Application of Robotic Systems for NDT
Aplikace robotických systémů pro NDT

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Abstract

In today's industrial and manufacturing environment, automation is gaining increasing importance, including in the field of non-destructive testing (NDT). The investigation of internal and surface defects, as well as irregularities within materials without causing any damage to the tested objects, is pivotal role in ensuring the integrity, safety, and reliability of materials, components, and structures. The use of robots and automated systems in NDT offers significant advantages over traditional methods. Consistent accuracy, the ability to access complex or hazardous environments, ensuring of a consistent coverage of inspection areas, reducing human error, speed, and continuous operation are just some of the benefits that automation provides.

The presentation focuses on the applications of robotics systems developed at ATG s.r.o. for various NDT techniques. We present their advantages and potential that these systems bring to non-destructive testing and how they can improve the efficiency, safety, and quality of this crucial industry.

Keywords: Defectoscopy 2023, article, abstract, non-destructive testing (NDT), testing, robotic systems, ultrasonic, magnetic particle, eddy currents, visual inspection, vision, handling, manipulation, industry 4.0, bin picking, aerospace, automotive, immersion

Abstrakt

V dnešním průmyslovém a výrobním prostředí získává automatizace stále větší význam, a to včetně oblasti nedestruktivního testování (NDT). Inspekce vnitřních a povrchových vad a nehomogenit v materiálech bez poškození testovaných objektů má klíčový význam pro zajištění integrity, bezpečnosti a spolehlivosti materiálů, komponent a konstrukcí. Využití robotů a automatizovaných systémů v NDT přináší značné výhody oproti tradičním metodám. Konzistentní přesnost, schopnost práce v náročných nebo nebezpečných prostředích, zajištění konzistentního pokrytí oblastí inspekce, snížení lidské chyby, rychlost a nepřetržitost provozu jsou jen některé z benefitů, které robotizace nabízí.

Prezentace se zaměřuje na aplikace robotických systémů vyvinutých ve společnosti ATG s.r.o. pro různé techniky NDT. Představujeme jejich výhody a potenciál, který tyto systémy přinášejí do nedestruktivního testování, a jak mohou zlepšit efektivitu, bezpečnost a kvalitu této klíčové průmyslové oblasti.

Klíčová slova: Defektoskopie 2023, příspěvek, abstrakt, nedestruktivní testování (NDT), testování, robotické systémy, ultrazvuk, magnetické práškové testování, vířivé proudy, vizuální inspekce, zobrazování, manipulace, průmysl 4.0, odebírání dílů z koše, letectví, automobilový průmysl, ponoření

On the Question of Determining the Elastic Modulus of Metals During Dynamic Indentation
K otázce určení modulu pružnosti kovů při dynamické indentaci

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Abstract

Industry places high demands on used metals and alloys, the quality of which is judged by their physical and mechanical characteristics. One of the most important physical and mechanical parameters of metals and alloys is their elastic modulus. Determination of the elastic modulus using tensile tests or instrumental indentation requires cutting samples for laboratory experiments. Dynamic indentation allows to determine hardness numbers directly on large objects using the Leeb method. At the same time, the hardness number depends on the elastic modulus.

To date, there are no devices and systems that implement the method of dynamic instrumental indentation, however, the above mentioned allows us to set the task of modifying the the transducer according to the Leeb method to measure the elastic modulus. Modelling, calculations and experiments showed that for the modernised Leeb transducer it is possible to obtain classical dependences of contact load P on the displacement of the impactor h and calculate the dissipated impact energy, elastic impact energy and contact pressure.

The obtained data set of the alternating EMF signal $e(t)$ was converted to the velocity value $v(t)$ using the proportionality coefficient k. The time dependence of the impactor acceleration $a(t)$ was determined by numerically differentiating $v(t)$ by time. The contact load of impact interaction $P(t)$ was obtained by multiplying the acceleration by the known value of the impactor mass m = 5.44 g. The integral $v(t)$ gives the impactor displacement $h(t)$. The following data was obtained from the $P(h)$ relationships: the reduced modulus of elasticity E_r and the elastic modulus during indentation E_{IT}. Maximum test load F_{max}, maximum indentation depth h_{max}, residual indentation depth after removal of the test load h_p, depth h_r determined by the point of intersection of the tangent to the unloading curve at F_{max} with the axis of displacement h. From these data, the indentation depth of the tip into the test sample at F_{max} h_c, the cross-sectional area of the tip at a distance h_c from the vertex $A_p(h_c)$, the ductility at the point of contact C, the reduced modulus of elasticity E_r and the elastic modulus during indentation E_{IT} were calculated. When calculating h_c, was used the coefficient ε equal to 0.75, since the impactor has a spherical indenter with a radius of 1.5 mm.

The experimental results, reference values of the elastic modulus of the studied alloys and their comparison are presented in Table.

Test results

Test number	Elastic modulus during indentation E_{IT}, MPa		
	steel	steel	bronze
Parameter	Value		
Mean value, GPa	153	136	84
Reference value of elastic modulus, GPa	204	204	106
Absolute error, GPa	51	68	22
Relative error, %	25	33	21

The obtained results demonstrate a correlation of the measured values with reference data, but a significant systematic deviation is observed. The reason for this may be both errors in measuring the primary parameters $P(t)$ and $h(t)$, and the use of the technique for analyzing the dependences $P(h)$, adopted for static instrumental indentation. These problems can be solved by increasing the accuracy of measuring primary parameters by analyzing the actual dimension of the received indentation, as well as developing a technique for analyzing the dependences $P(h)$ considering the dynamic nature of the interaction. The result of the research can be considered confirmation of the possibility of using dynamic indentation to determine the mechanical properties of materials, however, to improve the accuracy of the method, additional research is required, which will also be discussed in the paper.

Keywords: elastic modulus, dynamic indentation, Leeb method