D.In. Shkarivskyy // Interdepartmental thematic scientific journals "mechanization and electrification of agriculture." - Glevaha NSC "IMESH." - Vol. 88. - 2004.- P. 70-77.

AndResults analysis zlozhenы development yntehralnoy structurally komponovochnoy scheme эnerhosredstv selskoho-zyaystvennoho purpose.

Mobylnoe эnerhetycheskoe funds, layout, layout yntehralnoya, constructions, development.

The results of analysis of development of integrated design-layout scheme of power unit for agricultural purposes.

Mobile power, tool arrangement, integralnoya layout, design and development.

UDK 630.56.7

CriterionHer EVALUATION warping PARTS DURING HEAT TREATMENT

OE Semenov, Ph.D.

InstallationFor whatever reason warping of parts during heat treatment. Criteria of evaluation of this magnitude.

Steel, doping, cementation, technology, warping, internal pressure.

Resolutionska problem. Suchasleep makes equipment to construction materials increasingly high requirements for mechanical properties and serial and mass engineering with regard to their adaptability. Skladnoprofilnist modern details gears requires inclusion in the process of manufacturing operations forming, machining, welding, surface hardening, finishing honing operations. This places the material increasingly high technological requirements shtampuvalnosti, machinability, weldability, prohartovuvannosti, tsementuyemosti, warping during hardening.

AnaLease Finalnnih dossurvey findings. In the EQUIPMENTsti thismentuvalnyh selection of steel compositions with optimal physical-mechanical and technological capabilities complicated

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lack of information about the impact of their structure on these properties. In addition, the data are inconsistent and are mainly qualitative in nature. Once enough data vzamozv'yazky between different properties cementing steels can not predict these properties, significantly increasing the amount of their choice or design.

We were tasked with not only the quality but also the quantitative evaluation of such technological properties as steels tendency to warping during thermochemical treatment in order to enter
there isDean characteristics that determine susceptibility to deformation of steel during quenching.

SelIP grade of steel is determined not only by the operating conditions and technological capabilities of the equipment. In [1-3] performed a comprehensive analysis of used stamps
heavy duty steel gears. Analyzing the data of this work, it can be concluded that the choice of material pretty
extent determines the application of appropriate technology to strengthen. The most promising technology to strengthen gears should be considered as chemical and heat treatment.

Metand research. The main objective of our work was
establishing a single quantitative assessment criteria susceptibility to warping steel during heat treatment.

Rezultaty dperssurvey findings. Change geometrychnyx parameters
parts occurring in the thermochemical treatment is critical to economic performance production. Removing warping require additional finishing operations, such as restoring basic holes, sanding and finishing work ends profiles. In addition, poor machinability cutting materials with high hardness, imposes the need to protect the operations of carbon saturation during grouting surfaces of parts that are processed after thermochemical treatment. To do this, usually used electrolytic copper plating processes or application of protective antytsementatsiynyh pastes. These operations are labor-intensive, cost-savings and require expensive and scarce materials.

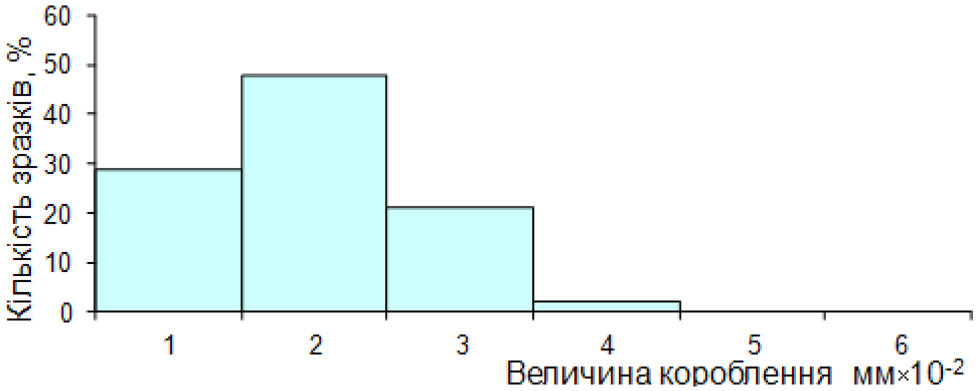
Actness issues warping of parts subject to surface hardening, especially acute in connection with
uat significantly increased requirements metaloyemkosti and precision manufacturing gears [4, 5]. It is well known that the main cause warping in chemical and heat treatment is hardening.

Ojolodzhennya during hardening leads to the appearance of a temperature gradient in the cross section details the value of which determined by the temperature of heating, the size and shape details

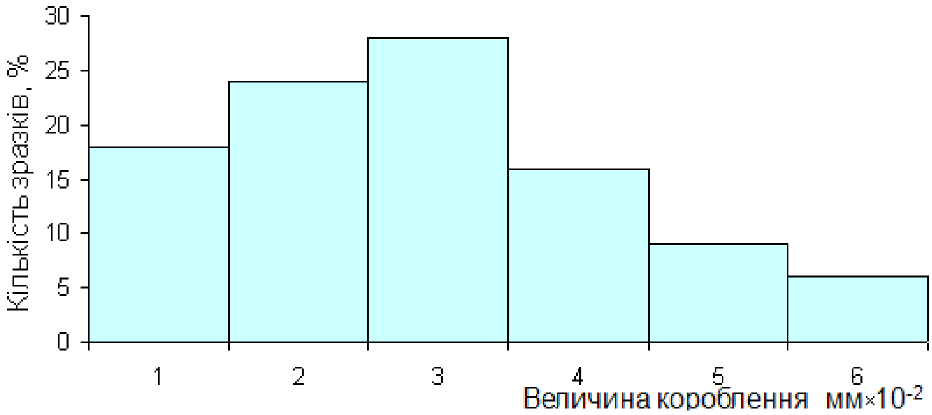
Healoprovidnistyu steel quenching medium cooling capacity, its circulation [6].

Neodnochasnist temperature change in the depth of the materials during cooling, along with the flow neodnochasnistyu phaseing transformations involving changes in specific volume, gives rise to tensions. The stresses arising from thermal deformation simultaneously, are called thermal or thermal.

Since our work was the task of not only quality but also forilkisnoyi evaluation of such technological characteristics as the propensity of steel to warping during thermochemical treatment, then based on the analysis of comparative studies magnitude warping of parts of various steels, results are presented as histograms in Fig. 1, proposed the introduction of a single characteristic that determines susceptibility to deformation of steel during quenching. It is a factor that is determined from the ratio between the number of parts that fit the permissible value warping, according to the technical data, the number of parts - that do not fit in the technical documentation permissible deviation (defective parts).



*and)*steel 15HHNBTCH



*to)*steel 12HN3A

Ric. 1. Histograms of size parts warping during quenching.

TacoS quantitative characteristic in this case the Riemann - the content limits Darboux sums (as curvilinear trapezoid area). With the indicator variable belonging to the set, defined for any set. But also a variable "x"

next orNom $\chi_A(x) = \begin{cases} 1, & x \in A \\ 0, & x \notin A \end{cases}$, it is possible ondates withtceinchastyy

graph of the function $\Im(x)$ in youSee:

$$\Im(x) = \sum_{i=1}^{m} \left(n_i \chi_{(Ai;\, ai_{+1})}(s) \right).$$

Let n_j - from-identification functionsth to Categoriesapivzakrytomu othersThervayLee $(a_{j,}\, a_{j+1}]$. Charactersjoints, introduced then written as:

$$\Re(x) = \Re(\Im(x)) = \frac{\int_{b}^{x} \left(\sum_{i=1}^{m} \left(n_i \chi_{(and\ i;\, ai_{+1})}(S) \right) ds \right)}{\int_{and}^{x} \left(\sum_{i=1}^{m} \left(n_i \chi_{(and\ i;\, ai_{+1})}(s) \right) ds \right)} = \frac{\sum_{i=j+1}^{m} \left(n_i \Delta a_{i\ i+1} + \frac{n_j (and_{j+1} - x)}{m - j} \right)_{j: x \in (a_j,\, a_{j+1}]}}{\sum_{i=1}^{j-1} \left(n_i \Delta and_{i\ i+1} + \frac{n_j (x - and_j)}{m - j} \right)_{j: x \in (a_j,\, a_{j+1}]}}$$

where: $\chi_{And}(x) = \begin{cases} 1, & x \in And \\ 0, & x \notin And \end{cases}$ – funktsiya-LED belonging to the variable x A plurality;

n_j - from-identification functionsth Categoriesand Categoriesapivzakrytomu otherstershaft $(a_{j,}\, a_{j+1}]$ a

$\Im(X) = \sum_{i=1}^{m} \left(n_i \chi_{(and_i;\, {}_{i+1})}(S) \right)$ – functionalonal bydependence, uabout responsible eastidchastomu earlILA, different personadovanomu by eksperymentalnymy data.

DFor example, conduct a calculation factor for susceptibility to deformation of steels and 12HN3A 15HHNBTCH.

DA steel 12HN3A calculation is:

$$\Re(x) = \begin{cases} \dfrac{101 - 18x}{18x}, x \in (01] \\ \dfrac{107 - 24x}{24x - 6}, x \in (12] \\ \dfrac{115 - 28x}{28x - 14}, x \in (23] \\ \dfrac{79 - 16x}{16x + 22}, x \in (34] \\ \dfrac{51 - 9x}{9x + 50}, x \in (45] \\ \dfrac{36 - 6x}{6x + 65}, x \in (56] \end{cases}$$

$$
x=\begin{cases}
\dfrac{101}{18(R_0+1)}, & x\in(0,1] \\
\dfrac{107+6R_0}{24(R_0+1)}, & x\in(1,2] \\
\dfrac{115+14R_0}{28(R_0+1)}, & x\in(2,3] \\
\dfrac{79-22R_0}{16(R_0+1)}, & x\in(3,4] \\
\dfrac{51-50R_0}{9(R_0+1)}, & x\in(4,5] \\
\dfrac{36-65R_0}{6(R_0+1)}, & x\in(5,6]
\end{cases}
$$

$$
\mathbf{R_0 = 0.03 \Rightarrow x \geq 5.5097}
$$

DA steel 15HHNBTCH calculation is:

$$
\Re(x)=\begin{cases}
\dfrac{29(1-x)+61}{29x}, & x\in(0,1] \\
\dfrac{48(2-x)+23}{48(x-1)+29}, & x\in(1,2] \\
\dfrac{21(3-x)+2}{21(x-2)+77}, & x\in(2,3] \\
\dfrac{2(4-x)}{2(x-3)+98}, & x\in(3,4]
\end{cases},
$$

$$
x=\begin{cases}
\dfrac{90}{29(R_0+1)}, & x\in(0,1] \\
\dfrac{119+19R_0}{48(R_0+1)}, & x\in(1,2] \\
\dfrac{65-35R_0}{28(R_0+1)}, & x\in(2,3] \\
\dfrac{1-23R_0}{2(R_0+1)}, & x\in(3,4]
\end{cases}.
$$

$$
\mathbf{R_0 = 0.03 \Rightarrow x \geq 2{,}956}
$$

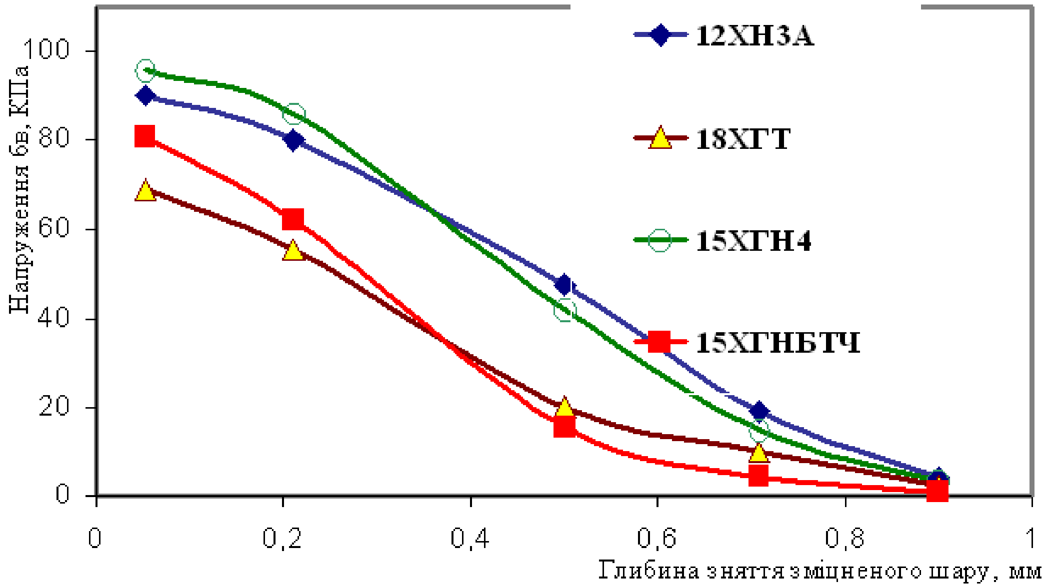
In our particular case, the allowable percentage of quantitative characteristics and defective parts within nebrakovanyh - 3% 15HHNBTCH steel, with low susceptibility to warping, provide the value of tolerance - 0.029 mm and steel 12HN3A - 0,055 mm. And in the case when the serial steel provide the same tolerances as designed, the number of defective parts will be 30%.

Stillof the proposed factor in our work makes it possible to quantify

the susceptibility to warping and steel
will providethere is a choice of the chemical composition of the steel according to

the required size tolerances and technological possibilities of production. Determination of this ratio is quite time-consuming process. To simplify the exploration work on the study of the properties held its comparison with other technological properties of steel. In terms of causes warping of parts during quenching closest characteristic that has a correlation coefficient of deformation is the value of tension in the consolidated layer.

Bulland considered depending distribution of residual internal stresses (Fig. 2) for steels with varying degrees of doping. The nature of the curve suggests that,
uof complex-alloy steel has a sharp reduction in stress, as the distance from the surface, compared to the serial 12HNZA steel.



Ric. 2. The distribution of residual internal stresses in a reinforced layer.

Basedand physical meaning of this size, one could argue that the relationship of the considered feature is the sum of all the stress around the surface layer. It can be represented as a Riemann integral.

DA steel 12HN3A:

$$\mathbf{I}_{\substack{12H2H \\ H}} = \int_{01}^{09} \left(-953{,}12h^4 + 2343{,}8h^3 - 1910{,}3h^2 + 456.06x + 57.948\right) \cdot dx = 37{,}0398.$$

DA steel 15HHNBTCH:

$$\mathbf{I}_{\substack{15H5HHN \\ B}} = \int_{01}^{09} \left(263.02h^4 - 527.08h^3 + 479.32h^2 - 314.73x + 107.08\right) \cdot dx = 20{,}7075.$$

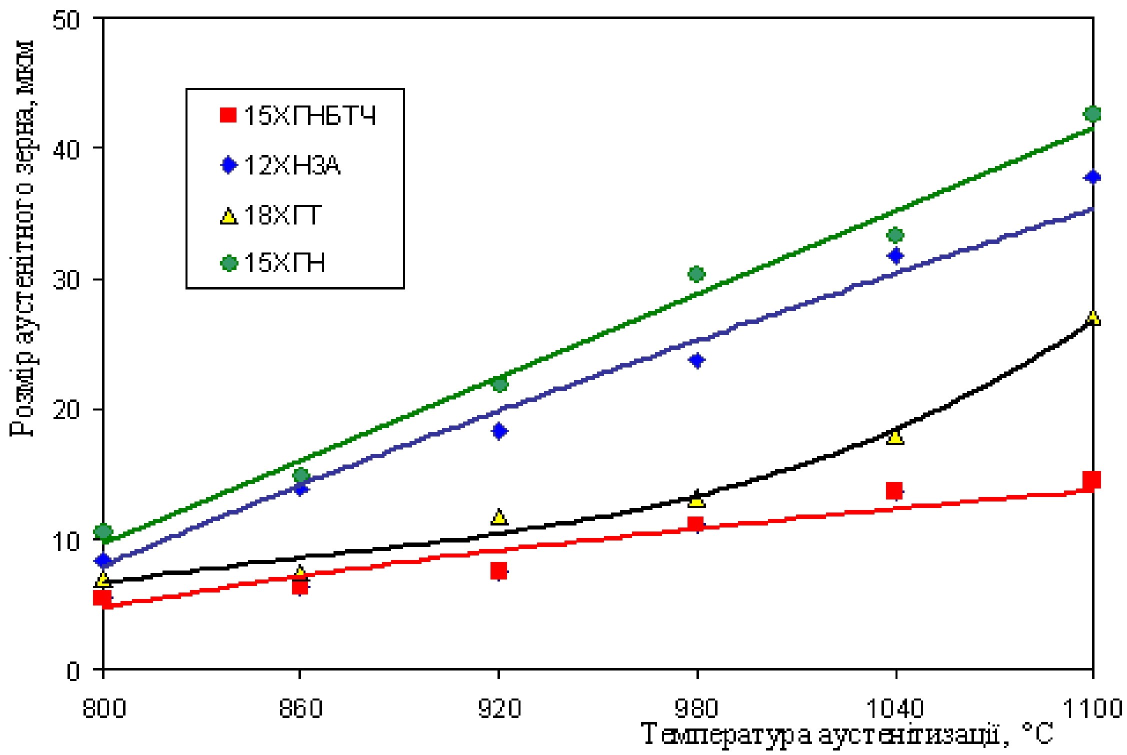
DA steel 18XGT:

$$I_{18HH\,T} = \int_{01}^{09} \left(-3208{,}3h^4 + 6672{,}9h^3 - 4562{,}3h^2 + 1046.8x - 2.2063\right) \cdot dx = 25.305.$$

DA steel 15HHN:

$$I_{15HH\,H} = \int_{01}^{09} \left(1296{,}9h^4 - 2579{,}2h^3 + 1736{,}6h^2 - 504.21x + 82.005\right) \cdot dx = 15.5048.$$

Computer processing of the total value of all the stress hardened layer showed that serial steel 12HNZA this figure is 1.5 times higher than in developed our steel.



Ric. 2. austenitic grain growth kinetics.

However recommend this characteristic to determine susceptibility to warping steel impractical for two reasons. First, the magnitude of residual internal stresses only indirectly connected with the stresses that cause deformation of the product (sample) during heat treatment, and is not the cause but the consequence. Second, its definition is associated with considerable technical difficulties. At the same time, both qualitative characteristics, it confirms our results in the study habits steels with different compositions alloying elements to warping.

Closest characteristic that has a connection with the deformability factor is the tendency to increase steel
aystenitnoho grain procB CategoriesExpJoanna.
Youwalking with fizychnoho

fromcity propensity to steel austenitic grain growth during heating characterized by speed change function that describes this process. Having examined the image depending on features. 3, after approximation of experimental data using a power trendline type, specify the rate of change of curves approximated as

FSUsid $f(x)'$. XieDdnye significanceof onderivatives *f (x)'* nu to moothersizku *[A, b]*

Sectionidrahuyemo from Basedand pivnosti $\int_a^b [f'(x)]dx = f'_{cp}(\theta)\cdot(b-a)$, where

$\theta \in [a.b]$. Where $f'_{cp}(x) = \frac{\int_a^b [f'(\theta)]dx}{(b-a)}$. Dl l da bouts lidzh uvan yh wi than dLeu

calchovana value of the properties will be: For steel 12HN3A:

$$V_{12XH3And} = \frac{\int_{800}^{1100} \left[\frac{\partial}{\partial x}\left(7.9655x^{0.8324}\right)\right]dx}{1100-800} = 2.10298.$$

DA steel 15HHNBTCH:

$$V_{15HHNBPM} = \frac{\int_{800}^{1100} \left[\frac{\partial}{\partial x}\left(5.16x^{0.53}\right)\right]dx}{1100-800} = 0.109308.$$

DA steel 18XGT:

$$V_{18HCGT} = \frac{\int_{800}^{1100} \left[\frac{\partial}{\partial x}\left(5.68x^{0.72}\right)\right]dx}{1100-800} = 0.6006.$$

DA steel 15HHN:

$$V_{15HCGH} = \frac{\int_{800}^{1100} \left[\frac{\partial}{\partial x}\left(6.3709x+3.36\right)\right]dx}{1100-800} = 6.3709.$$

Aboutvivshy analysis of mathematical calculations technological

characteristics of the investigated steels and comparing it with us entered coefficient characterizing susceptibility to warping steel, we can conclude that the tendency to steel austenitic grain growth during exposure at high temperatures is sufficient
Korelyatsiyu warping coefficient of steel.

Conclusions

1. Reduced susceptibility to warping steel makes it possible to increase the economic performance of production by reducing the number of finishing operations.

2. In the course of the research found that the level of steel warping during thermochemical treatment is directly dependent on the degree of dispersion of the original austenitic structure.

3. Dll tsementuyemyh steels in the chemical and thermal treatment prolonged exposed to high temperatures, it is necessary to minimize the tendency to alloy austenitic grain growth, which is achieved by a complex alloying elements such as titanium and niobium which form a carbide phase, stable
to high temperatures.

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Causes Ustanovlenы deformation of parts in the process termycheskoy processing. Razrabotanы Criteria otsenki эtoy velychynы.

Steel, alloying, tsementatsyya, tehnolohychnost, deformation, vnutrennye voltage.

The causes warping of parts during heat treatment. Developed criteria for assessing this value.

Steel, doping, cementation, technology, warping, internal tensions.