ELEMENTARY PROCESSES IN KINETICS OF MECHANICAL FAILURE OF PP-PELD POLYMER COMPOSITIONS

I.K. ALIYEVA[1], P.B. ASILBEYLI[2], T.M. VELIYEV[3], E.S. SAFIYEV[4], A.A. KHADIYEVA[2]

[1]Azerbaijan Noval Academy,
[2]Institute of Physics of Azerbaijan National Academy of Sciences, AZ1143, Baku, Azerbaijan, H.Javid ave.,131
[3]Odlar Urdu University, Az1071, Baku, K.Ragimova str.,13
[4]Azerbaijan Oil Academy,Baku, Azdalig ave.,20
e-mail: asilbeyli@mail.ru

The distribution of optimal polymer compositions of low density polypropylene-polyethylene PP-PELD on τ mechanical durability, which is the rupture waiting time (mechanical failure at constant voltage) is measured The test results of continuous field action on samples with discontinuous one, saving them in intact state after endurance during the time corresponding to lgτ average value, are compared. The action duration and temperature are varied, that's why the different regeneration degree of strength of polymer compositions is observed. It is shown that the accumulated changes, which are identified as fluctuating rupture of chain molecules, are reversal ones in the case of mechanical failure of polymer compositions.

Keywords: polymer compositions, mechanical failure, supmolecular structure, over-barrier transition, failure kinetics
PACS: 81.05.Rm

INTRODUCTION

The sample rupture under action of applied mechanical load are the final acts of developing processes in loaded objects preparing the appearance of continuity macroscopic loss. Many experimental data on observation of so-called "late failure" when sample rupture doesn't become at once after application of some constant mechanical load, but after some time the duration of which depends on mechanical load value and also on series of other factors (temperature, structural object state, environment, radiation interaction and etc) indicate it [1].

We can conclude that during this time the changes take place in loaded object, processes leading to total loss of object stability to load action develop in one. Thus, the mechanical failure isn't the critical accident but there is kinetic phenomenon.

The questions of reversibility and irreversibility of elementary processes preparing the body rupture are the important ones.

The revealing of reversibility degree of accumulated processes in mechanical failure kinetics of polymer compositions is carried out for this purpose.

EXPERIMENT TECHNIQUE AND SAMPLE PREPARATION

The samples from polymer optimal compositions low density polypropylene-polyethylene (PP-PELD) in percent ratio 80/20, correspondingly with different submolecular structures (SMS) are taken in the capacity of investigation objects. The film thickness is the several decades of micrometers.

The measurements of mechanical durability are carried out on tearing machine in which the temperature value and tension stress are given for each sample and the time interval from load moment up to sample rupture is defined. The durability value in time interval from several seconds up to 10^5sec is measured.

The durability measurement of samples series not less 30 is carried out for each combination voltage-temperature because of the character essential spread of durability values at measurements

The investigation of reversibility degree of accumulation processes leading to mechanical failure is carried out on the base of known method which is the comparison of durability measurement results at continuous action of mechanical load with durability measurement results at discontinuous action. Note that quantitative analysis of test results of similar type for polymer mechanical failure is carried out but not for polymer compositions and without necessary account of durability statistics [2].

Thereto, the measurements of mechanical durability (τ) of polymer compositions PP-PELD are carries out in series from 30 samples in present work because these measurements with the discontinuous action of mechanical load on single samples don't give the possibility to analyze the sample distribution functions on mechanical durability.

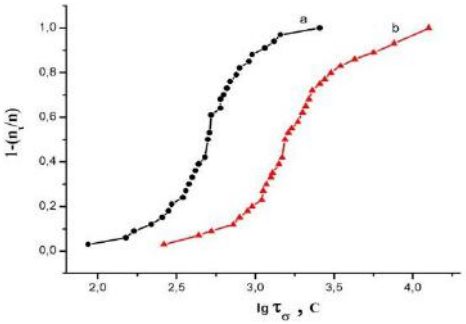

Fig. 1. The integral distribution of polymer composition samples on durability. The mechanical failure of 30 samples at T=223K.
a) SC samples of PP-PELD,σ=80 MPa;
b) RC samples of PP-PELD,σ=90 MPa.

131 H.Javid ave, AZ-1143, Baku
ANAS, G.M.Abdullayev Institute of Physics
E-mail: jophphysics@gmail.com

The integral functions of distribution for slowly cooled (SC) and rapidly cooled (RC) samples of PP-PELD correspondingly on $lg\tau$ at corresponding mechanical load (σ) and temperature (T) are shown in fig.1 (a,b).

The function $1\text{-}n_\tau/n$, where n is total number of samples in series is given on ordinate axis ; n_τ is number of samples saved in intact state after τ endurance time. As it is seen the plots of these functions for τ in both compositions has the unified S-form with effective distribution width $\Delta lg\tau \simeq 1\div1{,}5$. The distribution form is close to normal distribution of random variable (probability integral). The distribution width is caused by structure variation and sample imperfection and etc. The mechanical durability values appropriating to failure of half number of samples for SC and RC of PP-PELD, τ_1=504sec and τ_1=1590sec correspondingly, are defined from fig.1(a,b). Further, the new series of the same samples are endured at the same σ and T values during $\tau_1$time correspondingly, after that the load (σ). As a result, the half number of samples, with which the further operations are carried out, stay in intact state. The meaning and method of data analysis is diagrammatically explained in fig.2.

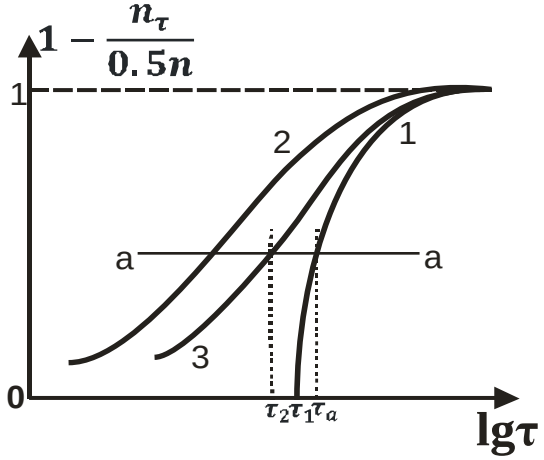

Fig.2. The distribution scheme of polymer composition samples PP-PELD by durability is: 1. Samples which become indifferent ones after endurance during τ_1 time; 2. The distribution by secondary durability $lg(\tau-\tau_1)$; 3. Samples treated by partial regeneration.

Here the curve 1 is upper part of distribution curves (fig.1), i.e. it is constructed from level 0,5 in fig.1 and renormalized one on total number of samples (with ordinate $1\text{-}n_\tau/0{,}5n$, which are not broken. If we propose that accumulated changes in samples, which are not broken, during interruption time are disappeared (total regeneration) after endurance under mechanical load during τ_1 time, then the distribution of these samples on secondary durability should coincide with curve 1after secondary application of the same load. If the accumulated changes are totally kept during interruption time after endurance during τ_1 and load taking off, then sample distribution on secondary durability should obtain by reconstruction curve 1 from values $lg\tau$ to $lg(\tau\text{-}\tau_1)$ ones and has the form of curve 2 (fig.2), i.e. in the region of lesser τ values, especially in the region of distribution initial (low) part. Finally, if partial regeneration of accumulated changes takes place in the interval between load taking off and its repeated application in the samples, then the sample distribution on secondary durability should take place between 1 and 2 curves, i.e. correspond to curve 3. The distributions on durability at continuous load action for slow cooling (SC) PP-PELD samples with durability exceeding τ_1=504 sec, i.e. renormalized upper parts of distribution curves from n on 0,5n (fig.1).

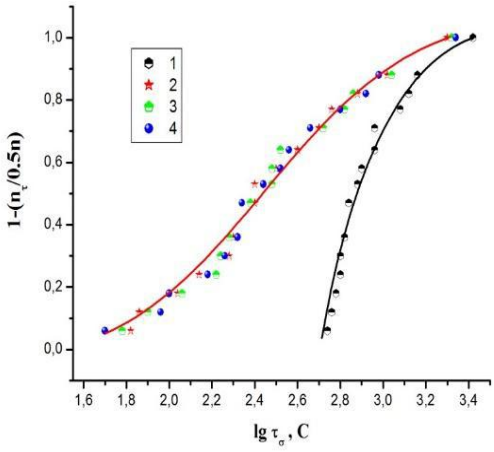

Fig. 3. The integral distribution of SC samples PP-PELD on mechanical durability. σ=80 MPa, T=223K.
1is failure during time exceeding τ_1=504sec; 2 is distribution of the same samples on $lg(\tau\text{-}\tau_1)$; 3 is measured sample distribution on secondary durability after "resort" during 10^3sec at 223K; 4 is measured sample distribution on secondary durability after "resort" during 10^3sec at 323K (regeneration absence).

Points 3 are reconstruction results of points 1on coordinate $lg(\tau\text{-}\tau_1)$. Points 3 are experimental data on secondary durability after sample endurance under load during time τ_1 and load interruption time 10^3sec at 223K. The closeness of 2 and 3 points in fig.3 evidences on fact that changes accumulate in samples during τ_1 of first endurance under load. These changes keep in load interruption time at the same temperature that leads to lower values of secondary durability, The corresponding data for RC samples PP-PELD are similar ones, i.e. the accumulated changes in both samples behave as irreversible ones under conditions of mechanical failure kinetics at comparatively low temperatures.

For mechanical failure during the "resort" the samples are endured at the exceeded temperatures. The results of such tests when unloaded SC samples of compositions are endured at 323K during 10^3 sec in interval are presented in fig.3 (points 4).It is seen that "resort" temperature increase doesn't lead to change of sample distribution on secondary durability, i.e. change regeneration doesn't observed. This allows us to conclude that changes caused by action of mechanical load are the enough stable ones. The earlier mentioned irreversibility of accumulated changes at mechanical failure of polymer compositions [2] is confirmed in present work. This well agrees with conception on accumulation of chain

molecule rupture during the time. Especially the rupture act chain molecules at mechanical stress carried out by fluctuation mechanism, behaves itself in the capacity of elementary failure act of polymers and compositions on the base polymer-polymer [1].

The further polymer failure process is developed on the base of such molecular ruptures: the formation of germ cracks and rupture of whole sample [1]. It is natural that recombination of chain molecule rupture is enough incredibly, so the secondary free-radical reactions, "convolution" of molecule parts unloaded by rupture prevent to regeneration of its continuity [1,3] after rupture. In this fact we can see the specific of polymer failure process and their compositions. Note that continuity regeneration at mechanical failure of three-dimensional atom-molecular structure bodies, in particular, metal is possible [4]. At corresponding conditions (temperature, pressure) we can reconstruct the initial continuity of objects ("cure" of accumulating micro-cracks and pores) and whereas to multiply increase of their mechanical durability.

CONCLUSION

The results of our investigation are data on character of accumulation processes leading to rupture of polymer compositions with confirmation of irreversibility of these processes in the case of mechanical failure of polymer compositions obtained on the base of statistical analysis of mechanical durability.

[1] *B.L. Qilyarov*. FTT 2005, t.45, №5, s.808-811. (In Russian).
[2] *A.I. Sluchker, T.M. Veliev, I.K. Alieva, V.A. Alekperov, S.A. Abasov.* FTT 1990, t.32, №8, s.2399-2344. (In Russian).
[3] *V.A. Zakrevskiy, V.A. Paxotin.* FTT, 2010,t.52, №6, s.1083-1089. (In Russian).
[4] *V.I. Betextin, A.I. Ormanov*. FMM 1989, t.67, №5, s.318-322. (In Russian).

Recevied: 07.10.2015