Yield and Fracture

محاضرة سلوك ميكانيكي للبوليمرات

1 (21) المحاضرة

Fracture of polymers:-

- Brittle solids fracture because the applied stress is Amplified by minutes cracks ($1\ \mu m$ in size) which occur naturally as a result of fabrication, solidification, fatigue damage. These cracks are termed Griffith cracks.

a: crack length

a_c: Critical crack length.

- If $a < a_c \rightarrow$ yield (ductile failure)
- If $a > a_c \rightarrow$ fracture (brittle fracture)

All materials contain small defects of some kind. impact and other forms of rapid loading cause brittle fracture.

- PE necks and cold draws in a manner described in Fig. (1). As it is a semi-crystalline polymer, yielding involves considerable disruption of the crystal structure, slip occurs:-

1. between the crystalline lamellae which slide by each

other like pack of cards.

2. within the individual lamellae by a process comparable to ~~glide~~ monatomic crystals.

- The necking of polymers is affected by:- the material, length and thickness of specimen, test conditions especially strain rate (The yield stress is depends on strain rate). The drawing of fibers, films and sheet in forming operations occurs at very high strain rates. → وكذا في اختبار الشد

- In some polymers, dramatic changes in toughness take place at room Temp. when the thickness is varied over the range. For example:- under impact loading, ~~sharp~~ sharp cracks in thick sections can give rise to low-energy fractures, even in poly carbonate, which is normally a very tough polymer.

* Heating at the crack tip appears to be largely responsible for the observed frequency effects, but again the result

3

Can be either faster or slower crack growth depending on the material.

plastics become more brittle at low Temperatures (as a_c decreases) and more ductile at high Temperatures (as a_c increases.)

Crazing and shear yielding are affected differently by Temp. and strain rate, and in more ductile polymers the most obvious effect of raising the Temp. is to accelerate shear yielding.

Very short chains are held together only by vander Waals forces, and are unable to form stable crazes.

Degradation may be purely thermal, but is accelerated by a trace of water in polymers containing hydrolysable linkages; careful drying is therefore necessary before moulding polyesters, polyamides, and polycarbonates.

by ~~using~~ adding suitable stabilizers and processing agents to the polymer, few problems are encountered in moulding fresh material, but difficulties are likely to arise when large amounts of reground polymer are used.

Molecular orientation is one of the most important factors affecting on the fracture resistance of moulded or formed polymeric products. Biaxial stretching in the melt state makes a polymer much more resistant to crazing and cracking under the action of stresses, and is used to improve the properties of film, sheet, and other products.

Anisotropy is a more obvious problem in uniaxially drawn material.

The Tem <u>static fatigue</u> is used to refer to slow crack growth under long-term steady loading.

Dynamic fatigue is a more serious problem, because ~~fluctuation~~ fluctuations in load accelerate sub-critical crack growth.

#5

One way to study this effect is to subject specimens to alternate loading between a fixed stress and zero. Comparisons can be made between the fixed stress applied continuously for a certain period, and the same stress applied intermittently for the same total time. In practice, ~~and the same stress~~ most experiments employ sinusoidal loading, which gives lower fatigue crack propagation rates.

In design of polymers taking into account many factors such as: ~~chemical~~ chemical resistance, fracture, fatigue, and forming constraints, in addition to the V.E. limitations.

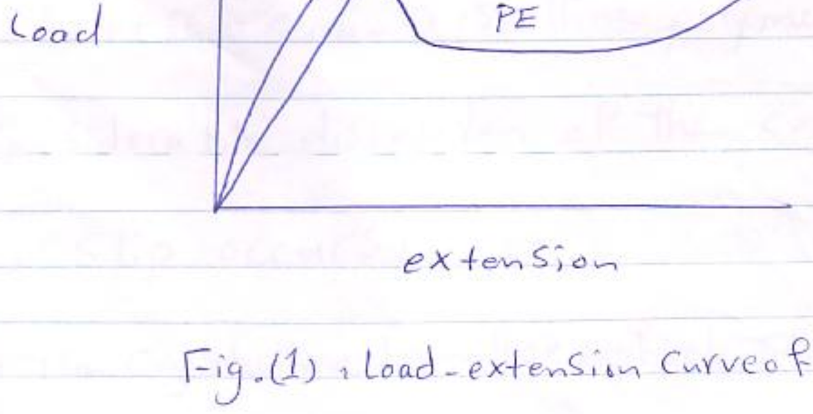

Fig.(1): Load-extension curve of PE