8 ~~[illegible]~~ -

Fatigue in polymers :-

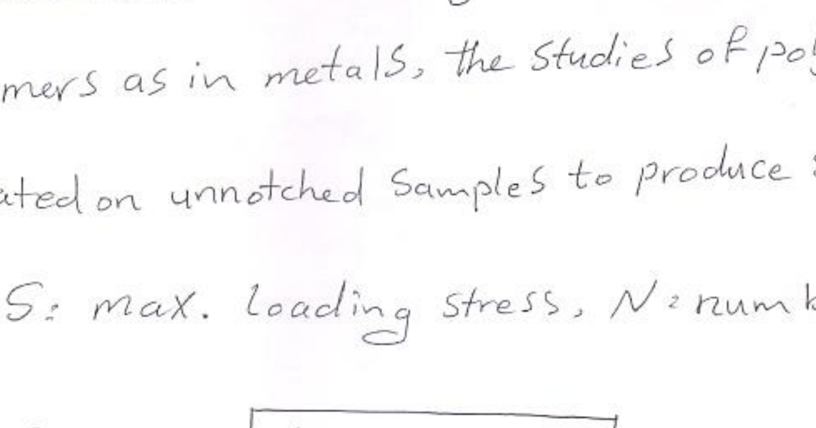
محاضرة (١٢)

Fatigue is Common Form of Failure of materials in practical use ; the failure occurs due to the cyclic application of Stresses which are below the Stress required to Cause yield or Fracture by Continuously rising Applied stress.

The effect of Such cyclic stresses is to initiate microscopic Cracks at Centres of Stress Concentration within the material or on the Surface and subsequently to enable these cracks to propagate leading to eventual Failure.

~~In metals, the studies of fatig~~

In polymers as in metals, the studies of polymers Concentrated on unnotched Samples to produce S versus N plot ; S: max. loading stress, N: number of Cycles to failure.



Fatigue response of PVC

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atigue Crack growth rate Could be expressed in the Form of empirical relationship : $\frac{dc}{dN} = A T^n$ — (A)

For a single edge notch specimen : $T = 2 K_1 C U$

C = Crack length , N : number of cycles , T is Surface work parameter (analogous to G ~~fracture energy~~ in linear elastic fracture mechanics).

$U = \sigma^2/2E$ = the Stored energy density for a linear elastic material; K_1 : Const. varies from π at Small extensions (linear elastic value) to approximately unity (1) at large extensions. A and n Constants depend on the material and vary with test Conditions Such as Temp. . n lies between (1 - 6) and equal to 2 for rubbers.

T is positive quantity vary during the test Cycle from Zero ($T = T_{min}$) to a finite value ($T = T_{max.}$). if T_{min} is increased, there is a corresponding decrease in the Const. $\underline{A}$;

This attributed to reduced crack propagation where strain induced Crystallization occurs.

~~The limiting value $T \leq T_0$~~

The limiting value $T = T_0$ is called the fatigue limit below ~~which~~ it a fatigue crack will not propagated.

~~$T \leq T_0$~~ The above relationship is Applicable on rubbers.

For glassy polymers, the fatigue crack growth rate is usually expressed in the form of empirical relationship :-

$$\frac{dc}{dN} = A'(\Delta K)^m \quad \text{(B)}$$

c: crack length ;

N: number of cycles ; ΔK: range of the stress intensity factor $(K_{max} - K_{min})$; K_{min} is generally Zero.

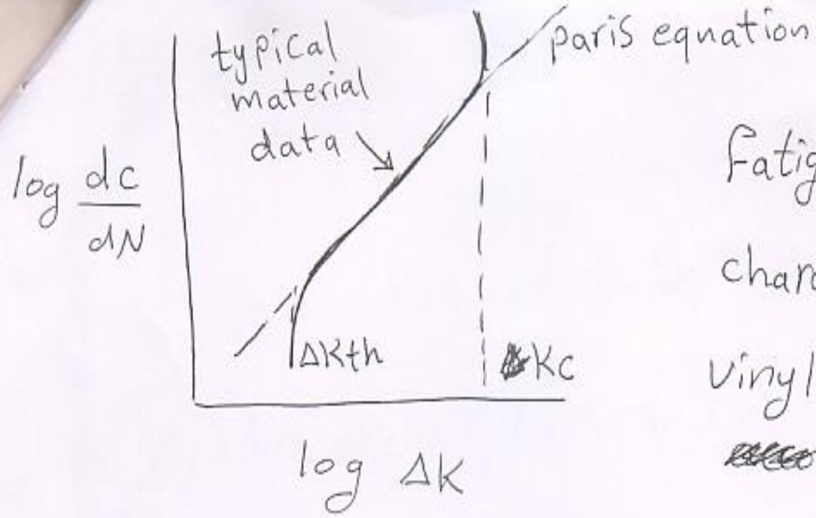
A' and m are Constants depending on the material and test Conditions. (equation (B) is called paris equation).

Strain energy release rate $G = K^2/E$ for plane stress

$G = 2T = K^2_{max}/2E = (\Delta K)^2/2E$

A and B equation are identical if $K_{min} = 0$ and equivalent if $m = 2n$; equation B is Applied for predicting fatigue Crack growth rates in metals.

The following figure is represented Paris equation



Fatigue crack growth characteristics for a vinyl urethane polymer

ΔK_{th} = thershold value of ΔK, below which no crack growth is observed, as ΔK approaches the critical stress intensity factor K_c, the crack accelerates.

There is a strong sensitivity between fatigue crack growth and molecular weight.

For example: in PS a five fold increase in molecular weight resulted in amore than 10-fold increase in fatigue life.