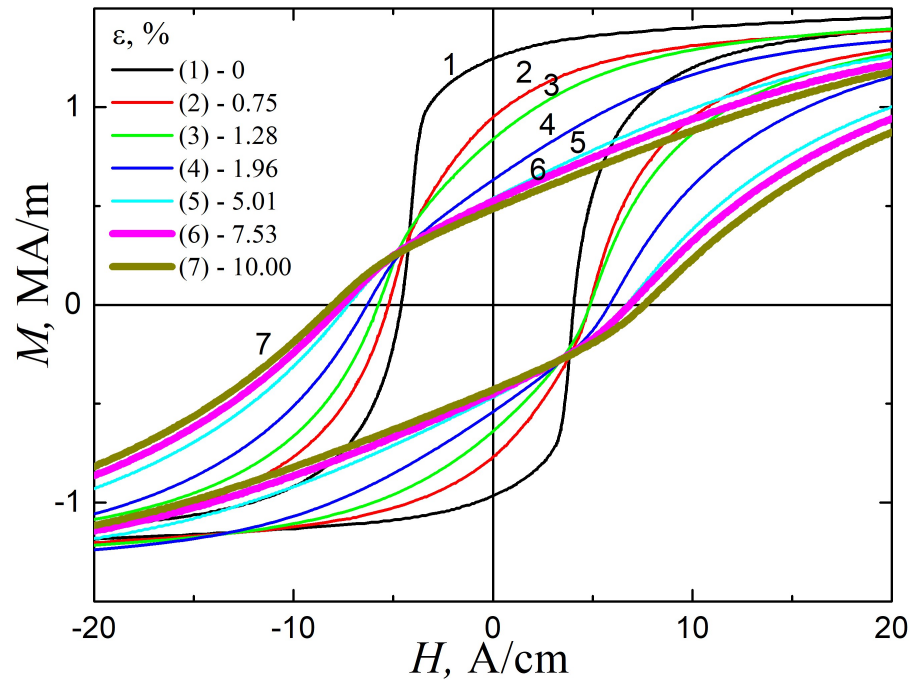


Relative variation of magnetic parameters (coercive force (*a*), residual induction (*b*), and maximum magnetic permeability (*c*)), measured in a closed magnetic circuit, as dependent on the value of plastic strain  $\varepsilon$

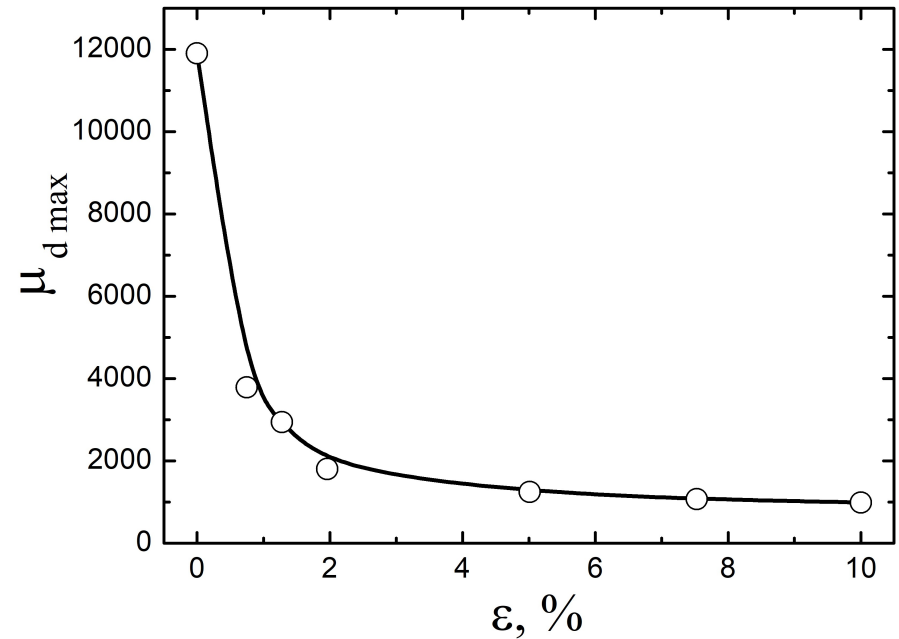


The field dependence of differential magnetic permeability  $\mu_d(H)$  for the specimens plastically deformed to different values of plastic strain  $\varepsilon$ : 0 (curve 1), 0.75 (2), 1.28 (3), 1.96 (4), 5.01 (5), 7.53 (6), and 10% (7)

## RESULTS

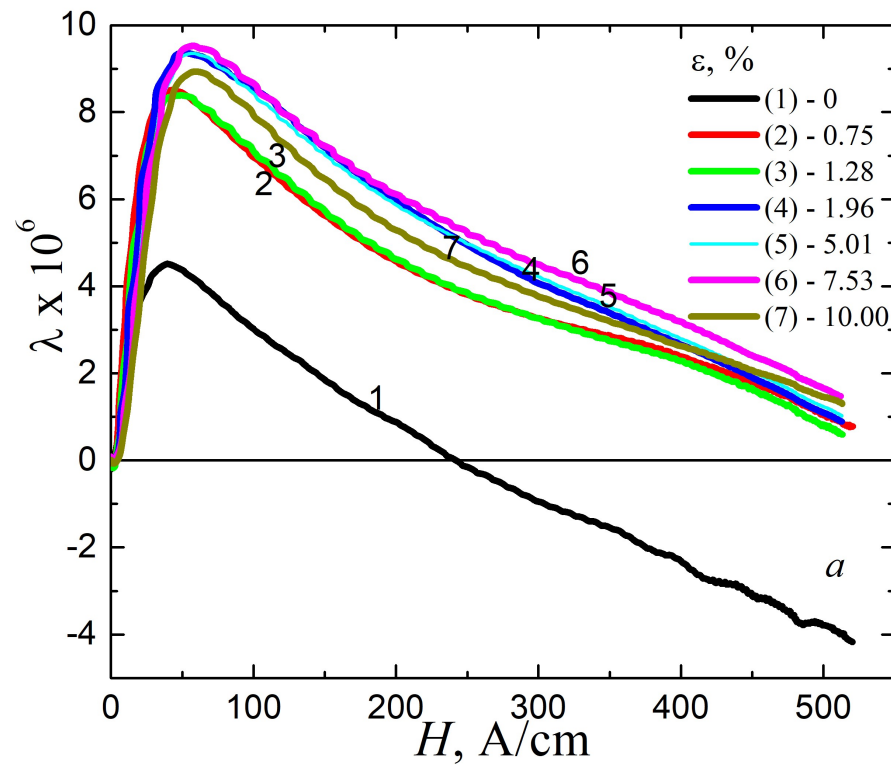


Major magnetic hysteresis loops for the specimens plastically deformed to different values of plastic strain  $\varepsilon$ : 0 (curve 1), 0.75 (2), 1.28 (3), 1.96 (4), 5.01 (5), 7.53 (6), and 10% (7)

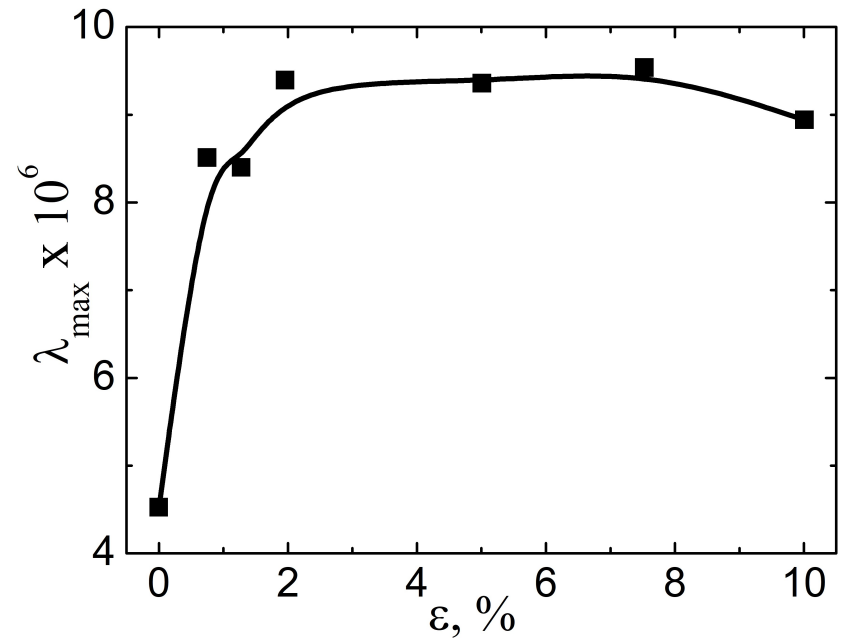


Plastic strain dependences of the value of the peak of the differential magnetic permeability in negative fields

## RESULTS



Field dependences of magnetostriction for the specimens plastically deformed to different plastic strain values  $\epsilon$ : 0 (curve 1), 0.75 (2), 1.28 (3), 1.96 (4), 5.01 (5), 7.53 (6), 10 % (7)



Magnetostriction maximum for the specimens plastically deformed to different plastic strain values

## **CONCLUSION**

The regularities of all the investigated magnetic characteristics of the 20GN hull steel plastically deformed by tension to various levels, confirm the appearance of the “easy magnetization plane” texture in the specimens. This is due to the presence of residual compressive stresses of various levels in the direction of the action of plastic deformation in the specimens.

It has been shown experimentally that the main features of the dependences of the magnetic parameters on the level of plastic deformation, as well as the regions of plastic deformation in which these features manifest themselves, are the same for all the studied magnetic parameters. The magnetic parameters change abruptly and significantly until the strain reaches about 2% and then less abruptly or only slightly until the strain values reach 7.5–10%.

The coercive force measured in the direction of tension has the greatest sensitivity to the value of strain, and it monotonically changes in the entire range of plastic strain.

## **ACKNOWLEDGMENTS**

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