The Energy of Break or Deformation in Some Semi- Crystalline Polymers

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Abstract

The aim of the current study is the investigation of tensile behavior of the semi - crystalline polymers : polypropylene (PP) , high density polyethylene(HDPE) and low density polyethylene (LDPE) .

The energy to break or deformation was determined as a function of extension rates , (PP) was break at extension rate (5) mm/min but (HDPE) break at higher extension rates (25) mm/min while(LDPE) not break even at very high extension rates but it is deformation or failure .

Keywords : energy to break , extension rates, polypropylene (PP) ,high density polyethylene(HDPE) and low density polyethylene (LDPE).

Introduction

The energy at break of polymers is required firstly to select a material which enables desired performance of the plastics component under conditions of its application . Furthermore , they are also essential in design work to dimension a part from a stress analysis or to predict the performance of a part under different extension – rates involved [1] .

IF a material is subjected to stress , the polymeric material behaves as a linear elastic solid .The local maximum in load- extension curve is called the yield point , beyond this point the material stretches out considerably and a neck is formed , this region is called the plastic region .

In some polymers , further extension leads to an a abrupt increase in stress(load /cross sectional area) which is named strain hardening , then the material is rupture , the(load – extension) or (stress - strain) behavior of polymeric material depends on various parameters like microstructure and extension rate (strain rate) [2].

The very Common thermoplastic materials used for drainage pipes are high density polyethylene (HDPE) , low - density polyethylene (LDPE) and polypropylene (PP) , these polymers characterized as a semi - crystalline polymers , made up of crystalline regions and a amorphous regions [3,4].
crystalline regions are those of highly ordered, where the amorphous is a random region

High–density polyethylene (HDPE) with density(0.941- 0.965) gm/cm^{3}is a thermoplastic material composed of carbon and hydrogen atoms joined together forming long main chain of molecules or mers (C_2H_3R) where the root R is H , the longer the main chain , the greater the number of atoms , and consequently , the greater the molecular weight[6] .The molecular weight and the amount of branching determine many of the mechanical properties of the end product . Other common polyethylene materials is low – density polyethylene (LDPE) with density (0.91- 0. 925 g /cm^3) which is more branched , strength and flexibility than HDPE [7] . another thermoplastic materials used for drainage pipes is polypropylene with chemical stature C_2H_3R mers , where the root (R) is (CH_3) and density (0.900) g /cm^3 [4, 8] .

The physical and mechanical properties of plastics are governed by the structure and composition [9] , the mechanical properties like stress - strain relationship of some polymers are studied by Einar Dahl in 1973 [10] .

The tensile deformation properties of several semi - crystalline polymers were studied by R . Hiss by developed a video - control for the stretching device in 1996 [11] .In1999 R. Hiss et. al carried out experiments of stress on polyethylene [12] and another experiments of stress –strain were carried out on polypropylene in 2003 by Y.Men and G.Strobl[13] .

In 2007 P.Nagy and L.M.Va ,studied the relationship between constant strain rate and stress relaxation behavior of polypropylene [14] , Abdullah A.Hussein etal studied the mechanical behaviour of (LDPE) in 2011 [7] .

In this investigation the entire stress - strain relationship of two grades of polyethylene and polypropylene was determined .

Experimental

ASTM D638 (Standard Test Method) for tensile properties of plastics , is used to shape the drain pipes made by (PP , HDPE and LDPE) , the specimens are usually shaped as a flat (dog bone) with dimensions of (65 x 13x 3) mm , using the testing machine Fig .(1) ,we try different extension rates , until the rupture is occured , or the specimen is failure .

Result and Discussions

The energies to break or deformation have been determined by calculating the area under the curves of (load – extension) or (load - stroke) as in figures (2 – 4) with extension rate (5) mm/min for (PP , HDPE , LDPE) respectively , these curves are a basis of classification of a polymers [9] .

The microstructure of (PP) is different than (PE), so (PP) was broken with brittle fracture at extension rate (5) mm / min but (HDPE) was broken at (25) mm/min as shown in the figure (5) , while (LDPE) was not broken even at very high extensions rates but it was deformation because its high flexibility which is in agreement with Gensler et.al. [15] , the further extension leads to an a abrupt increase in load (strain hardening)as in figure (4).

For (HDPE) and (LDPE) the energies to deformation are increased with the increase of the extension rates , as shown in figure (6 , 7) respectively , which agree with Peterlin [16] and Jonnan et. al.[17].

Figure (8) showed the influence of microstructure of polymers on the values of energies to break or deformation.

Table (1) illustrates that (LDPE) has higher values of energies to deformation than the values of (HDPE) because it was more flexible , Soft and Toughness.

Conclusion

1- The tensile (load – extension) curve is a basis for classify the polymer in term of there brittleness , softness and toughness .

2- (LDPE) has a soft and tough behavior because its structure (branch chain)with largely amorphous regions .

3- (HDPE) and (LDPE) have the same chemical structure but HDPE has a higher degree of crystalline , resulting in improving the strength and stiffness .

4- PP has higher strength and stiffness then it has higher values of energy to break than HDPE at (5) mm /min .

5- The energies to deformation of (HDPE)or (LDPE) are increased with extension- rates

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Table No. (1)The influence of extension rate on the energy to deformation of HDPE and LDPE

Extension rate (mm/ min)	Energy to deformation (Kgf.mm)	
	HDPE	LDPE
5	5273.39	17545.6
10	5277.47	17936.1
15	5284.57	18723.4
20	2647.55	19066.3

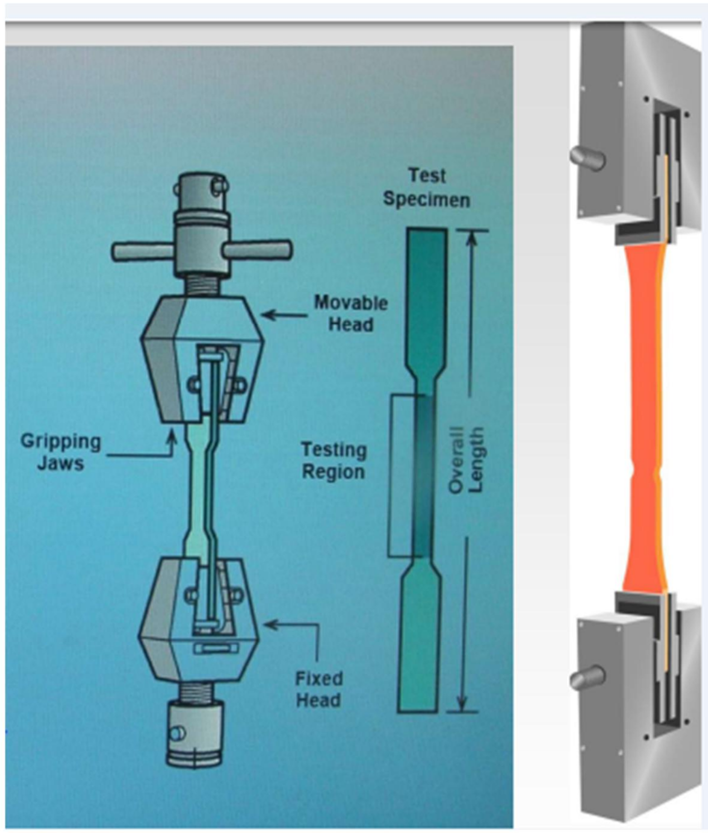

Figure (1)Tensile machine and the specimen of tensile.

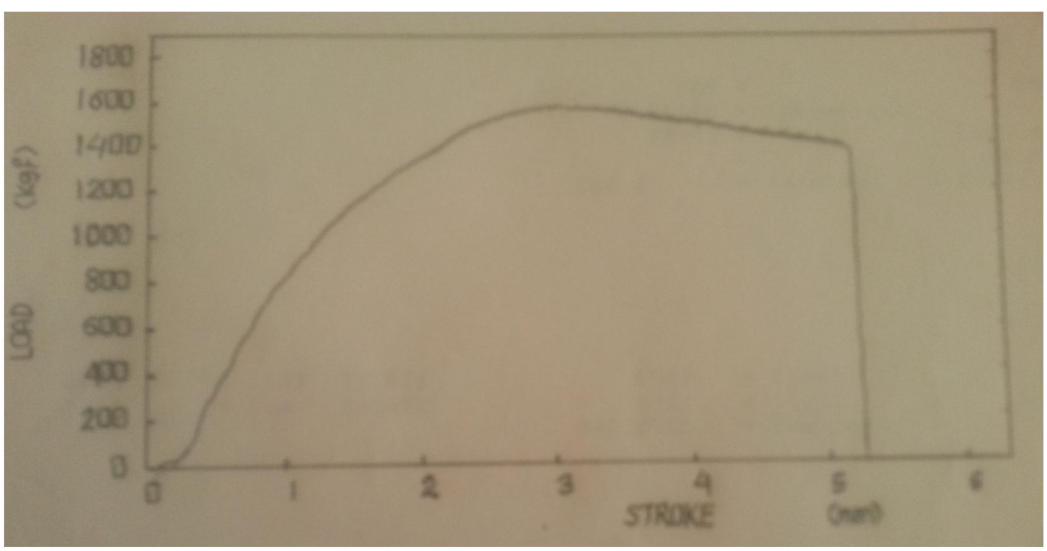

Figure (2) load as a function of stroke for pp at extension rate 5 mm/min .

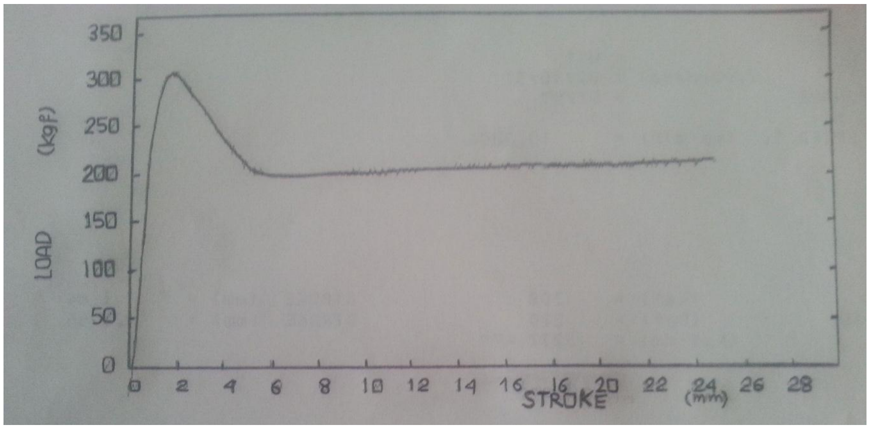

Figure No. (3)Load as function of stroke for HDPE with extension rate 5mm/min

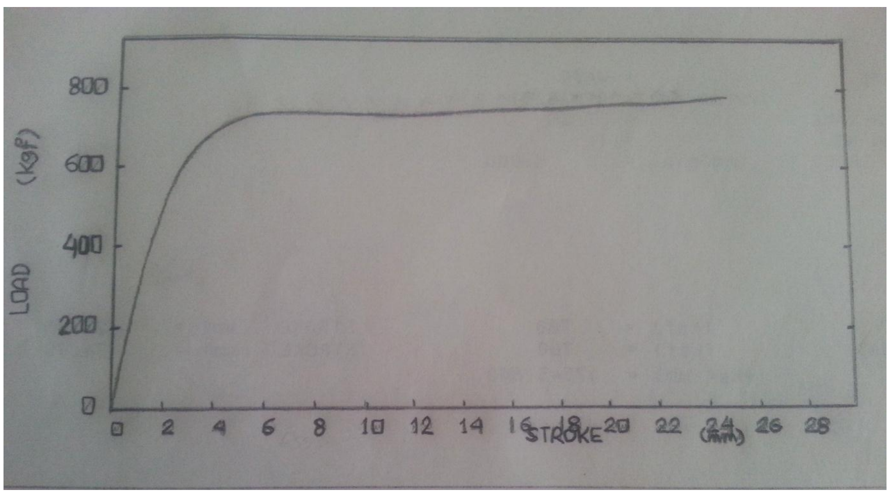

Figure No. (4)Load as function of stroke for LDPE with extension rate 5mm/min

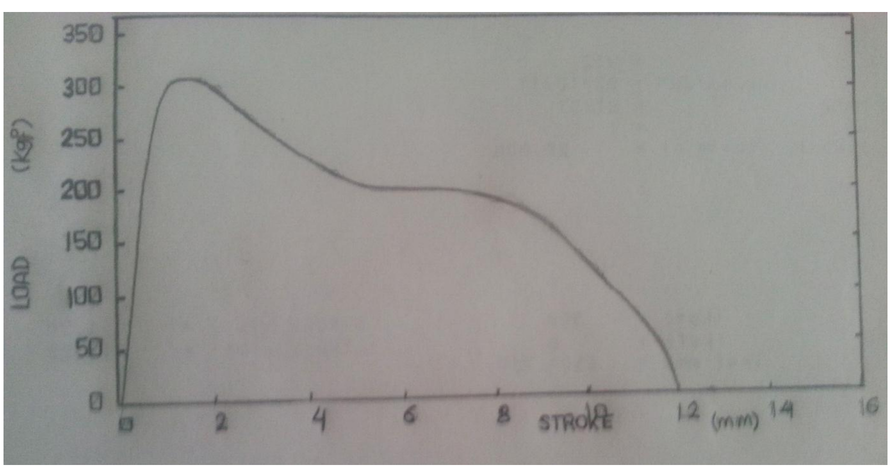

Figure No.(5)Load as function of stroke for HDPE with extension rate 25mm/min

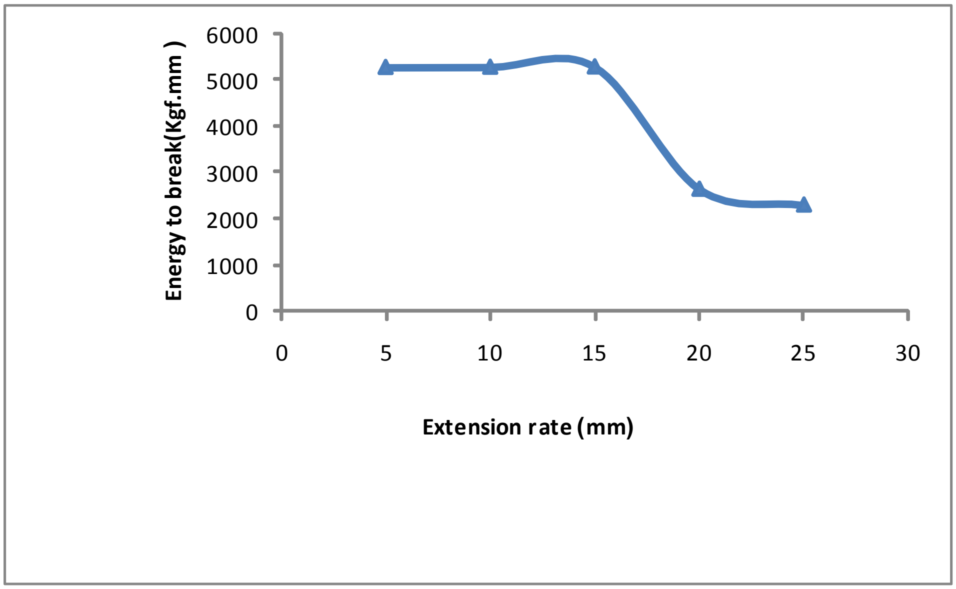

Figure No. (6)Energy to deformation as a function of extension rate for HDPE

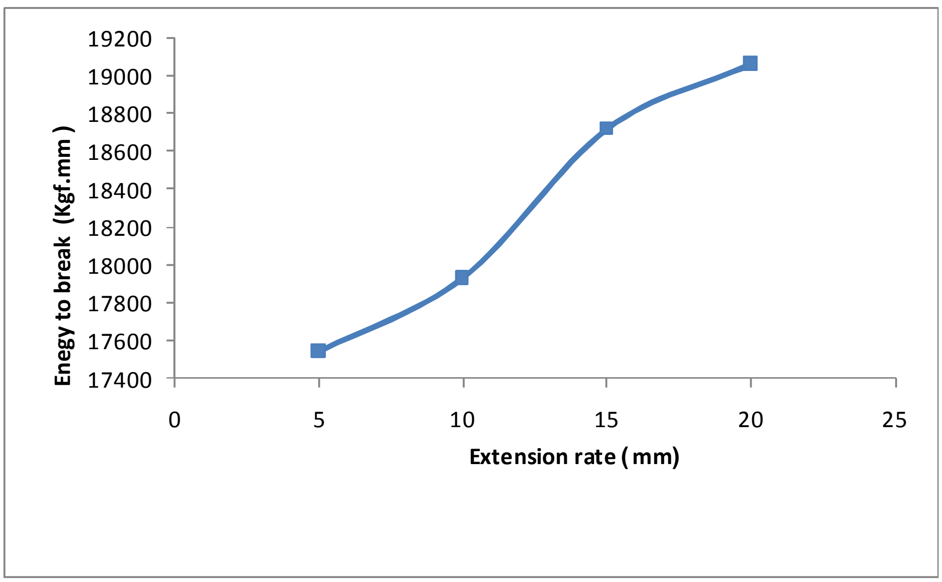

Figure No. (7)Energy to deformation as a function of extension rate for LDPE

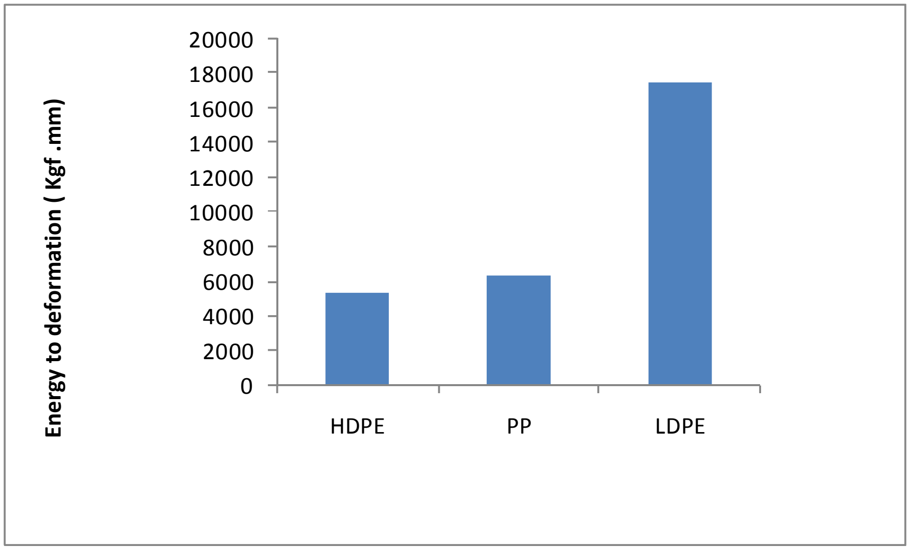

Figure No.(8)The influence of the kind of polymer on the energy to deformation

طاقة الكسر أو التلف لبعض البوليمرات شبه – بلورية

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الخلاصة

ان الهدف من الدراسة الحالية , هو البحث في طبيعة العلاقة (القوة – الاستطالة) للبوليمرات شبه-بلورية مثل البولي بروبلين(pp) ،البولي أثيلين عالي الكثافة و البولي أثيلين واطى الكثافة.

وأنجزت فحوصات الشد لقياس طاقة الكسر أو فشل الأنموذج دالة لمعدل السحب ،ينكسر البولي بروبلين بمعدل سحب mm/min(5) ولكن البولي أثيلين عالي الكثافة ينكسر عند معدلات عالية جدا للسحب mm/min(25) ، بينما لا ينكسر البولي أثيلين واطى الكثافة حتى عند المعدلات العالية جدا للسحب ولكنه يتلف .

الكلمات المفتاحية : طاقة الكسر , معدلات الشد , بولي بروبلين (PP) , بولي أثيلين عالي الكثافة (HDPE) والبولي أثيلين واطى الكثافة (LDPE) .