Analysis of the structure of the surface layer of spheroidal cast iron GJS casts

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Abstract

Formation of appropriate properties of final product surface layer in time of manufacturing processes decide about its useful application. Exploitational product surface formed in range of transitory zone of surface layer is characterized by specified exploitational properties. Incorrect selection i.e. technological surpluses leads to decreasing of technological properties and to decrease of exploitational properties of final products surface layer. Practical using of surface layer properties by using parameters of already used technological process is one of possibilities for increasing of durability and reliability machine parts. By example of spheroidal cast iron cast GJS, the form and range of surface layer was demonstrated. This allow to determine the minimal technological surpluses and in this way to define the most advantageous properties for already used technology.

Keywords: surface layer, technological properties, exploitational properties, spheroidal cast iron GJS, structure

1. Introduction

Wide using of cast-iron casts is a result of some advantages, good casting properties, comparatively simply casting technology, and different of technological and mechanical properties which depend of cast sort.

In respect of essential mechanical and usable properties (e.g. coefficient of trembling suppression), spheroidal cast iron (one should among different species of cast irons) is a main casting iron-carbon alloy. This kind of alloy is very usable, first of all as a material onto motor industry casts, agricultural machine casts, pipes and armatures casts, in a glass industry (as a glasses mould forms and pre-forms), as well as metallurgic casts which with success replace a cast steel and steel details. Possibility of increasing machine units resistance by formation of casts surface layer (SL) properties, is one of criterion for choosing a spheroidal cast iron as a constructional material. Possibility of increasing a resistance only in external layer of detail, in most of case gives a better results in respect of technical and economical conditions. The exploitational investigations and observations (which are much time-consuming) show that, the main factor which decide about machines units durability is a surface layer (SL) state [1], [3], [12].
2. Analysis of the problem

Analysis of raw cast surface layer (CSL) properties mainly follows an aim that to work out about methods of exploitational surface constitution in order to obtain the best properties and the lower cost of the final product. Up to now investigations, were about properties qualifications of the top layer after initial technological process. Half-product in form of cast was machined with assumed technological surpluses, without essential causes, why this surpluses have such and not different values. The most often given reason are under-surface defects arising in process of casting (e.g. a cramp pit). So, up to now investigations were concerned about surface layer properties qualifications and improving of this properties after initial technological process (machining). Thermal and thermal-chemical processing are the next stage of exploitational surface product properties formation which are defined by a constructor. The effects proceeded during machining are investigated in many scientific canters in Poland and on the whole world.

Defining of the surface layer in up to now investigations was concerned of layer already machined how it was before mentioned. Investigations about using the transitory zone of top layer were not taken so far. This investigations could considerably decrease technological surpluses and it would permit to changing a machining methods. One from possibilities of essential influence onto casts quality is a possibility to formation of definite properties both in transitory zone of the surface layers and in main material [4-5], [8], [10].

So, to obtain the highest mechanical strength, especially expansion strength with comparatively large extension of the spheroidal cast iron, attempts of formation some chosen parameters e.g. strength onto expansion $R_m$, minimum yield limit $Rp02$, minimum extensions $A_5$ and hardness HB [2], [4], [7], [9].

The problem of formations and using a properties of surface layer on the exploitational surface of spheroidal cast iron casts was not taken so far. In literature, there is not description about using the transitory zone of surface layer casts in refer to spheroidal cast iron. The presented paper attempts indication of possibility for using the surface layer properties. It is possible on the basis of the full structure analysis on casts transverse section, with different side thickness.

3. Preparation of the research

Mede investigations included:
- structures investigations onto side transverse section with special regard of cast surface layer.

3.1. The research object

Samples, performed for investigations became of type GJS - spheroid cast iron. Cast iron was smelted in SPADE ZGH BOLESŁAW inductive network stove, batch 5 T. Flooding temperature: 1450°C.

3.2. Microstructures investigations object

Metallographic sections were made by cuttings fragments of steps. This, permit to demonstrate structure changes in surface layer of spheroidal cast iron GJS (Fig. 3.1).
Microstructure investigations were made on the metallographic microscope EPITYP 2. Results recording was made in form of photo using a digital camera with microscope.

4. Researches

Researches are based on assumptions:
- no interfering into metallurgical process,
- indication of possibility for increasing of surface layer properties with existing and applied technology,
- indication of a using range for cast SL transitory zone for formation in her range the best product exploitational surface.

4.1. Investigations of the top layer structure

Metallographic research were carried out onto samples which were made from stairs technological sample, by cutting method (fig. 3.1). This researches were carried out to a different, individual depths measured from the cast side geometrical surface and for each of discussed sides thickness: 10, 20, 30, 40 mm.

In this work pictures (research results) only for ranges witch a considerable structure difference are presented, i.e. 0.25, 0.75, 1.25, 1.75, 2.5, 3.75, 3.25, 4.25, and 4.75 mm measured from cast surface.

It is introduced:

Photos of graphite quantity in samples from spheroidal cast iron GJS has a thickness of 10 mm, without quench annealing, with magnification 100x (Fig. 4.1.),

Microstructure photos for samples from spheroidal cast iron GJS has a thickness of 20 mm, without quench annealing, with magnification 250x (Fig. 4.2.),

Microstructure photos for samples from spheroidal cast iron GJS has a thickness of 10 mm, without quench annealing, with magnification 250x (Fig. 4.3.),

Photos of graphite quantity in samples from spheroidal cast iron GJS has a thickness of 30 mm, without quench annealing, with magnification 100x (Fig. 4.4.),

Microstructure photos for samples from spheroidal cast iron GJS has a thickness of 30 mm, without quench annealing, with magnification 250x (Fig. 4.5.),

Photos of graphite quantity in samples from spheroidal cast iron GJS has a thickness of 40 mm, without quench annealing, with magnification 100x (Fig. 4.6.).
Fig. 2 Photos of graphite quantity in samples, symbol 5 from spheroidal cast iron GJS (100X60X10) nital etched, magnification 100x where:
1) sample – 4.75 mm measured from cast surface, 2) sample – 4.25 mm measured from cast surface, 3) sample – 4.25 mm measured from cast surface - different fragment - structure defects, 4) sample – 0.25 mm measured from cast surface.

Fig. 3 Microstructure photos for material samples, symbol 5 from spheroidal cast iron GJS (100X60X10) nital etched, magnification 250x where: 5) sample – 4.75 mm measured from cast surface, 6) sample – 2.5 mm measured from cast surface, 7) sample – 1.25 mm measured from cast surface, 8) sample – 0.75 mm measured from cast surface, 10) sample – 0.25 mm measured from cast surface.

Fig. 4 Microstructure photos for material samples, symbol 3 from spheroidal cast iron GJS (100X60X20): nital etched, magnification 250x where: 11) sample – 4.75 mm measured from cast surface, 12) sample – 2.5 mm measured from cast surface, 13) sample – 0.25 mm measured from cast surface.

Fig. 5 Photos of graphite quantity in samples, symbol 2 from spheroidal cast iron GJS (100X60X30) nital etched, magnification 100x where: 14) sample – 4.75 mm measured from cast surface, 15) sample – 2.5 mm measured from cast surface, 16) sample – 0.25 mm measured from cast surface.

Fig. 6 Microstructure photos for material samples, symbol 2 from spheroidal cast iron GJS (100X60X30) nital etched, magnification 250x where: 18) sample – 0.25 mm measured from cast surface.

Fig. 7 Photos of graphite quantity in samples, symbol 7 from spheroidal cast iron GJS (100X60X40) nital etched, magnification 100x where: 19) sample – 4.75 mm measured from cast surface, 20) sample – 2.5 mm measured from cast surface, 21) sample 1.25 mm measured from cast surface, 22) sample – 0.25 mm measured from cast surface.

Metallographic analysis
Preliminary conclusions are concerned with individual sides thickness:

- for casts samples: dimensions: 100x60 mm, side thickness: 10 mm,

  In casts with side thickness of 10 mm on samples 0.25 mm and 2.5 mm in depth from cast surface, the pearlitic quantity 90-94%, and comparatively small cementite quantity: 2-25%, were observed. For distances 0.75; 1.25; 1.75; 3.25; 3.75; and 4.25 mm, the ball graphite in warp of transformed ledeburite, pearlitic and small part of ferritic were observed.

- for casts samples: dimensions: 100x60 mm, side thickness: 20 mm,

  In casts with side thickness of 20 mm, the ball graphite in pearlitic and ferritic warp is characteristic. On each of studied distance from cast surface (0.25 to 4.75 mm) pearlitic quantity on surface microstructure is about 80-94%.

- for casts samples: dimensions: 100x60 mm, side thickness: 30 mm,

  In casts with side thickness of 30 mm, without quench annealing the ball graphite with pearlitic-ferritic warp is observed, and ferritic quantity on surface microstructure is about 10÷15%.
  Ball graphite with pearlitic-ferritic warp is observed on each depth from surface onto cast core.
  The graphite quantity decrease to distance of 0.25 mm. From distance of 0.25 mm to about 1.25 mm graphite quantity increase and next is stabilizing.

- for casts samples: dimensions: 100x60 mm, side thickness: 40 mm,

  In casts with side thickness of 40 mm the ball graphite with pearlitic-ferritic warp is observed and ferritic quantity is 10-15%. Different graphite quantity is observed: decreased in direction of the cast core. Moreover the ball graphite quantity is different too:
  0.25 mm in depth - 30÷120 μm,
  1.25 mm in depth - 60÷120 μm,
  2.50 mm in depth - 60÷120 μm,
  4.75 mm in depth - 60÷120 μm.

Conclusions is found that:

- for distance about 0.25÷1.50 mm from cast surface to direction of core, graphite quantity decreasing in transitory zone, is observed,
- for distance above 1.5 mm in direction of core, graphite quantity stabilization is observed,
- metallic warp structure of casts without quench annealing is pearlitic with not much ferritic quantity surrounding graphite, or pearlitic-ledeburitical, and even ledeburitical,
- hardness increase on depth 1.5÷2.0 mm in direction of cast core, could be explain by higher ledeburitic quantity, which cause increase of hardness.

5. Final conclusions

Results of researches permit to formulate following conclusions:

- using the transitory zone of surface layer casts from spheroidal cast iron, by formation in its range exploitative top layer is possible without interference into technology,
- ther is no unequivocal premise for practice applying large (recommended accord to norms in range of 3.5÷5.0 mm). Technological surpluses in range of 1.5÷2.0 mm, are purposeful and sufficient for use.
- the most essential parameters influenced onto tribological durability of exploitative surface (casts from spheroidal cast iron GJS) are:
  - cast side thickness,
  - applying of chill casting in casting process,
  - thermal processing (annealing) used after metallurgical process what make possible product formation with mechanical processing
- decreasing of technological surpluses according to form and range of raw cast top layer from spheroidal cast iron does
not decrease of properties of final product top layer.

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