Taylor Impact

by Stephen Walley (University of Cambridge, UK)

Contact: smw14@phy.cam.ac.uk

Towards the end of the 1930s, G.I. Taylor devised a relatively simple method to estimate the dynamic strength of materials in compression. Due to the Second World War, this work was not published until the mid to late 1940s (1-4). His method consisted of firing a solid cylinder of the material against a massive rigid target. The dynamic flow stress of the cylinder material could be estimated from the recovered cylinder by measuring the overall length of the impacted cylinder (before and after) and also the length of the undeformed (rear) section.

One of the assumptions they made in their published analysis was that the rear of the projectile undergoes constant deceleration. Taylor knew that this assumption is not true, but an analysis taking account of the variation in acceleration yields a set of expressions that are transcendental in the yield stress and in which the plastic wave speed acts as a free variable. Taylor and Whiffin's method of solving these equations consisted of numerically determining the plastic wave speed consistent with both the measured deformation and their theory. This then allowed the yield stress to be determined. In order to use this more exact method routinely, Taylor presented it as a set of graphs yielding multiplicative correction factors (2). Whiffin showed that the correction factor was velocity dependent, being ca. 1.12 at about 100 m s^{-1} and ca. 1.06 at about 800 m s^{-1} for mild steel cylinders (4).

The publication of this method occurred just before Kolsky's famous paper on the use of two Hopkinson pressure bars to measure the dynamic properties of materials in compression (5). This device became known as the split Hopkinson pressure bar (SHPB) and soon became the standard technique for obtaining such properties, having the advantages over the Taylor test of loading the material under nearly uniform stress and strain rate.

However, the Taylor test, or variants on it such as rod-on-rod impact (6, 7), has been used and developed to the present day (there are over 200 papers in the literature on this topic). It has not often been used for its original purpose of obtaining dynamic yield stresses of materials (but see refs (8-12)). It has, however, come into its own in recent years for checking constitutive models by comparing the shapes of recovered cylinders with computer predictions, e.g. (13-33). This work is best performed using high-speed photography (even for metals) as most materials exhibit some recovery after deformation. High-speed photography is essential for checking models if viscoelastic materials such as polymers (8, 34, 35) or polymer bonded explosives are being studied (36, 37).

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