A NEW METHOD FOR THE NON-DESTRUCTIVE TESTING OF METALS

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The endeavour to satisfy simultaneously the generally antagonistic requirements of high quality and low first cost has largely contributed to the development of several industrial methods for testing our most important structural materials, i. e. the metals. Among testing methods used for quality control of metal products and their production processes, these giving quick and exact information about the usability of the product — while keeping it intact — have gained utmost popularity. Thus a few more or less known methods of non-destructive testing have been developed. Some of them are mentioned in the following paragraphs.

Different testing methods are based on magnetic and electrical interactions. E. g. surface defects, such as cracks and other discontinuities may be detected by magnetic defectoscopes when testing metal parts possessing magnetic properties, because surface discontinuities on the metallic surface may be easily indicated through the use of magnetic powders suspended in a fluid utilizing the effect of stray flux or deflected magnetic flux lines in the neighbourhood of such defects. In order to achieve increased detectability, indicating powders of different colours, such as black, brown, white, red, etc. are being kept in suspended state.

Another method makes use of the adsorption by defective spots of a fluorescent indicating fluid or a fluid having a harsh.

X-ray or gamma-radiographical methods are employed rather for the detection of internal discontinuities, cracks, fissures, etc.

Ultrasonic testing may be regarded also as a non-descructive irradiation method, generally utilized in several variants.

Spark analysis methods, used as a rule for the identification of different steel types, represent another class of non-destructive testing.

Frequent hardness testing of metals is also an approximation to a non-destructive testing method. Hardness numbers provide a basis from wich to infer other qualities of the metal, its hardness grade after heat-treatment, abrasion resistance, machinability, identity, etc.

Non-destructive testing methods as enumerated give results which frequently prove to be unreliable. This is the case e. g. with ultrasonic testing methods, still in the development stage after two decades of experimenting. Forged steel parts found to be defective by ultrasonic testing, proved to be of impeccable quality when sectioned ; thus the evaluation of ultrasonic defectoscopic indications has led to erroneous results.

In fact many fields of non-destructive testing still do not extend farther than the mere collection of data, although there is an ever increasing tendency to improve the quality of products and to reduce production costs.

Thus it appears to be almost incomprehensible, why a much more sure and reliable method of testing has not been employed for the purpose. This method is the non-destructive microscopical testing of the metallographic structure of metals. In most cases this provides more extended, more exact as well as more reliable information on the quality

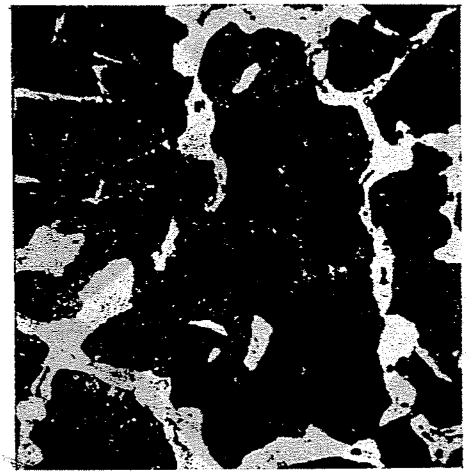

Fig. 1. Impact strength 0,6 mkg/cm^2

of a metallic material and also on several of its properties and may be compared very favourably with hardness testing or any other method based on the investigation of some magnetic or ultrasonic property, being complicated to realize and difficult to evaluate.

By employing microscopical testing of metals, either instead of previous testing methods or by complementing them, a characteristic pattern of many quality parameters of metallic products may be gained which by other methods may be not even approximated. Microstructure of metals is namely in close relation to their other physical and mechanical properties and contains, as a rule, much more information on the metal than any other testing method used sometimes in lack of better methods. On the other hand one may see tendencies even to determine the metallographic structure of metals not by microscopic testing but through inferring on it from their ultrasonic transmission parameters, even if this may be equivalent to total uncertainty. In similar cases not only the grain size, but also the configuration of grain boundaries carbide and other segregations along them have a strongly disturbing effect and all these effects cannot be separated by means of ultrasonic testing. An almost identical state of affairs may be seen with other testing methods utilizing electroinductive or magnetic measuring principles.

Microstructural analysis of metallic objects and half-products provides us with much more characteristic data than testing results obtained by other non-destructive methods or by testing specimens cut from different locations. By handling the problem with the expert's knowledge and with some technical common sense, quite a number of metal products may be tested through quality control methods based on metallographic microstructure investigations and this testing may even extend to the technological process as a whole.

Let us mention a few examples from the field of iron and steel products, which have been checked many times by the author during the last four years, but also let us point out that this statement cannot be regarded even as a mere enumeration of the vast field of possible applications.

It has been our task to determine the quality of already installed or ready-to-be-built-in steel parts, without resorting to the use of destructive methods and without integrally cast specimens in order to check whether each piece has been heat-treated accordingly to secure specified impact strength. The author tried to find an appropriate

Fig. 2. Impact strength 1,5 mkg/cm^2

testing method for this purpose. He succeeded in composing a series of photographic standards obtained from microphotographs of impact test specimens cut from already tested parts. This series of standards enabled the investigator to define the impact value of a steel part only through applying microscopical tests and without performing impact strength tests. Such a series of standards may be seen on Fig. 1 to 6. For practical purposes, however, testing equipment had to be designed, ensuring easy, cheap and reliable non-destructive testing of steel castings, if necessary, in the finished or already installed condition.

Hitherto no such equipment and consequently no such testing method has been known. In realizing the testing apparatus according to the author's design, engineer E. Fuchs has provided valuable assistance to him. The present testing equipment ensures quality control of a large number of steel parts on a cheap, quick and reliable way, thus achieving substantial economies and many other advantages.

Testing apparatuses already designed and tested have been described in No. 10., Vol. 1954. of the periodical "*Öntöde*" (Foundry, a supplement of "*Kohászati Lapok*"). In the author's opinion, however, the broad possibilities of applying this method of testing

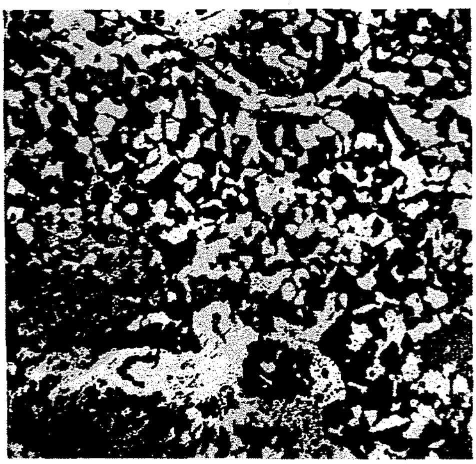

Fig. 3. Impact strength 2,5 mkg/cm²

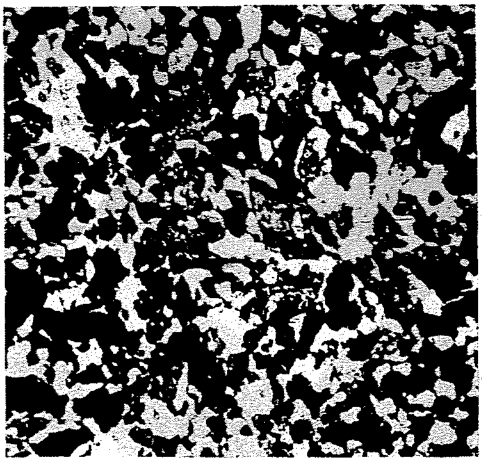

Fig. 4. Impact strength 3,5 mkg/cm²

have been only insufficiently recognized, although further experience in the quality control of metal products has shown that similar series of standards may be prepared for many other types of machinery and metallurgical industrial products. One should not forget, that during the last few years an ever increasing number of standards have specified microscopical testing for certain metal products. E. g. standard specifications relevant to grain size and carbide enrichment of steels or graphite grain size of cast iron are today not only well known, but also obvious. Thus a steel with a finer grain size will have a higher resistance against dynamic loads, while coarser-grained steels have an elevated hardenability which may be of decisive importance in some cases. In the production of tools, rolling bearings etc. finer and more uniform carbide distribution will result in higher quality, while the fineness of graphite distribution and the configuration of graphite crystals is of paramount importance so far as sound strength qualities of cast irons are concerned. Consequently there is unavoidably a substantial need in creating a novel portable metallographical testing apparatus and an analysis method to be realizable with it in order to testing cheap, quick and sure control of metal product quality.

Beyond the standards already mentioned microstructure will provide decisive information on many other properties of the majority of metal products, so that the knowledge of the microstructure — if it can be defined by means of a cheap and quick method — will render superfluous a great deal of other, sometimes more expensive testing methods, or will largely complement their results, providing more comprehensive information on the properties of metals.

E. g. plain steel grades and many alloy steel types may be easily selected by means of this method; temper, i. e. the state of heat treatment: normalizing, annealing, tempering, etc. may be easily controlled to check proper processing.

Having prepared the necessary standard series, any other control may be performed by cheap, semi-qualified labour.

A main point in the application of similar testing methods is their cheap and quick performance not only in laboratories but also in stores, workshops or even on sites for from the electrical mains (on built-in-rails, piping, bridges, ect.). A semi-automatic device complying with these requirements has been designed by thauthor and engineer E. Fuchs (Pat. appl. pending) and has been already marketed under the trade name "Intactor Microport". Four years of industrial experience have proved the viewpoints of the author and also that a similar testing apparatus will enable the manufacturer to satisfy simultaneously the high quality requirements and to realize substantial production economies.

Fig. 5
Impact strength 4,5 mkg/cm^2

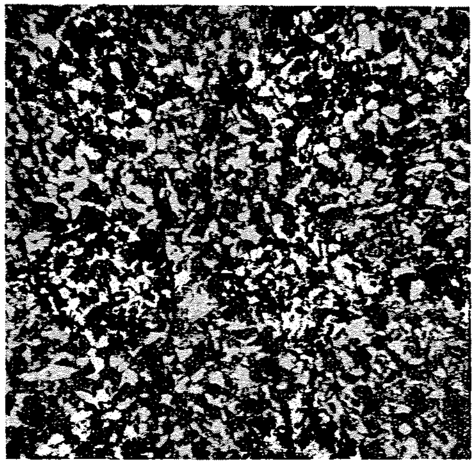

Fig. 6
Impact strength 5,5 mkg/cm^2

Uniformity or non-uniformity of metal grain size, preferred orientations in the crystal structure will present valuable assistance to decide upon the usability of materials, while the occurence of certain structural phases, their quantity, configuration and size may be of decisive importance so far as the machinability or any other property of the material shall be investigated.

During production or transport, materials of different grades are often intermixed; this, however, can be easily solved through microscopical testing, preventing at the same time many operational troubles.