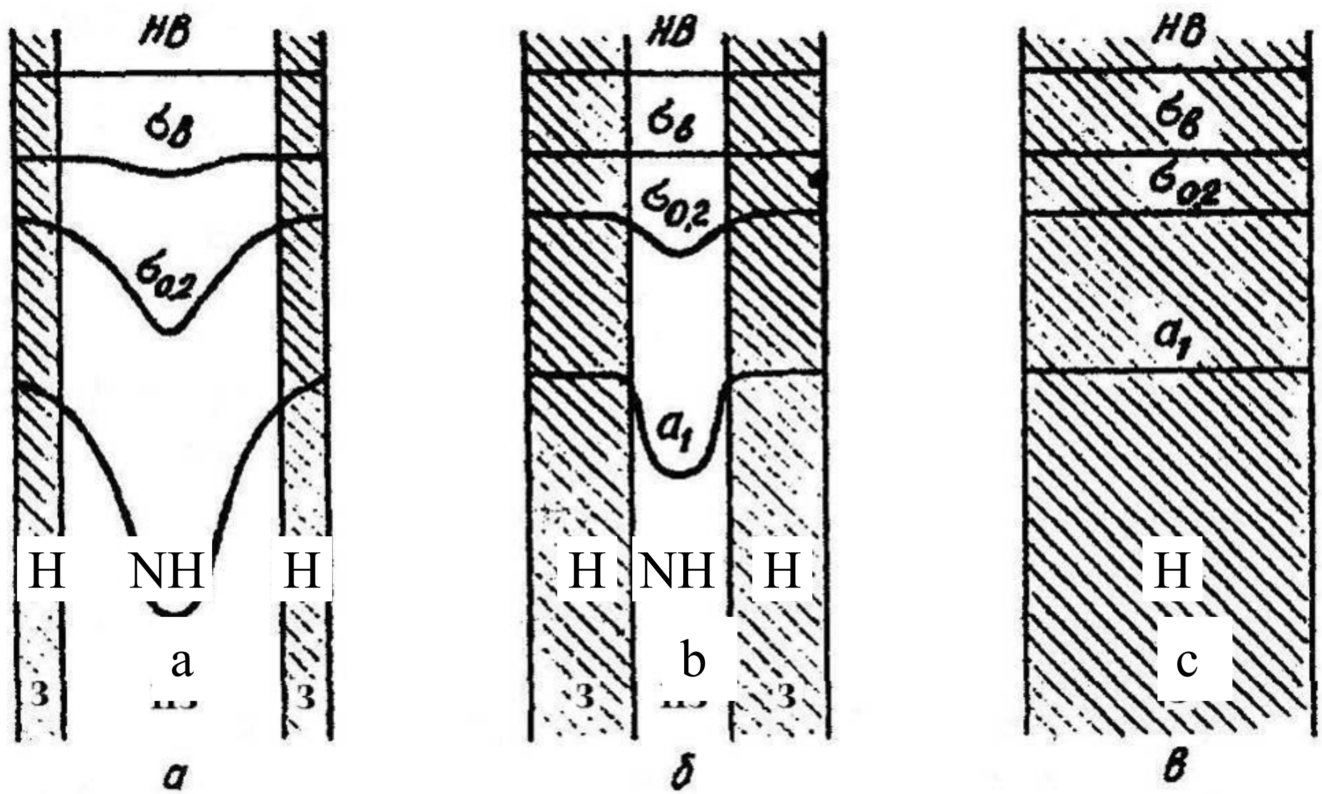
8 laboratory work.
Steel hardenability capacity and hardenability

Hardenability capacity *(загартованість)* ***is*** the steel ability to take maximum hardness after of the quenching.

Hardenability is the depth of hardened zone.



The steel mechanical properties dependence of hardenability: a, b – non full hardenability; c - full hardenability. H - hardened layer; NH - not hardened layer.

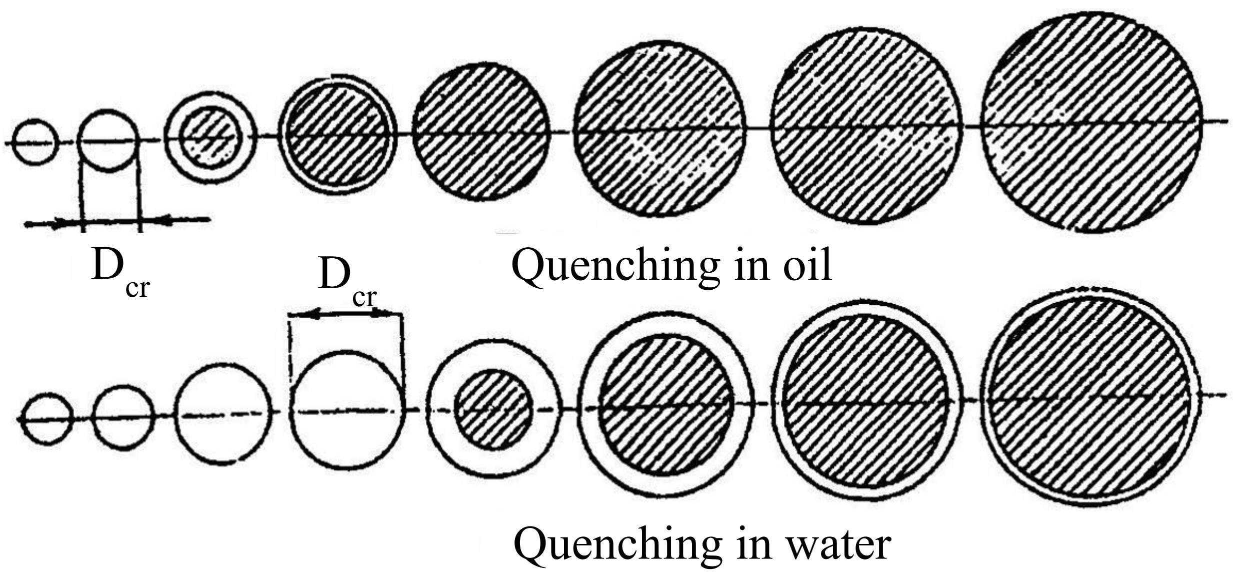
Steel hardenability

The part has not full hardenability, when the part cooling rate (V_c) is less than the critical (V_{cr}) for steel, which manufactured the product (slide 16 a, b). The hardened zone depth increases with decreasing V_{cr} the material (slide 16 a, b). Part has full hardenability and martensitic structure at $V_c > V_{cr}$ (slide 16 c). If the part section has great [greɪt-великі] sizes and it is impossible to reach critical cooling rate even [‘iv(ə)n-навіть] on the surface, such a part does not quenched.

Parts working in conditions of high pressure and large dynamic loads are made of steels with high hardenability. In the case of incomplete hardenability mechanical properties differs significantly in external and internal layers of parts (slide 16 a, b)., It is which reduces The reliability operation [rɪlaɪə'bɪlətɪ ɔp(ə)'reɪʃ(ə)n-надійність експлуатації] decreases in the case. For steels with a through prohartovuvanistyu mechanical properties are practically identical (slide 16 c).

Steel hardenability

Hardenability criteria [kraɪ'tɪərɪə] is critical diameter (D_{cr}) and the semi martensitic (50% martensite and 50% troostite) zone length. Critical diameter (D_{cr}) is the maximum diameter of the cylindrical sample that has full hardenability in the cooling environment [ɪn'vaɪər(ə)nmənt].



Hardenability of different diameter samples at cooling in water and oil: Shaded [ˊʃeɪdɪd-заштрихована] area – non quenching.

The ideal critical diameter (D^{∞}) corresponds [kɔrɪ'spɔnd-відповідає] to the maximum part cross section that has full hardenability in ideal cooling environment with infinitely ['ɪnfɪnətlɪ-безкінечно] high (великою) of cooling rate.

Steel hardenability

At the transition [træn'zɪʃ(ə)n-перехід] of the semi (напів) martensitic (50% martensite and 50% troostite) to the martensitic structure (100% martensite) critical diameter (D_{cr}) decreases. Critical diameter (D_{cr}) decreases at replacement [rɪ'pleɪsmənt-зміна] of a cooling environment [ɪn'vaɪər(ə)nmənt-середовище], for example of water to mineral oil (slide 18).

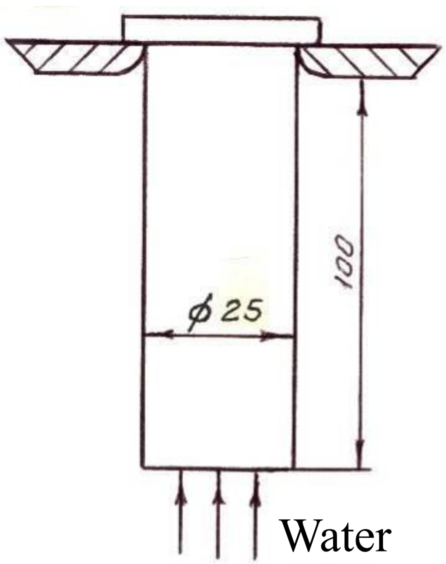
If necessary mechanical properties are provided by semi (напів) martensitic structure, for example structural steels, D_{cr} defined as D_{50}.

Structural steel hardenability is determined as the layer thickness that has semi martensitic structure. Semi martensitic structure hardness depends of the carbon concentration in steel and is determined by tables or graphs draw [drɔ-побудованими] in the coordinates of the "Carbon concentration, % - Hardness of semi martensitic zone, HRC".

Tool steel hardenability is determined by the thickness of the hardened layer with martensitic structure. Hardness is HRC 60.

Determination [dɪtɜmɪ'neɪʃ(ə)n-визначення] **of the steel hardenability**

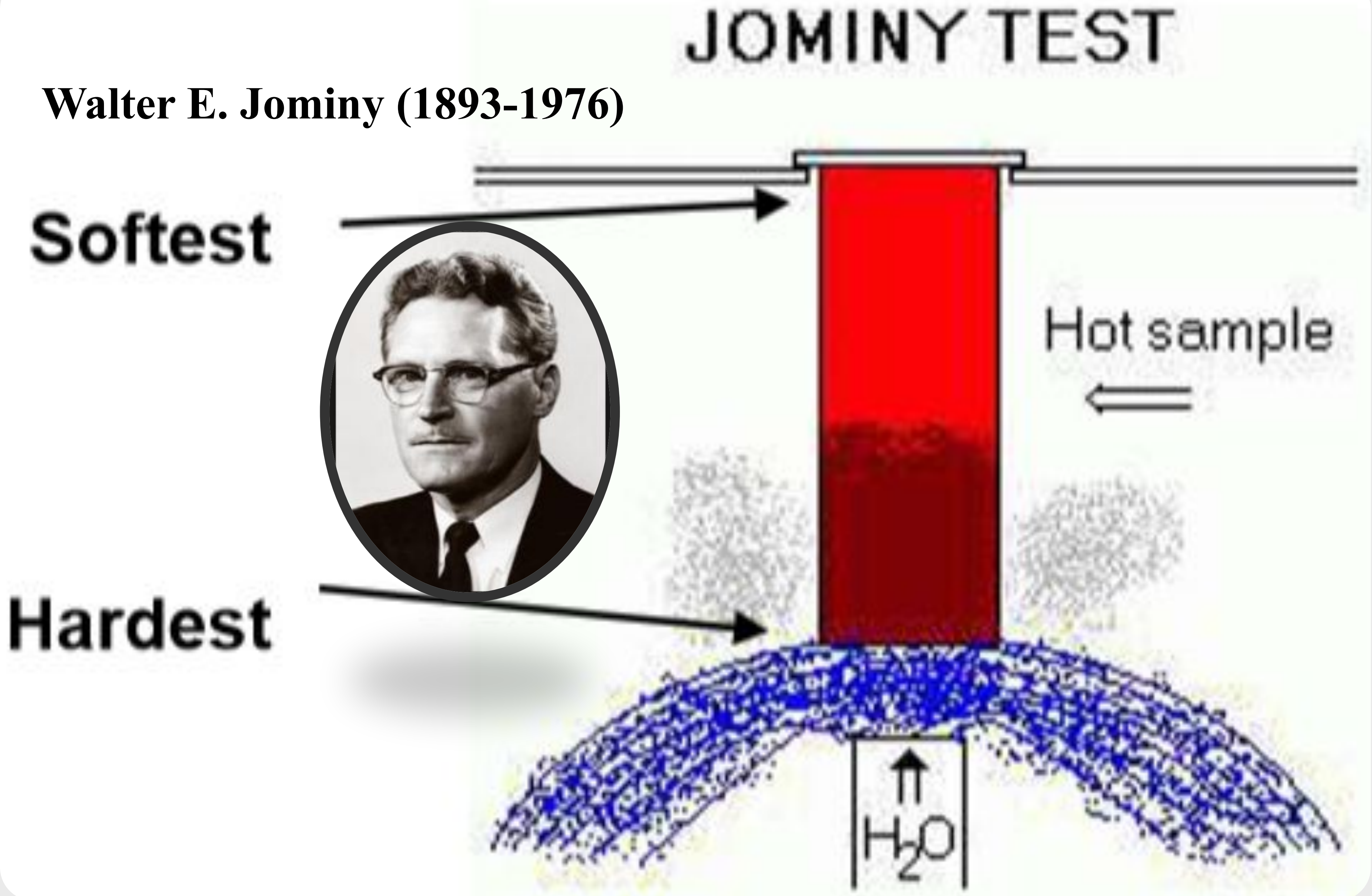
Steel hardenability is determined [dɪ'tɜ mɪnd] by the hardness changing after end (face) quenching. The normalized samples are heated in furnace up to of 820 to 900 °C (temperature depends of the carbon content in steel). Sample holding time is a 30 minutes ['mɪnɪts]. Sample quenching carried out in the installation located from furnace at a distance then (таким чином) that the time of sample transfer from furnace to the cooling does not exceed 5 s.



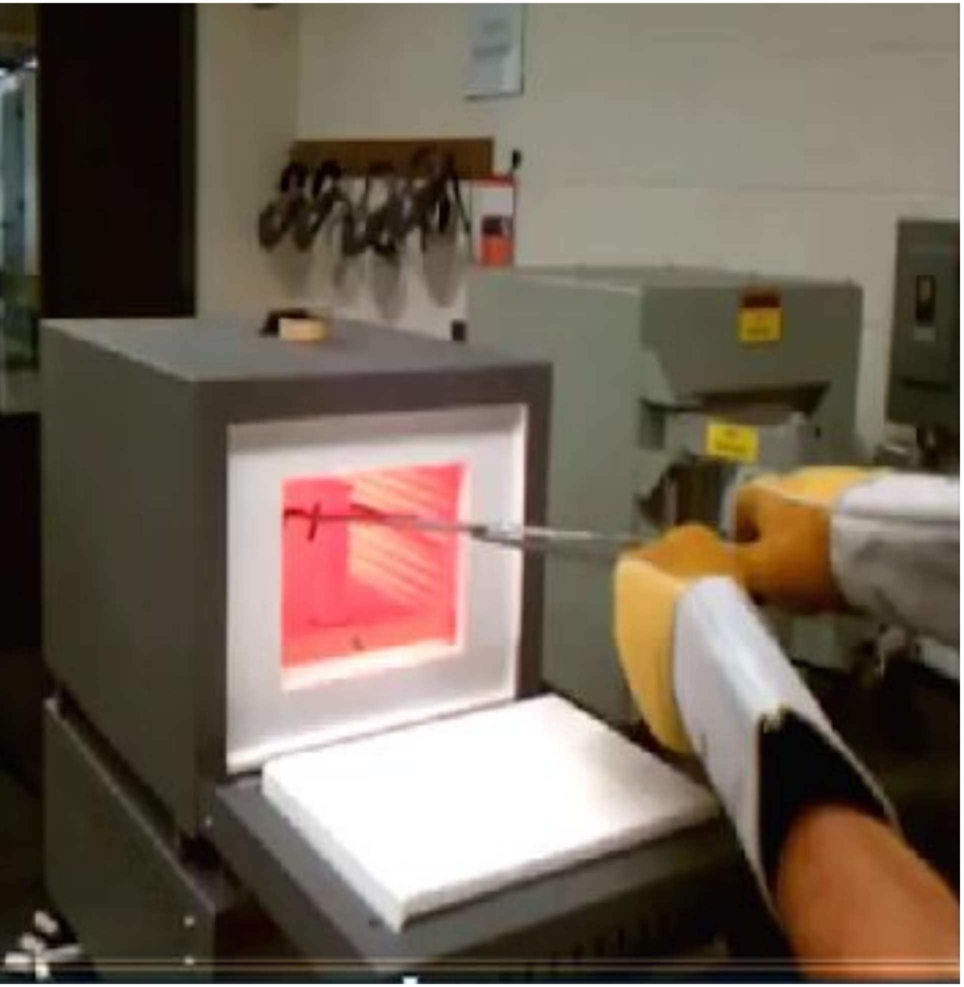
Sample and scheme [skim-схема] of end (face) quenching

The sample end is cooled by water jet after setting of heated sample in the device. Sample end has quenching and opposite end - normalization. When whole [həul-весь] sample is cooled up to room temperature, the sample both sides are polished on the length of 100 mm, depth of 0.5 mm and two parallel planes are formed. The hardness is measured of quenched to normalized of the ends.

Walter E. Jominy (1893-1976)



Jominy End-Quench Test Video



Jominy End-Quench Test Video

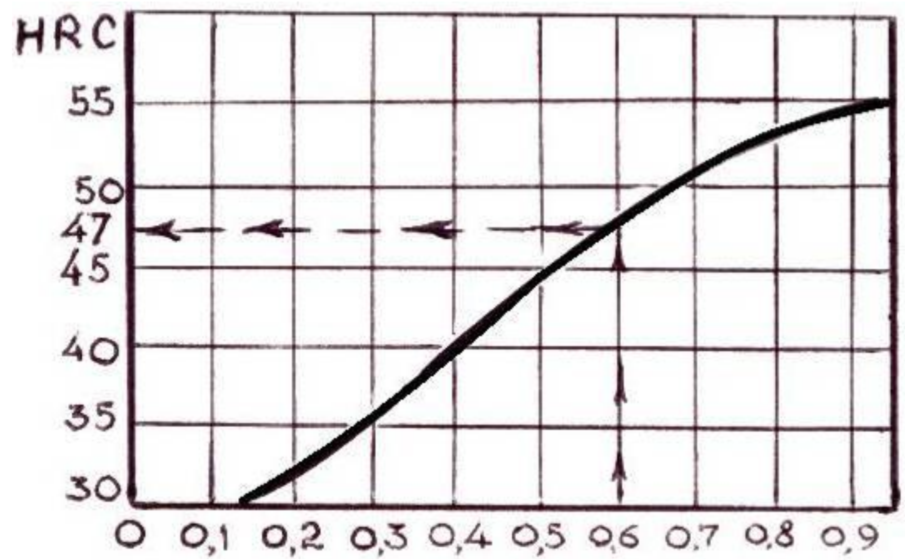



Determination of the steel hardenability

Hardenability indicator is the zone length of quenching sample end to place with hardness of semi martensite structure.

The hardness of semi martensitic zone depends of carbon concentration in steel and it is determined [dɪ'tɜmɪnd] by tables or graphs in coordinates [kəu‘ɔdɪnəts] "The carbon concentration in steel, % - Hardness semi martensite structure, HRC (see fig.).

For example, fig. shows that the hardness of the semi martensite structure of the carbon steel with 0.6% C is equal to 47 HRC.

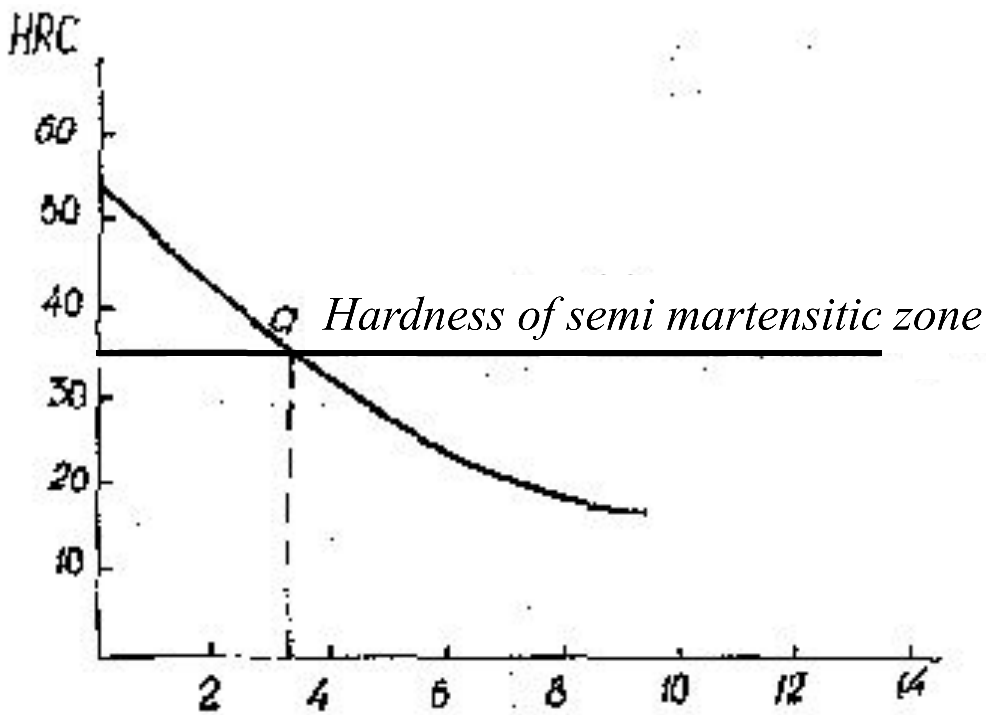


The carbon concentration, %

Carbon influence to hardness (HRC) of semi martensite structure of carbon steel

Determination of the steel hardenability

Hardenability steel curve draws in the coordinates [kəuʻɔdınəts] "Distance of quenching sample end, mm - Hardness, HRC". The semi martensitic zone [zəun] hardness is defined and ploted on graph [grɑːf].



Distance of quenching sample end, mm

Hardenability curve and hardness of semi martensitic zone [zəun]

For example, fig. (slide 21) shows that the hardness of the semi martensite structure of the carbon steel with 0,3% C is equal to 35 HRC. Hardenability steel with 0,3% C is equal 3,5 mm (see figure ['fıgə]).

Nomograms are existed for determination of the cooling rate and hardenability of parts by simple geometric shapes (cylinder ['sılındə], sphere [sfıə], square [skweə], parallelepiped [ˌpærəle'lepıped]).

Steel hardenability nomogram [nɒməgram]