IMPACT TESTER CONTACT CYCLIC TESTING

Antonín Kšíč
Petr Beneš
Jiří Šimeček

Department of Material Engineering and Engineering Metallurgy, ZČU-Plzeň,
Univerzitní 22, Plzeň 306 14, Czech Republic

Abstrakt
This paper deals with several application options of materials testing using an impact tester. An impact tester is a piece of testing equipment for investigation of response of materials to repeated impact loads. There are several types of this equipment with different designs and effects, which they produce in materials. Impact testers offer the benefit of examination of impact fatigue properties not only in bulk materials but also in layers and coatings. Impact testing is most widely used for testing fatigue properties of those components, which are subjected to repeated impacts and concurrent strong impact shocks. These include machining tools, railway wheels, piston rings and others.

1. SURFACE INTEGRITY
In terms of physical and chemical properties, the surface of material has certain specific features which set it apart from bulk materials. These features have significant impact on the end-use properties of the entire product. Unfortunately, despite this general knowledge, the state of surface actually receives very little attention in practical applications. For the purpose of cutting operations, mainly the productivity and durability of the tool are considered. Typically, the state of machined surface is not examined or is only evaluated on the basis of several roughness values. Yet, not only the surface relief, the description of which is often incorrectly derived from these roughness values, but also other surface features have decisive impact on its end-use properties. Characteristics based on the ANSI B211.1 1986 standard start to be employed in industrial applications these days. The standard contains a description of the surface in terms of a comprehensive set of properties, collectively termed as "surface integrity." Application of the standard can be expected to become common in Europe in near future. As a result, the requirements for surfaces will become more extensive than before. In machined and formed products, not only dimensional and geometrical accuracy will be examined, but also the surface state described in terms of its comprehensive characteristics. It is important, however, to take a practical approach to utilization of the standard. Despite the not inconsiderable influence of the surface, its state does not require any special attention in some types of machine parts. On the other hand, in numerous products even a slight alteration of their surface state results in a significant improvement in their end-use properties and life.
Findings on the impact of a change in the surface state upon the end-use properties of a product should be applied in practice without delay. In cooperation with the Hofmeister s.r.o. company, certain operations have been performed which improved the end-use properties of not only tools but machine parts as well. These practical applications provided valuable information suggesting that the changes observed in the surface integrity-related end-use properties should be properly monitored. For the purpose of identification of effects of surface state changes, not only new testing methods but also new equipment had to be developed. This made the authors of this paper construct the impact tester by their own design and develop the testing methodology.

2. THE IMPACT TESTER
The instrument (Fig. 1) allows investigation of fatigue characteristics of a material surface under dynamic cyclic contact loads. The test is based on cyclic impacts of a testing body with a defined force on the surface of material. Due to high number of impacts (up to 1 million impacts have been applied and tested), a number of phenomena take place on the surface. When correctly recorded and evaluated, they provide information on numerous important properties. In the real world, about 90% defects are caused by fatigue-related failures. Most frequently, the fatigue failure is initiated on the surface of the part. Upon reliable determination of the impact of the surface state on the fatigue properties, the properties of an examined material can be predicted. In order to obtain as reliable results as possible, one has to use not only an accurate instrument applying a defined load on the examined surface but also proper methodology for evaluation of related processes. This is why the current efforts of the authors are focused on evaluation of acoustic emission signals and recording the loading force intensity and the material’s response. Like the knowledge on the state of the impact crater (Fig. 2), these findings in relation to the number of impacts will make it possible to determine comprehensive characteristics of the surface of material. Specialist literature does not provide extensive information on the impact test, as there are only very few laboratories worldwide dealing with such a method. There are three instruments of this kind in the Czech Republic. Of these, two are at the authors’ laboratory and one at ÚPT (Institute of Scientific Instruments) Brno. Currently, the method is also being developed by the Polytechnic School and Research Committee of Aristoteles University of Thessaloniki, Greece.
Fig. 1 – An impact tester built according to authors’ design. The impact is generated by an induction coil which can provide a force of up to 1,000 N at the frequency of 50 Hz.

Fig. 2 – a) an impact crater upon 500 thousand impacts on a specimen taken from a railroad wheel; b) a zoomed-in view of the impact crater with a growing crack on its edge [1]

The advantage of the impact test lies in that it offers a rapid and accurate evaluation of the effect of the surface state on the end-use properties of the part. During the verification period of the instrument, not only surface-treated materials (thin-film-coated exchangeable cutting inserts, piston rings) but also bulk materials were tested. Results of cutting tool testing were compared with technological results from milling processes, as the latter allow accurate simulation of impact loads on the cutting tool edge during machining. It became apparent that the method can be used for determination of end-use properties of cutting tools. On piston rings, the effects of
a hard chrome plating on the contact surface were investigated. The test has shown that where pores are present, the resistance of the surface of the ring to contact fatigue increases. The resistance improved markedly upon reduction of surface roughness by polishing. As a result, a recommendation was given to the manufacturer to use operations which will alter the state of the surface. At present, these piston rings are being field-tested. Extensive tests were carried out using bulk materials in the form of specimens taken from a used railroad wheel. They were aimed at describing the growth of cracks in the railroad wheel during cyclic contact loading. Results of acoustic emission measuring and monitoring of changes in the impact force due to processes initiated within the material were used for evaluation as well. The results confirmed the risk of formation of new surface cracks and their growth under critical cyclic impact load. The instrument and the methodology will be deployed in cooperation with the University of Pardubice, Czech Republic, for testing new materials intended for production of railroad wheels, crossing frogs and switch rails.

3. CONCLUSION
The authors expect the surface integrity monitoring and evaluation of its direct impact on end-use properties of products to become ever more common in near future. These end-use properties will be also be reviewed in terms of contact fatigue. Our laboratory is now prepared for this thanks to the instrument and elaborated testing methodology. Further areas of application can be found in prediction of properties of in-service parts and equipment. Impact test can be carried out using very small specimens (equivalent to a coin) which can be taken from operating equipment without stoppage. Under certain circumstances, the results may be used instead of the results of demanding fatigue tests. This method may also be used for monitoring and description of degradation processes wherever contact loads occur.

Detailed information on the issue can be found at [www.ateam.zcu.cz](http://www.ateam.zcu.cz)

This study is a result of an internal grant of the University of West Bohemia investigated in 2008 and grant MŠMF 1M0519.

REFERENCES