



Plastic deformation testing

Materials producers want to develop plastics with enhanced properties for new industrial applications. At the same time, they want to reduce environmental impact by recycling plastics into new products. Both goals make production more complex. To advance research into innovative and more environmentally friendly plastics, new methods are needed to better understand the dimensional and mechanical properties of plastics and how they change during their life.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Innovative plastics are increasingly incorporated into car manufacturing and building materials, making products lighter and more cost-efficient. However, plastics deform under stress and over time. This problem is made more complicated as manufacturers recycle old plastics into new products. Blending recycled and raw materials results in plastics with different physical properties, both across the material as a whole, and localised in small areas. Producers face the challenge of developing plastics that need to remain stable and fit for purpose for decades from less well understood feedstocks.

One suitable method for testing materials properties on a very small scale is a technique called nano-indentation testing. This is used to understand the mechanical response of a material by measuring how much pressure is required to form an indentation and how it deforms over time. This technique is established for testing many metals but requires significant improvements to make it suitable for the complexities involved in measuring plastics.

Solution

The EMRP project *Dynamic mechanical properties and long term deformation behaviour of viscous materials* investigated how plastics deform over time using a variety of nano-scale measurement techniques including nano-indentation creep testing. Extensive physical measurements of mechanical properties and deformation rates were made for different plastics and other viscous materials leading to the derivation of best measurement practice for the mechanical testing of plastics. A new analysis model that can link mechanical material properties and predict their behaviour was validated using project test results.

Information on the best practise in performing nano-indentation creep testing generated in the project has contributed to the development of a new standard on this type of testing: a new work item has been proposed and approved as a new part of the ISO standard 14577 'Metallic materials - Instrumented indentation test for hardness and material parameters' as currently there is no equivalent standard for plastics.

Impact

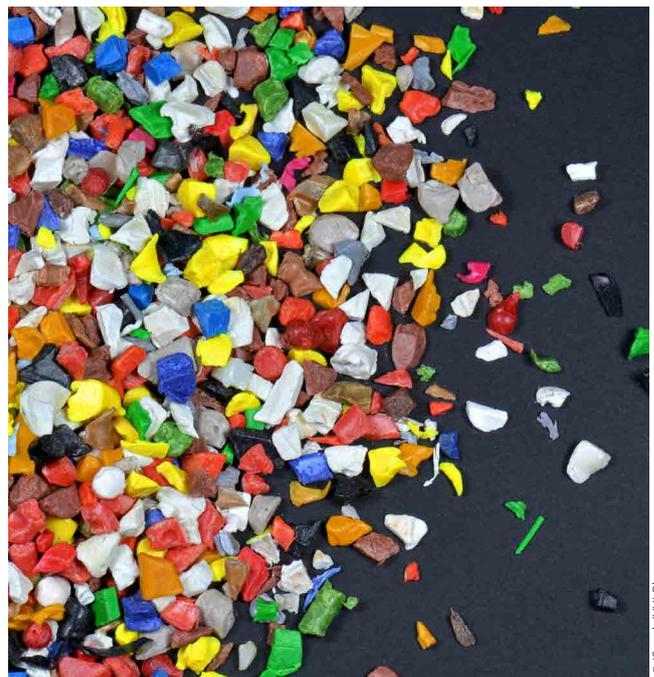
Anton Paar GmbH, a specialist in instrumentation for materials characterisation, made improvements to an instrument prototype specifically designed for nano-indentation testing of plastics as a result of interaction with the project. They redesigned its load control to achieve the low loads needed for plastics testing and integrated the new material property computer model into their software. This enables more reliable measurement analysis and corrections for the complex properties of plastics. These improvements have also been rolled out to their other nano-testing instruments.

Through the project, Anton Paar was able to demonstrate the thermal stability and versatile use of its instruments on a wide range of hard, soft, and multiphase materials. It can now provide customers - including global plastics developers such as Dupont and Dow - with traceable, validated measurements of plastics which give a reliable indication of their in-service life. It is estimated that over 15 million Euro in increased sales will result from the introduction of these new and upgraded Anton Paar instruments.

Standardised measurements and instruments specifically validated for plastics will enable manufacturers to have greater confidence in their performance under in-service conditions. This will promote innovation across a wide range of industries, leading to products with improved life times, lower production cost, and reduced environmental impact.

Dynamic mechanical properties and long term deformation behaviour of viscous materials

The EMRP project *Dynamic mechanical properties and long term deformation behaviour of viscous materials* provided validated indentation and contact methods to measure the shape, mechanical properties and deformation rate of viscous materials. New calibration routines and detailed analyses of measurement errors are helping instrument manufacturers to understand and improve the performance of their products, and new measurement and analysis protocols will improve the ability of the nano-indentation community to measure viscous materials.



© iStock/XXI Photo

EMRP

European Metrology Research Programme
► Programme of EURAMET



The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

www.euramet.org/project-IND05

Xiaodong Hou

NPL, UK

+44 20 8943 6637 | Xiaodong.hou@npl.co.uk

11326/0916 - IND05 14063