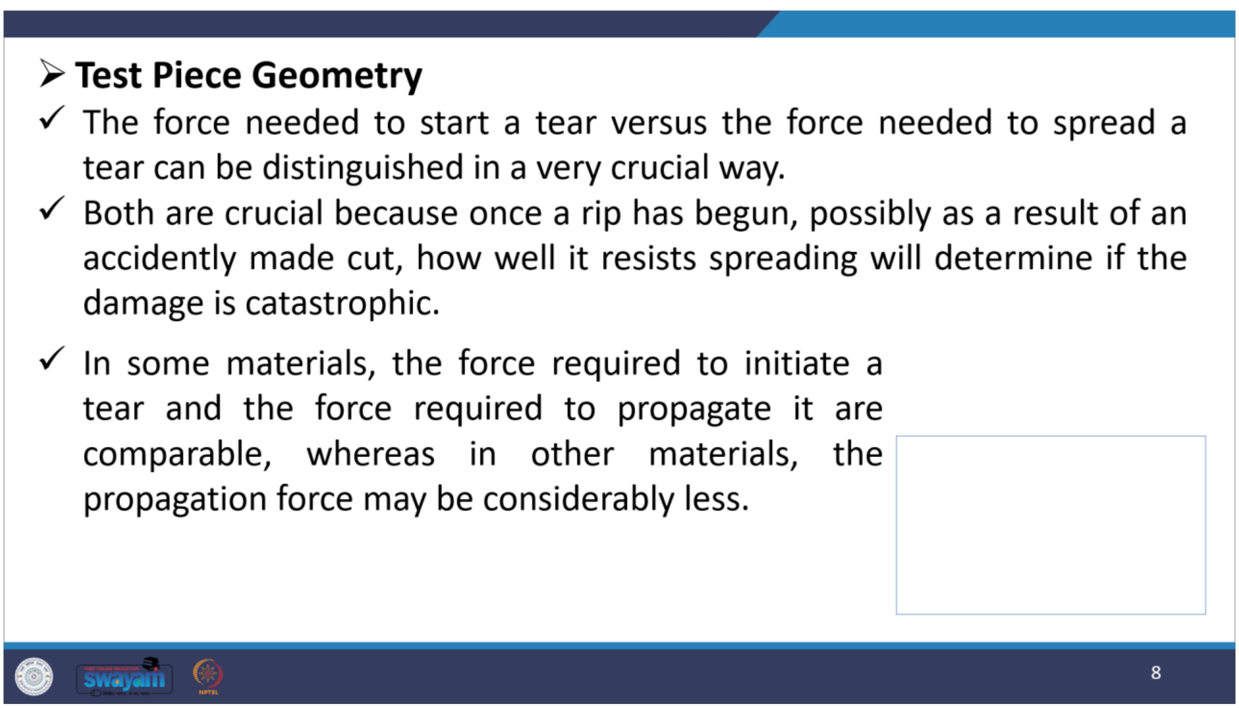
Lecture 43- Polymer Testing -08

Hello friends, welcome to the Tear and fracture concept of mechanical properties of polymer testing under the edge of polymer process engineering in the previous lecture, we cover about the impact strength under the head of mechanical properties in which we discussed about the factors those affecting the impact strength. We discussed the specific test carried out for the same purpose and we discussed the pendulum and drop method for evaluating the impact strength. In this segment, we are going to discuss tears. We will discuss the test piece geometry; we will discuss the standard methods. Apart from this, we will discuss the fracture toughness, then we will discuss the fundamental concept of fracture, then how the standard methods they are being evaluated and they are helpful for evaluating the fracture toughness. So, when we talk about the tear properties, in a tear test the force is concentrated on a purposeful fault or sharp discontinuity rather than being applied evenly and the force required to continuously produce new surface is measured.

The geometry of the test piece and the type of discontinuity will both play a significant role in determining the force required to initiate or maintain tearing. In addition to being a factor in abrasion and fatigue process in flexible material, tearing can happen in practically any product created for sheet or film. It can be challenging to draw a clear connection between the outcome of laboratory test and service performance since tear strength from typical tests is not a quality of the material that is inherent. a method to fracture mechanics for rubbers that leverages the idea of energy of tearing, the energy needed to create a unit area of new surface during tearing was developed in many years ago.



Theoretically, the tearing energy is a fundamental material attribute that is independent of the geometry of the test piece. So, it was important to imply a test piece where the relationship between the force and energy was rather straightforward in order to acquire the ripping energy. Additionally, the tearing of the plastic film has also been studied using a fracture mechanics technique. A tensile test machine with the proper grip is used for the majority of tear tests which entail applying the tensile force to a test item. because the force can rise very quickly and fluctuate dynamically during the several tests, the apparatus reaction properties are especially crucial.

A pendulum is employed in the commonly used Elmendorf apparatus applying a tearing force which is a distinct method. Tearing is caused by energy stored in the pendulum and the amount consumed is determined by the ratio of energy lost to the total available. it is possible that the initial motivation for this strategy was to have a freestanding device that was reasonably affordable and straightforward. Let us talk about the test piece geometry. The force needed to start a tear versus the force needed to spread a tear can be distinguished in a very crucial way.

Both are crucial because once a rip has begun, possibly as a result of an accidentally made cut how well it resists spreading will determine if the damage is catastrophic. in some material the force required to initiate a tear and the force required to propagate it both are comparable whereas in other materials the propagation force may be considerably less. cuts acute reentry angles or a combination of the two might create the discontinuity at which the stress concentration is produced. The majority of the standard test pieces have an artificial cut thus only a method with a sharp angle or no cut would be able to quantify the force that initiates tear. Of course, one may counter that a cut is always conceivable and that is the propagation strength will be the limiting factor if it is similar.

The geometry that occurs most frequently is one in which that applied force is applied at an angle to the direction of the tear and the stresses are virtually tensile at the tip of the tear. this figure there are three prominent variations are depicted. This is the crescent; this represents the delft, and this is the angle. This is showing the tear piece geometry. all of these test pieces are used for rubber but the only one that is currently standardized for plastic is the angle test piece.

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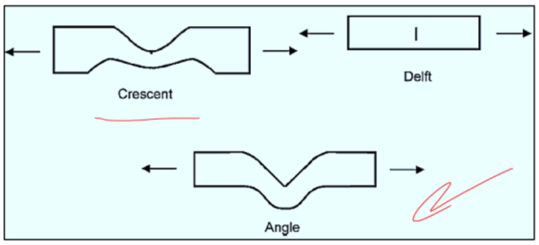
- ✓ In Figure, three prominent variations are depicted.



Figure; Showing tear test piece geometries

Source; Roger Brown, Handbook of polymer testing; short term mechanical tests; First edition, Rapra Technology Limited., (2002), ISBN: 1-85957-324-X. 10

The trouser test piece which is as per this figure is the other frequent geometry. This is the trouser test piece. Crescent tear which was so popular for rubbers is no longer utilized on plastic because the idea is so straightforward. If there is a lack of material the depth geometry is especially helpful. The only geometry in common use where an initiating force is measured is the angle tear without a cut although maintaining the angle of the cutter properly is necessary to produce repeatable result.

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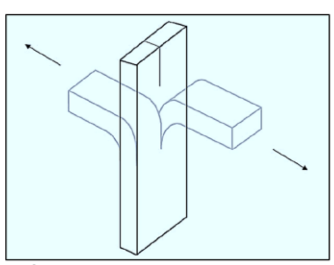
- ✓ All of these are used for rubbers, but the only one that is currently standardized for plastics is the angle test piece.
- ✓ The trouser test piece, which is shown in Figure, is the other frequent geometry.



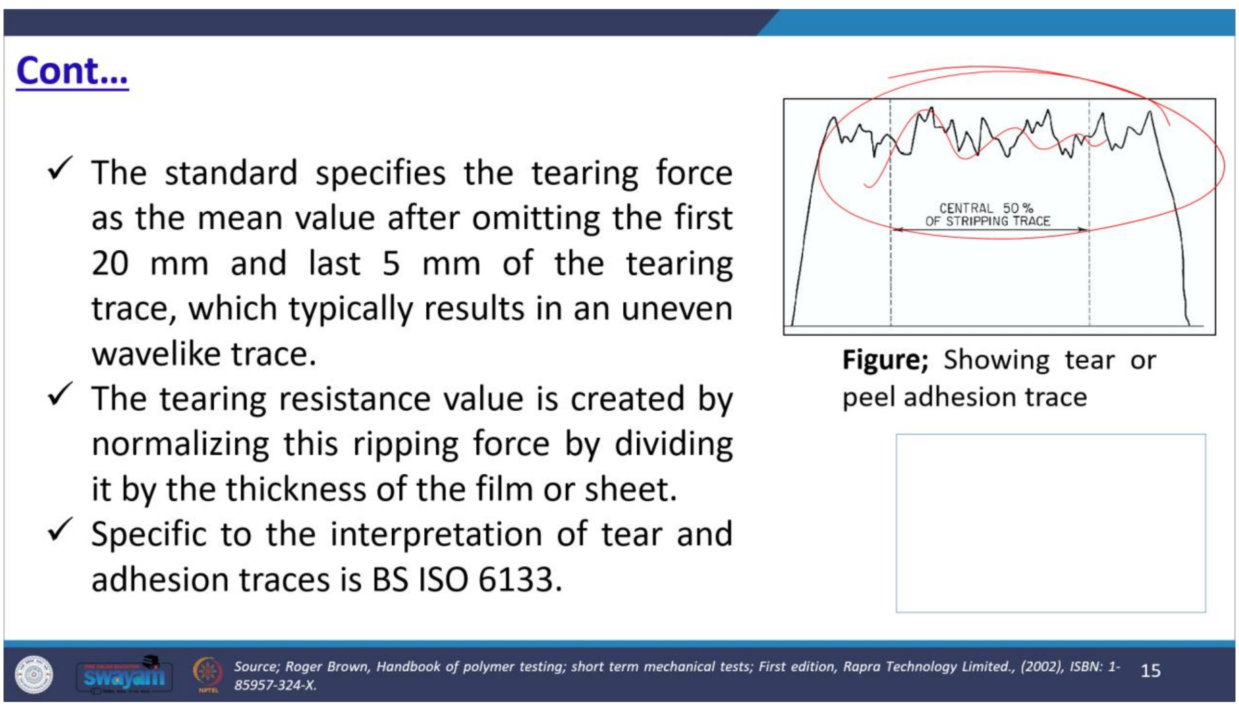
Figure; Showing trouser tear test piece

Source; Roger Brown, Handbook of polymer testing; short term mechanical tests; First edition, Rapra Technology Limited., (2002), ISBN: 1-85957-324-X. 11

Shear force must be present in stress during the trouser tear. It is reasonably simple or simple form to cut and allows one to track the tear propagation course. If cutting occurs while the material is under additional stress a sharp object will have the material tear. cutting uses both the material strength characteristics and friction. Therefore, if a stress is applied while cutting friction the force required to produce cutting are both greatly reduced.

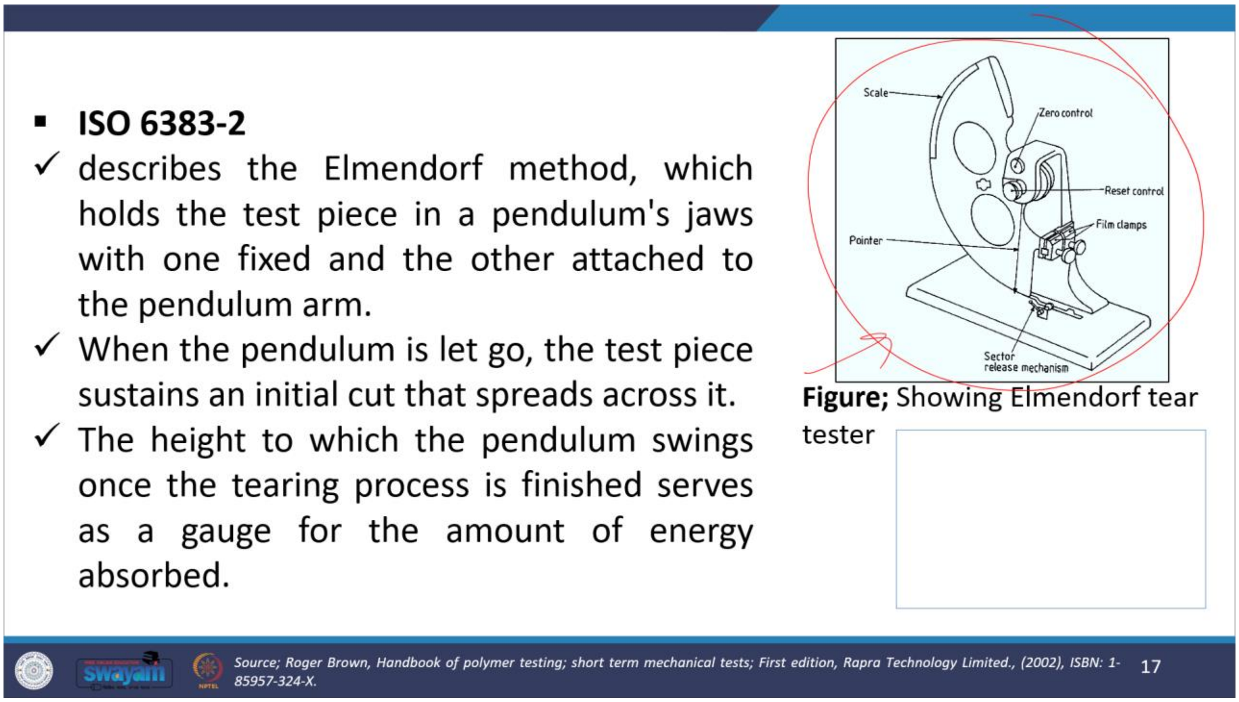
Although the geometry can be set up so that the test propagates after piercing puncture test could be seen as a typical type of tear initiation. Cutting or puncture tests often take place under ad hoc circumstances, meaning to mimic the load and geometry of service. Let us talk about some standard tests. An International standards only cover two techniques ISO 6383 the geometry of trouser test is described in the first section of ISO 6383 which is substantially the same as the geometry of rubber. A test piece measuring 150 mm by 50 mm is cut from one end halfway down its length along the center of its long axis.

The two legs are then separated at a rate of 200 or 250 mm per minute while being held in the stationary and moving jaws of universal testing machine or UTM. The standard specifies the tearing force as the mean value after omitting the first 20 mm and last 5 mm of the tearing trace which typically results in an uneven wave like trace like this. This is the wavy structure. The tearing resistance value is created by normalizing these ripping forces by dividing it by the thickness of the film or sheet. specific to the interpretation of tear and adhesion traces is BS ISO 6133.



for traces with less than 5 peaks or 5 to 20 peaks or more than 20 peaks the standard provides three approaches. For traces with fewer than few peaks, 5 peaks the medium of all peaks is calculated. For traces with 5 or 20 peaks the median of the peaks inside the central 80 percent of the trace is calculated and for traces with more than 20 peaks the trace is divided into 10th by 9 lines with the peak closest to each line being noted and the median of these taken.

Let us talk about ISO 6383-2. This describes the Elmendorf method which holds the test piece in a pendulum's jaw with one fixed and other attached to the pendulum like this. This is the figure showing the Elmendorf tear tester. When the pendulum is let go of the test piece sustain an initial cut that is spreads across it. The height to which the pendulum swings once the tearing process is finished serves as a gauge for energy absorbed.



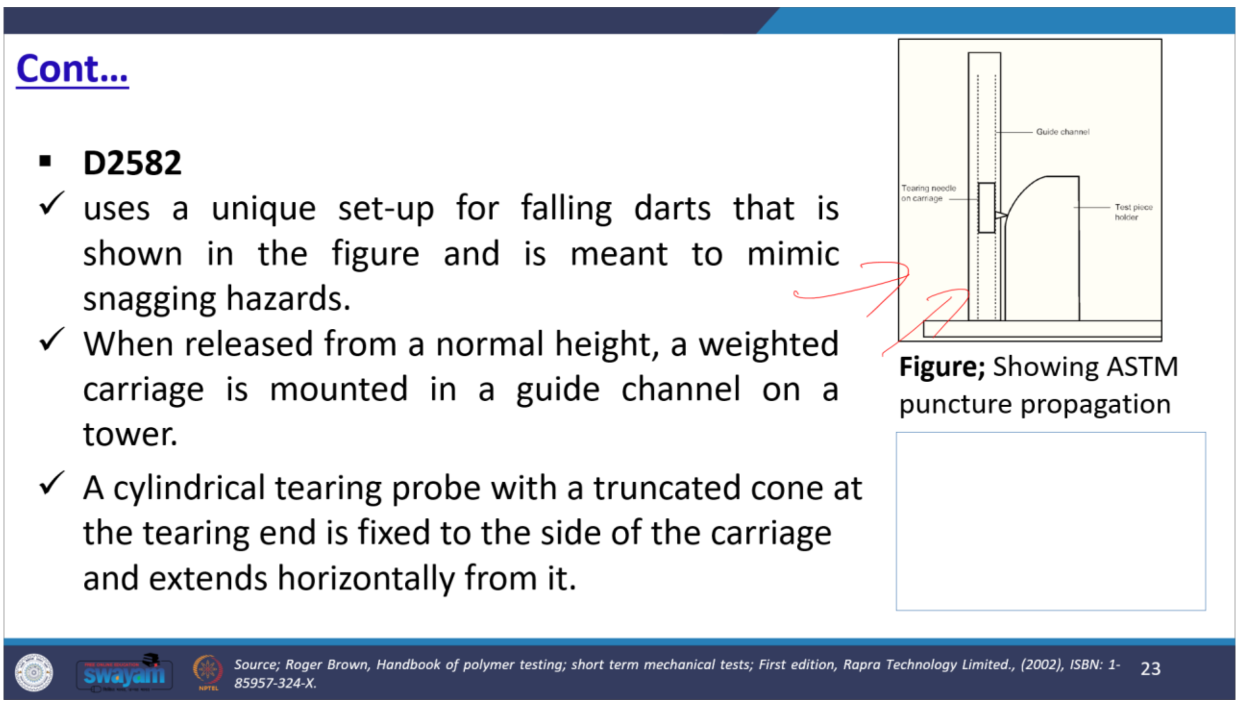
The rectangular test piece and the constant radius test piece are the two prescribed test pieces with the former being preferable due to higher reproducibility. The rectangular test piece as its name suggests has sides that measure 75 mm by 63 mm and a 20 mm long slit that is cut parallel to and in the middle of the longer side.

The constant radius test piece has the same 20 mm slit and 75 mm length but its age facing the cut is curved rather than straight having a radius of 43 mm. So, as a result the tear length and in theory the tearing energy should remain constant and if the rip propagates at an angle of to the pendulum's motion. The standard permits playing of test pieces are adding additional masses to the pendulum so that the energy utilized is between 20 and 80 percent of the pendulum's capacity. Even though the test is energy based the ripping force is determined by using the scale reading and the conversion factors that the manufacturer supplies. The tearing force, not the tearing force normalized to the test piece thickness determines the tearing resistance and the method for calibrating the pendulum by adding weight is provided in an appendix usually which referred in the reference.

However, it seems to assume that the pendulum factor is kn to and accurate. Let us talk about the British method BS2782 method 360C. It is based on the trouser method but uses a small test piece and only calls for 250 mm per minute as opposed to the ISO protocol. The maximum force is recorded as the dumbbell is pushed in a tensile machine that is speed of 250 mm per minute. The tear strength is determined by dividing the force by the thickness.

Before testing the test piece usually not to cut. Tear initiation is measured using this technique. If we compare it with the ASTM test there are 4 tear test procedures. Although D1938 is based on the trouser method it uses a small test piece and only splits a speed of 250 mm per minute. D1922 employs an Elmendorf pendulum and test piece with a constant radius is in accordance with the ISO standard.

The angle tear method D1004 only uses 51 mm per minute grip separation speed. This differs from the ISO and BS methodologies sufficiently for one to anticipate variation in test results. D2582 this uses a unique setup for falling darts that is shown in this figure and is meant to mimic the snagging hazard. This figure shows the ASTM puncture propagation. When released from a normal height a weight carried is mounted in a guide channel on a tower.

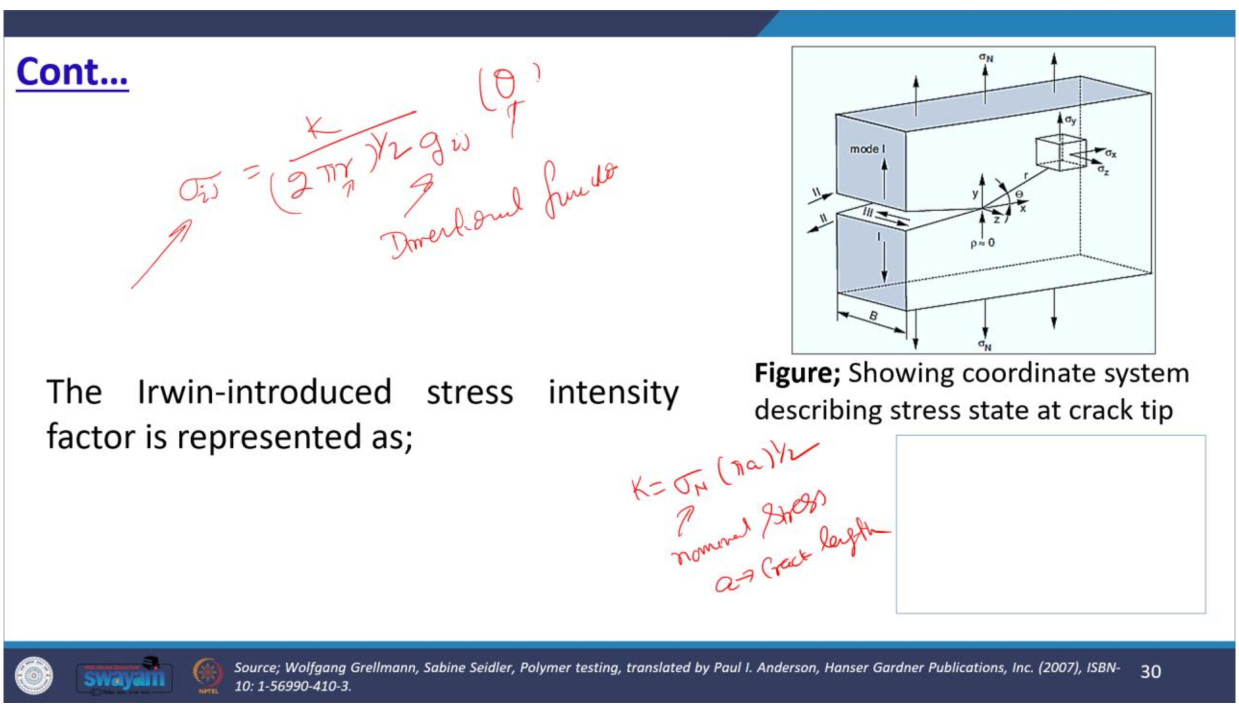


A cylindrical tearing probe with a truncated cone at the tearing end is fixed to the side of this carriage and extends horizontally from it. This hits a test piece that is attached to a curved holder right next to the tower. The carriage is falling down causing the distance between the film and the tower to get smaller as carriage descends the tower. The probe barely scraps the film surface after falling 508 mm before penetrating and ripping it apart. The length of the tear resulting from this is used as a proxy for tear resistance. Let us talk about the other test methods.

For ad hoc cutting and piercing testing to mimic a specific service situation the different methods have been used. Some individuals consider the impact test for falling darts on film to be a tear related puncture test. It may be useful to use a type of fatigue test in some application where a test is propagated by dynamic straining. To examine cut growth fatigue test for rubber in this way the tear analyzer device has been created expressly for this particular purpose and the fracture mechanics principle has been implemented. Dawson and Bose note the result from the element dot rip and falling dart impact are frequently incongruent and suggest using a single specimen J integral analysis and the fracture tip opening displacement techniques.

Eason and colleagues used to use the single specimen J-integral method on blown film and compared the result to the dart and Elmendorf test. Let us talk about the fracture toughness by considering the load or pressure that causes a crack to propagate fracture mechanics differs offers a method of understanding that material reaction irrespective of geometry. Griffith was the first to suggest this particular strategy in 1920 and it took until 2000 for the first worldwide standard for the fracture mechanics-based test on plastic this to be this was published. The idea behind the fracture mechanic technique says that the load will cause stress concentration at defects or cracks in the material. So, when cohesive strength of the material is exceeded by the stress intensity at the fracture strip a crack will begin to spread.

In brittle material a decrease in the total elastic strain energy of this stress sample balances the energy required to produce new fracture surfaces. The energy balance for ductile material will include the effect put forward to produce the plastic deformation as well as the development of a new fracture surface. Let us talk about the fundamental concepts for fracture mechanics. Linear elastic fracture mechanics LEFM according to the theory of fracture mechanics crack propagation leads to fracture in component and subsequently in its material. It examines the circumstances that led to crack propagation and enables the establishment of quantitative relationship between the external load operating on the component or specimen or nominal stress and the size and shape of a crack as well as the material crack propagation.



So, the stress situation close to the fracture tip is expressed by a linear elastic fracture mechanics concept as the stress intensity factor k., this is the mathematical relationship.

$$\sigma_{ij} = \frac{k}{(2\pi r)^{\frac{1}{2}} g_{ij}} \theta$$

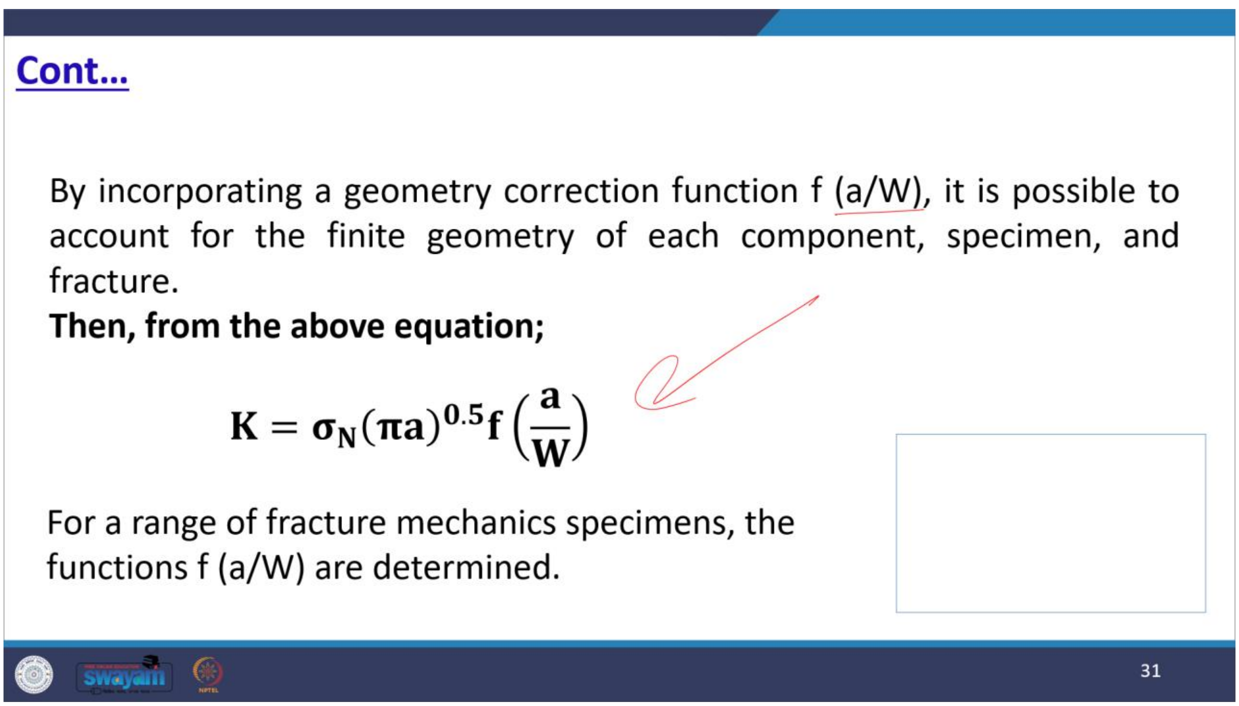
here σ_{ij} is the shear stress, r is the radius, and this one is the polar coordinates with crack tips as a point of origin dimensional origin. this g_{ij} is the dimensional function dimensional function. Irwin introduced a stress intensity factor which can be represented as k:

$$k = \sigma_N \ (\pi a)^{\frac{1}{2}}$$

Where σ_N is the nominal stress and a is the crack length. So, these are the mathematical representations. By incorporating a geometry correction factor say f (a/w), it is possible to account for the finite geometry of each component specimen and fracture. Then from these equations this can be represented as

$$K = \sigma_N \ (\pi a)^{0.5} f\left(\frac{a}{W}\right)$$

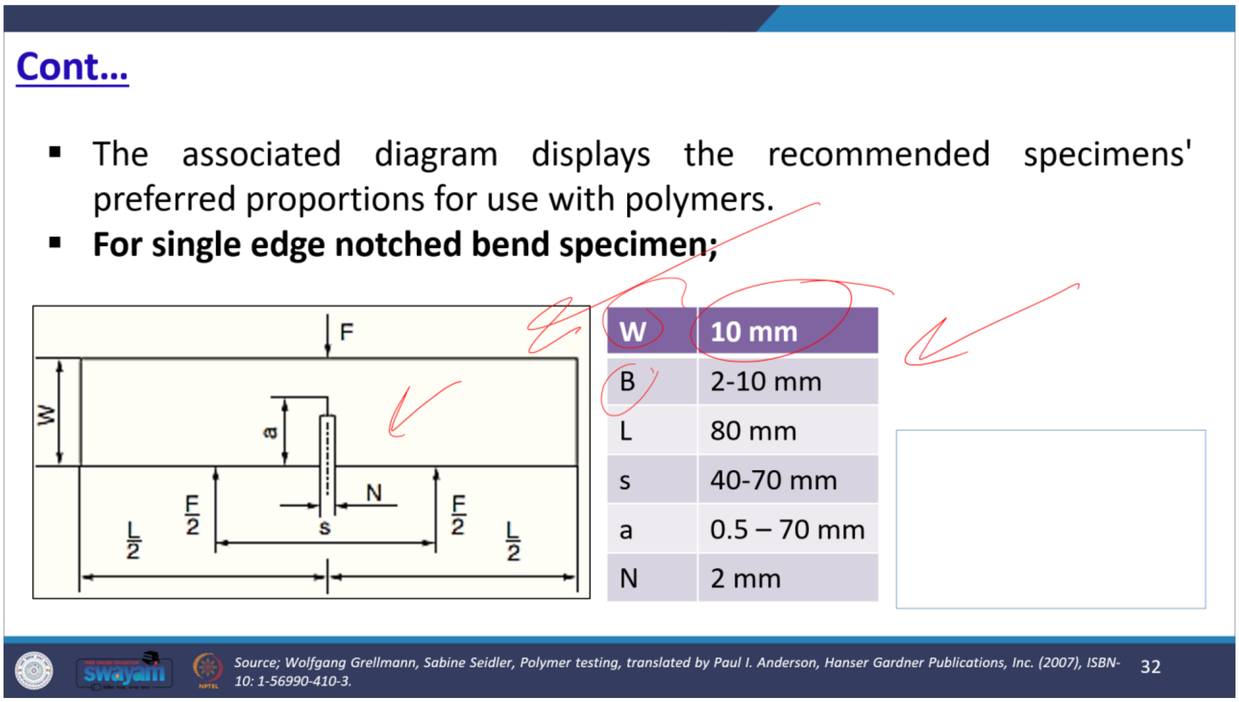
For a range of fracture mechanics specimen this function they are determined. The associated diagrams sometimes display the recommended specimens preferred proportion for use with the polymer.



For single edge notched band specimen here the

W	**10 mm**

B	2-10 mm
L	80 mm
s	40-70 mm
a	0.5 – 70 mm
N	2 mm



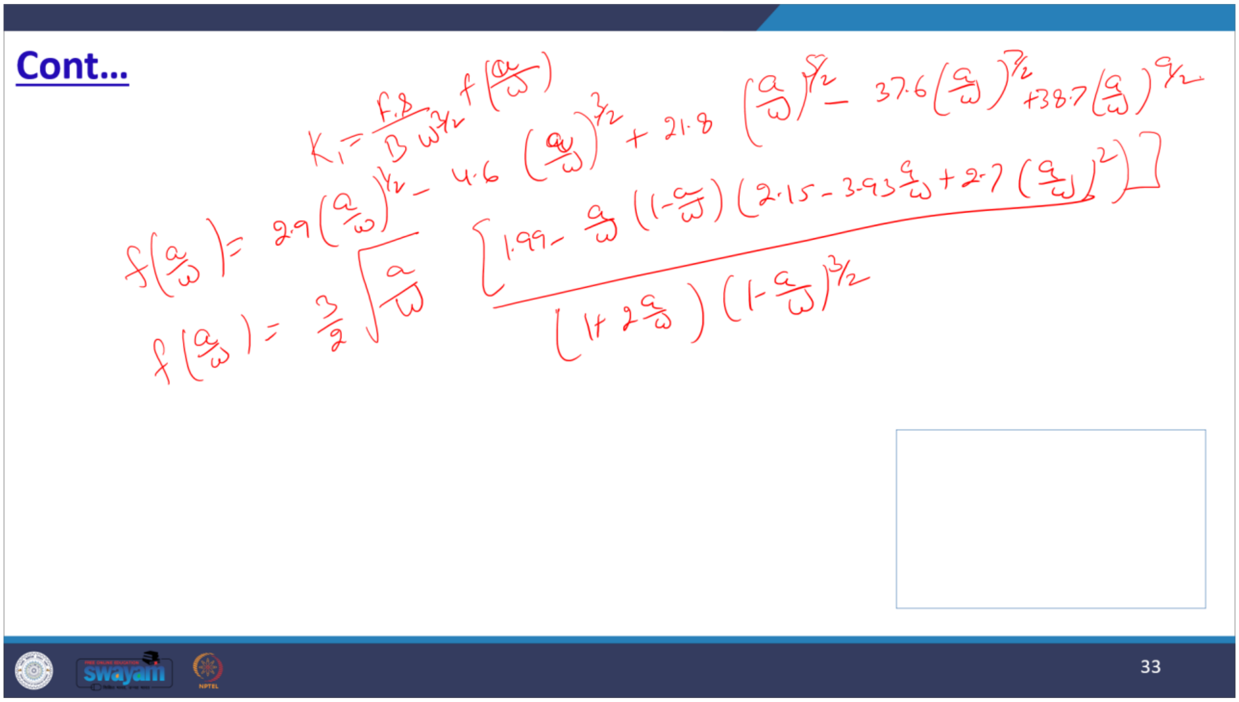
These different parameters have been given for the different types of a notched band specimen.

Let us develop this some mathematical approaches like

$$k_1 = \frac{fs}{Bw^{\frac{3}{2}}} f(a/w)$$

$$f\left(\frac{a}{w}\right) = 2.9\left(\frac{a}{w}\right)^{\frac{1}{2}} - 4.6\left(\frac{a}{w}\right)^{\frac{3}{2}} + 21.8\left(\frac{a}{w}\right)^{\frac{5}{2}} - 37.6\left(\frac{a}{w}\right)^{\frac{7}{2}} + 38.7\left(\frac{a}{w}\right)^{\frac{9}{2}}$$

$$f\left(\frac{a}{w}\right) = \frac{3}{2}\sqrt{\frac{a}{w}}\,\frac{\left[1.99 - \frac{a}{w}\left(1 - \frac{a}{w}\right)\right]\left[2.15 - \frac{3.93a}{w} + 2.7\left(\frac{a}{w}\right)^{2}\right]}{\left[1 + \frac{2a}{w}\right]\left(1 - \frac{a}{w}\right)^{\frac{3}{2}}}$$

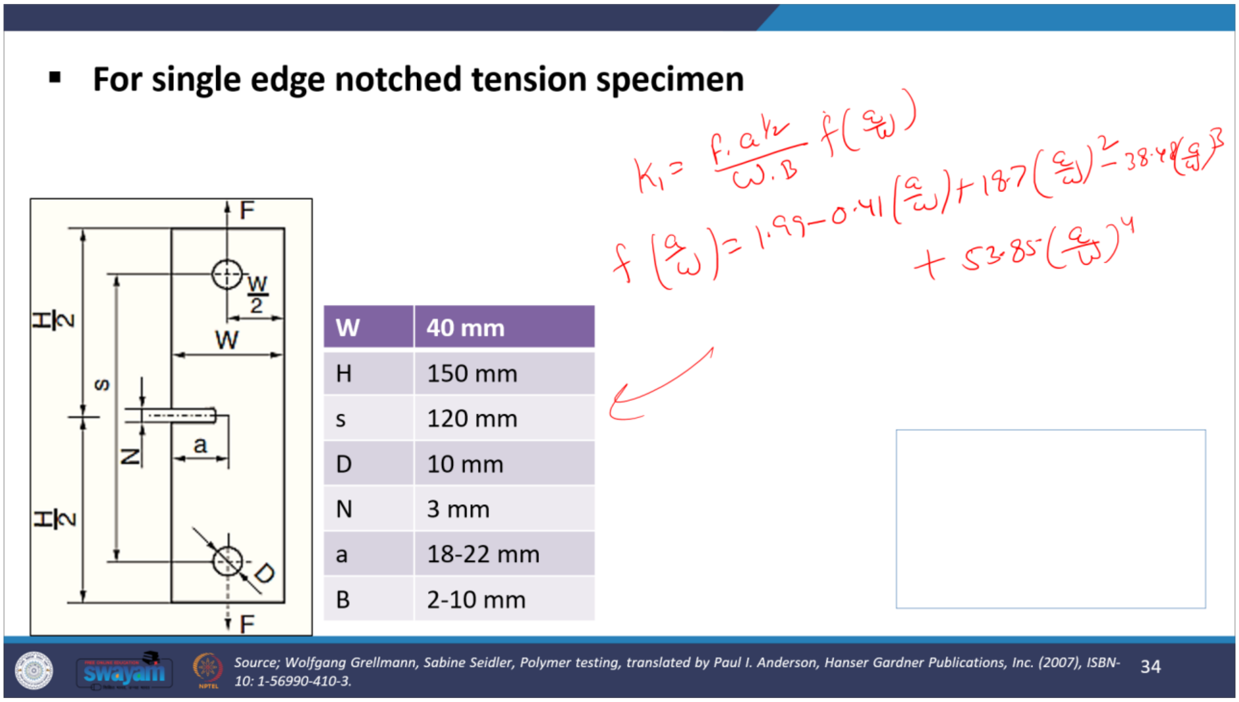


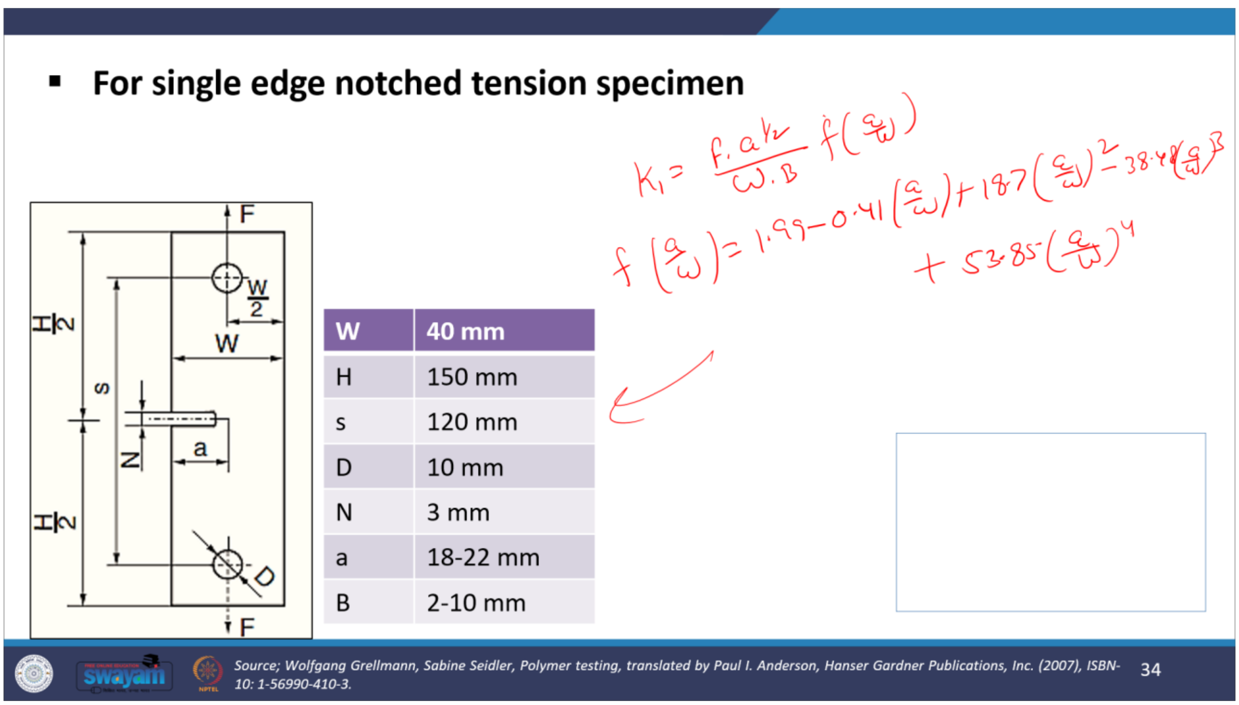
For single notched tension specimen this can be given as

$$k_1 = \frac{f a^{\frac{1}{2}}}{wB} f\left(\frac{a}{w}\right)$$

$$f\left(\frac{a}{w}\right) = 1.99 - 0.41\left(\frac{a}{w}\right) + 18.7\left(\frac{a}{w}\right)^2 - 38.48\left(\frac{a}{w}\right)^3 + 53.85\left(\frac{a}{w}\right)^4$$

So, relevant data is given in this segment.





If we talk about the compact tension specimen:

$$k_1 = \frac{f}{Bw^{\frac{1}{2}}} f\left(\frac{a}{w}\right)$$

and

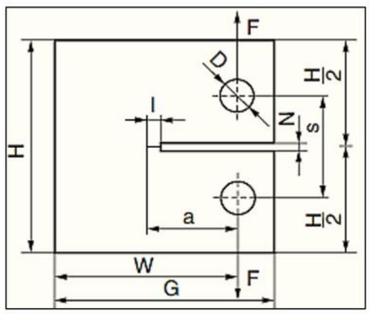
$$f\left(\frac{a}{w}\right) = 29.6\left(\frac{a}{w}\right)^{\frac{1}{2}} - 185.5\left(\frac{a}{w}\right)^{\frac{3}{2}} + 655.7\left(\frac{a}{w}\right)^{\frac{5}{2}} - 1017\left(\frac{a}{w}\right)^{\frac{7}{2}} + 638.9\left(\frac{a}{w}\right)^{\frac{9}{2}}$$

- **For compact tension specimen**

$$K_I = \frac{F}{BW^{1/2}} f\left(\frac{a}{W}\right)$$

$$f\left(\frac{a}{W}\right) = 29.6\left(\frac{a}{W}\right)^{1/2} - 185.5\left(\frac{a}{W}\right)^{3/2} + 655.7\left(\frac{a}{W}\right)^{5/2} - 1017\left(\frac{a}{W}\right)^{7/2} + 638.9\left(\frac{a}{W}\right)^{9/2}$$

W	40 mm
H	48 mm
s	22 mm
D	10 mm
N	2 mm
a	18-22 mm
B	2-34 mm
G	120 mm
l	1.5 mm



Source; Wolfgang Grellmann, Sabine Seidler, Polymer testing, translated by Paul I. Anderson, Hanser Gardner Publications, Inc. (2007), ISBN-10: 1-56990-410-3. 35

For an infinitely extended specimen and the borderline case of a crack with notch radius $\rho \sim 0$, then f (a/W) = 1. The stress intensity factor reaches the critical value KIc (in MPa $mm^{1/2}$), also known as fracture or crack toughness, at the beginning of unstable crack propagation. Index I refers to Mode I loading, in which the load applies perpendicular to the crack surface. The fracture criteria for this technically significant occurrence of loading is.

$$K_I \leq K_{Ic}$$

Wherein, provided the critical value is not exceeded component safety against the fracture is guaranteed. Different multi axial stresses might arise in front of the crack tip depending on the specimen geometry. The figure illustrates the impact of a specimen thickness on fracture behavior using the example of PVCC and PP. The change from the plane stress to a plane strain condition causes an apparent macroscopic increase in normal stress fracture.

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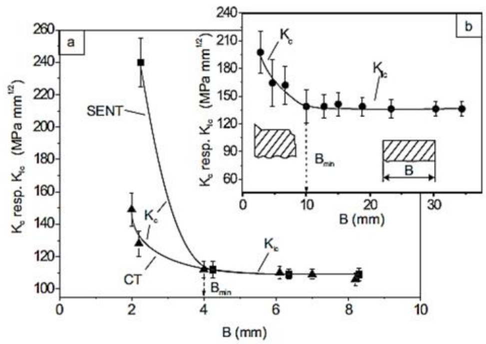


Figure; Showing dependency of fracture toughness K_c, K_{Ic} at room temperature on specimen thickness under quasi static load (a) for PVC with K_{Ic} = 110 Mpa mm^1/2 (b) for PP with K_{Ic} =139 Mpa mm^0.5 at traverse speed v_T = 8.3x10^-4 m/s.

Source; Wolfgang Grellmann, Sabine Seidler, Polymer testing, translated by Paul I. Anderson, Hanser Gardner Publications, Inc. (2007), ISBN-10: 1-56990-410-3. 38

This is the figure showing the dependency of the fracture toughness K_c, K_{Ic} at room temperature on specimen thickness under quasi static load (a) for PVC with K_{Ic} = 110 Mpa mm$^{1/2}$ (b) for PP with K_{Ic} =139 Mpa mm$^{0.5}$ at traverse speed $v_T = 8.3x10^{-4}$ m/s.

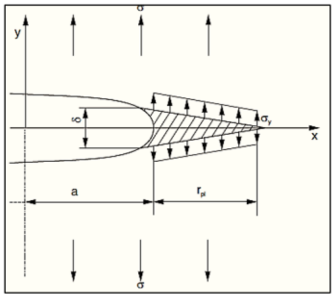
The fracture toughness depends on the specimen geometry when the crack tip is subject to plane strain. It depicts how toughness is impacted by the material structure, loading rate and environmental temperature. In the linear elastic technique of empirically discovered relation is used to stimulate the geometry parameters B, a, and ligament length (w-a). this can be given mathematically by this particular formula.

$$B, a, (W-a) \geq \beta \left(\frac{K}{\sigma_y}\right)^2$$

where σ_y is the yield stress yield point and β is the geometry constant that is the material dependent.

Let us talk about the crack tip opening displacement concept. This is given by the Dugdale crack model. The foundation of its presumption that in situation of ductile material behavior the crucial plastic deformation of the crack opening is also known as crack tip opening displacement (CTOD), determines the fracture process.

- **Crack tip opening displacement (CTOD) concept**
- **Dugdale crack model**
- ✓ The foundation of it is the presumption that, in situations of ductile material behavior, the crucial plastic deformation of the crack opening, also known as crack tip opening displacement (CTOD), determines the fracture process.



Figure; Showing Dugdale crack model

Source; Wolfgang Grellmann, Sabine Seidler, Polymer testing, translated by Paul I. Anderson, Hanser Gardner Publications, Inc. (2007), ISBN-10: 1-56990-410-3.

This is the figure showing the Dugdale crack. This equation is used to on CT specimen to determine the critical crack tip opening displacement that is.

$$\delta_{Ic} = \frac{V_c}{1 + n\left(\frac{a+z}{W-a}\right)}$$

$\boldsymbol{V_c}$ is crack mouth opening displacement at start of unstable crack propagation.

z; distance of knife edge from specimen surface

n; rotational factor

Cont…

The following equation is used on CT specimens to determine the critical crack-tip-opening displacement;

$$\delta_{Ic} = \frac{V_c}{1 + n\left(\frac{a+z}{W-a}\right)}$$

V_c is crack mouth opening displacement at start of unstable crack propagation

z; distance of knife edge from specimen surface

n; rotational factor

Based on the plastic hinge model for a bending loaded SENB specimen this can be given by the mathematical representation based on this figure.

$$\delta_{Ic} = \frac{1}{n}(W-a)\left(\frac{4f_k}{s}\right)$$

Where, s is support span

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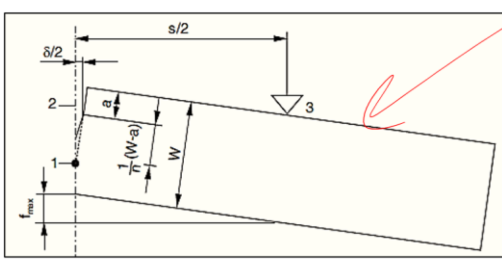
Based on the plastic-hinge model for a bending loaded SENB specimen

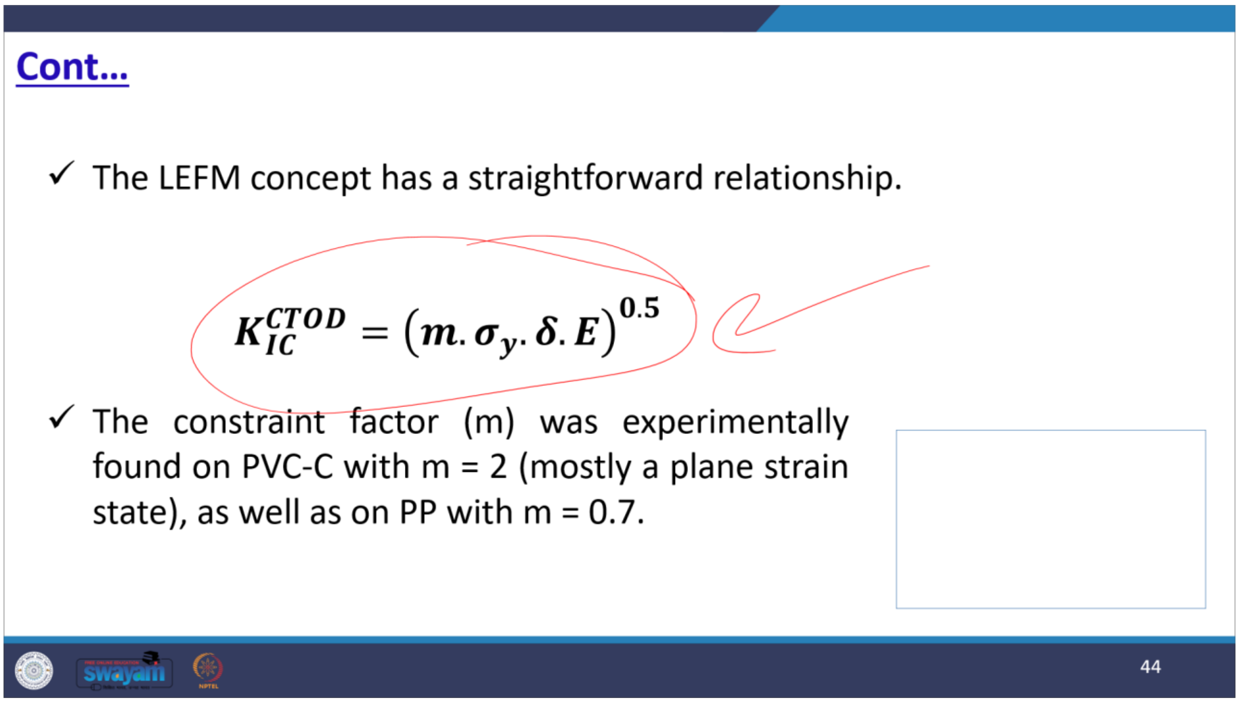


Figure; Showing plastic hinge model for estimating CTOD from single edge notched bend specimen (1-hinge point, 2- sharp notch, 3-support)

$$\delta_{Ic} = \frac{1}{n}(W-a)\left(\frac{4f_k}{s}\right)$$

Where, s is support span

By deducting the amount of deflection from an un-notched specimen from the maximum deflection f max of a notched specimen the calculation of critical crack tip opening displacement was restricted to the area at the notch tip. rotational factor n is load dependent and the load increases the hinge point moves closer to the fracture tip. Simultaneous crack mouth opening displacement and road line displacement measurements on the quasi-static load CT specimen this shows that the rotational factor takes on the limit value of n = 4 at the time of a fracture. So, if we talk about the LEFM concept has a straightforward relationship and that is given by this mathematical representation.



$$K_{IC}^{CTOD} = (m.\sigma_y.\delta.E)^{0.5}$$

The constraint factor (m) was experimentally found on PVC-C with m = 2 (mostly a plane strain state), as well as on PP with m = 0.7.

This is the figure showing an indication of the displacement of the crack opening and the creation of the stretch zone in front of the crack tip.

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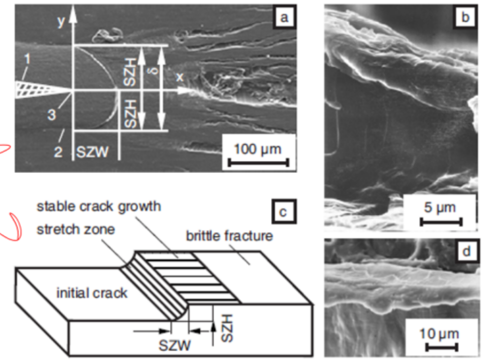


Figure; Showing (a) an indication of the displacement of the crack-tip opening and the creation of the stretch zone in front of the crack tip; deformation of crack tip under load (1-prior to loading, 2-subsequent to loading, 3-initial crack tip, SZH stretch zone height, SZW-stretch zone with width, (b) SEM image of stretch zone height of PP (c) Schematic diagram of a fracture surface (d) SEM image of stretch zone with PP

Source; Wolfgang Grellmann, Sabine Seidler, Polymer testing, translated by Paul I. Anderson, Hanser Gardner Publications, Inc. (2007), ISBN-10: 1-56990-410-3. 45

The deformation of the crack tip under the load one prior to the loading and subsequently subsequent loading three initial crack tip is given. (a) an indication of the displacement of the crack-tip opening and the creation of the stretch zone in front of the crack tip; deformation of crack tip under load (1-prior to loading, 2-subsequent to loading, 3-initial crack tip, SZH stretch zone height, SZW-stretch zone with width, (b) SEM image of stretch zone height of PP (c) Schematic diagram of a fracture surface (d) SEM image of stretch zone with PP. The scanning electron microscope images gives a clear-cut depiction about these cracks. When a material behaves ductile crack propagation is characterized by the steady crack growth and the beginning of which is determined by the critical value. This value is clearly visible in this same image as a stretch zone on the fracture surface originates from the blunting the initial crack tip due to the plastic deformation and thus the requirement for the specimen geometry is given in this mathematical representation.

$$B, a, (W - a) \geq \xi . \delta$$

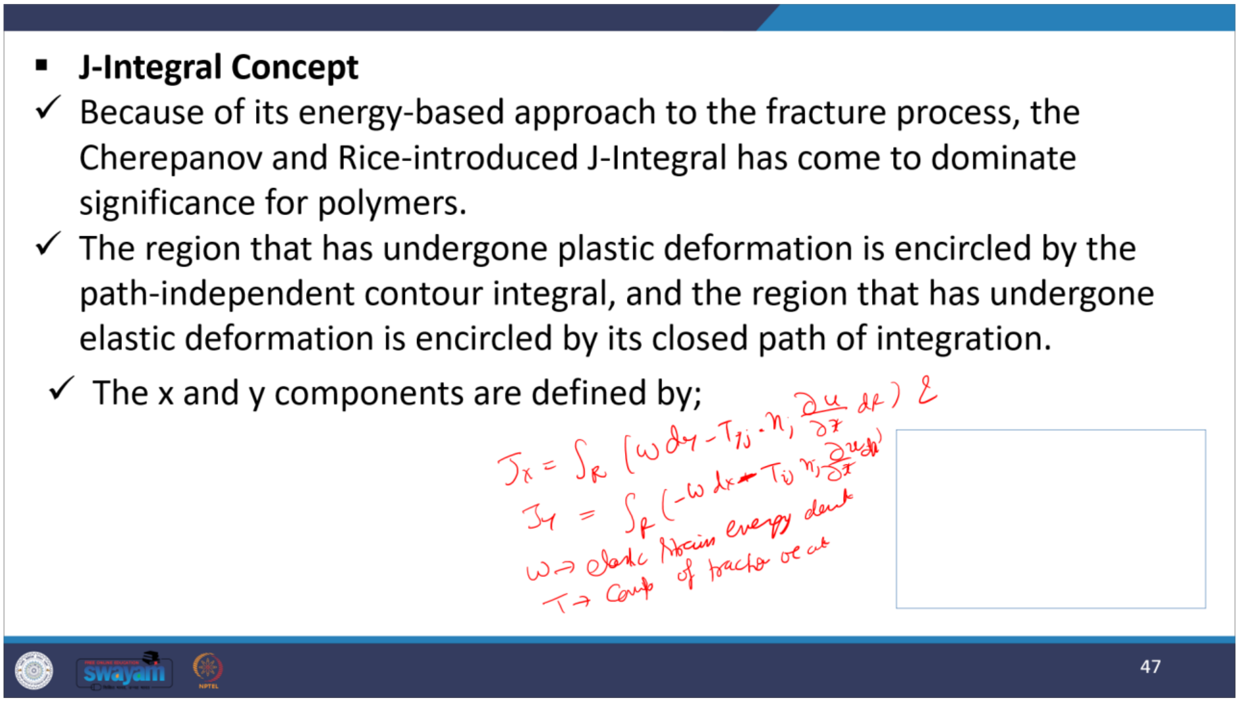
ξ is material specific constant of geometry criterion.

J-integral concept: because of its energy-based approach the fracture processes the Cherepanov and Rice introduced the J integral has come to dominate the significance for polymer. The reason that has undergone plastic deformation is encircled by the path independent contour that is the integral part and the region that has undergone the elastic deformation is encircled by the closed path of integration. So, X and Y components they are defined as

$J_x = \int_R (wdy - T_{ij}\, n_j \frac{\delta U}{\delta x} dR)$ and

$$J_y = \int_R (-wdx - T_{ij}\, n_j \frac{\delta U}{\delta x} dR)$$

Where, w is elastic strain energy density, T is the component traction vector and n are the component of unit vector normal to r around the crack tip and U is the displacement vector component.



The following figure shows the procedure to determine the J-integral; (a) Path independent contour integral with 1-plastic deformed region (energy dissipative zone) and 2-elastic deformed region (b) experimentally determined load vs load line displacement curves for various crack length (c) energy obtained by planimetry the dependency F= f(v,f) in relation to specimen thickness as a function of crack length (d) by differentiating the curve (c) determined J-integral

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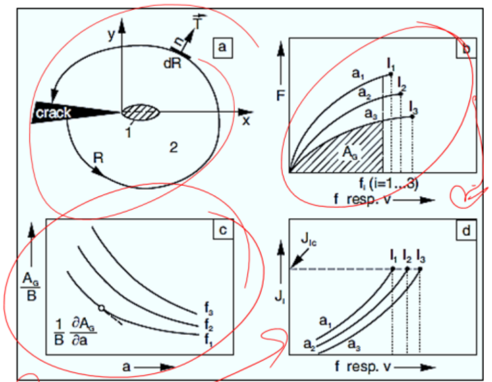


Figure; Determination of J-integral; **(a)** Path independent contour integral with 1-plastic deformed region (energy dissipative zone) and 2-elastic deformed region **(b)** experimentally determined load vs load line displacement curves for various crack length **(c)** energy obtained by planimetering the dependency F= f(v,f) in relation to specimen thickness as a function of crack length **(d)** by differentiating the curve (c) determined J-integral

Figures B to D show how the experimental determination is carried out using recorded load versus load line displacement curves with a different fracture length as a starting point planimetry is utilized to calculate the deformation of the energy AG as a function of A and AG/B relation is given.

Using graphic differentiation, we have

$$J = 1/B.\frac{\delta A_G}{\delta a}$$

The outcomes based on load-line deflection or displacement.

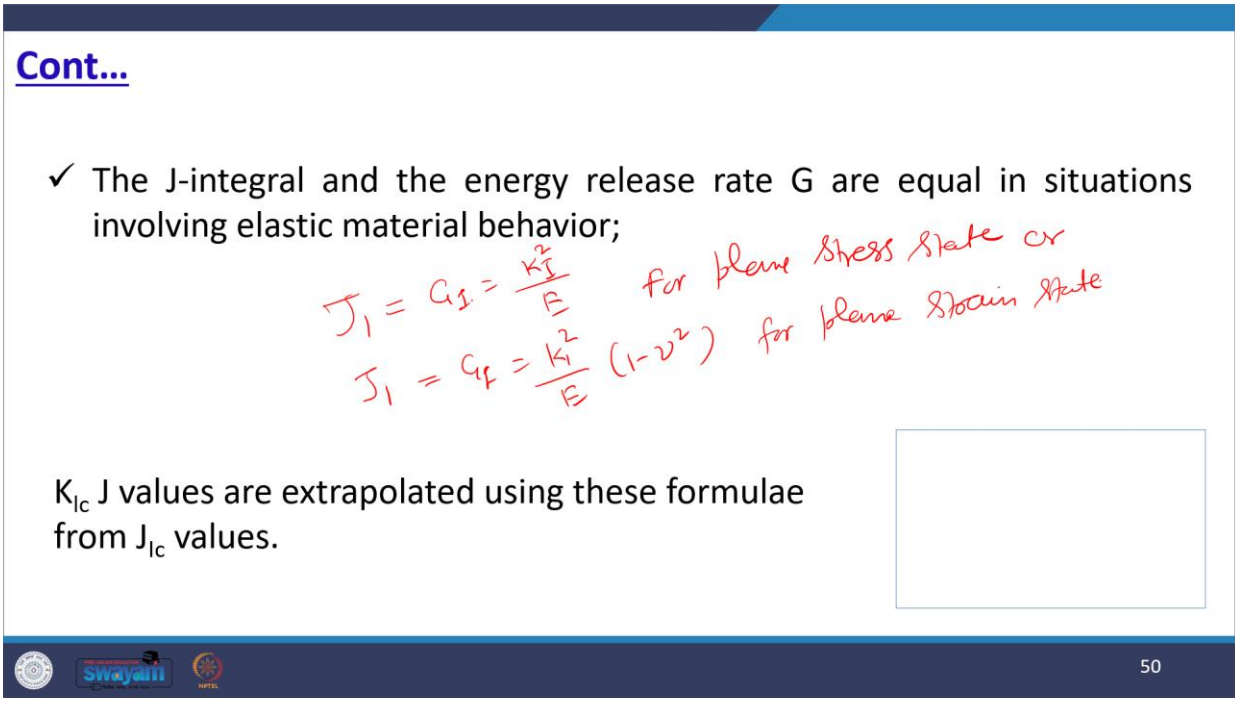
The J integral and energy release rate G are equal in the situation involving the this plastic material behavior and this can be represented as;

$J_1 = G_i = \frac{k_i^2}{E}$ for plane stress state

Or

$A_i = G_i = \frac{K_1^2}{E(1-\nu^2)}$ for plane strain state

K_{Ic} J values are extrapolated using these formulae from J_{Ic} values.



The connection between CTOD idea and J integral is provided by.

$$J = m\sigma_y\delta_{ic}$$

where m is referred to as a constant factor. If the requirement is met, the crucial values of J and that is the genuine material values they are independent of geometry.

$$B, a, (w-a) \geq J/\sigma_y$$

Epsilon (ϵ) is the proportionality constant for geometrical size criteria in J integral concept.

Cont…

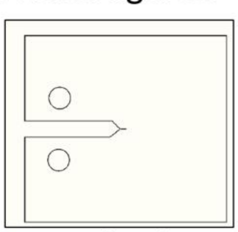
The connection between the CTOD idea and the J-integral is provided by

$$J = m \sigma_y \delta_{1c}$$

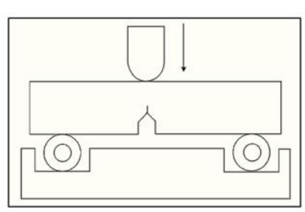
Where m is referred to as the constraint factor. If the requirement is met, the crucial J values i.e., genuine material values are independent of geometry.

Standard methods: Currently ISO 13586 is the sole worldwide standard used to measure fracture toughness. This is based on LEFM employing either compact tensile (CT) test piece or single edge notch bending (SENB) test piece as per this figure are provided. The techniques are primarily meant for the rigid and semi rigid plastic however there are restrictions on the dimensions of the test piece and linearity of the load displacement curve to ensure that LEFM conditions are at least somewhat true. The limit on linearity is arbitrary and corresponds to the better than 10 percent non-linearity.

- **Standard Methods**
- ✓ Currently, ISO 13586 is the sole worldwide standard used to measure fracture toughness.
- ✓ This is based on LEFM employing either compact tensile (CT) test pieces or single edge notch bending (SENB) test pieces, as illustrated in the provided figures.



Figure; Single edge notch bending (SENB)



Figure; Compact tensile (CT) test pieces

Source; Wolfgang Grellmann, Sabine Seidler, Polymer testing, translated by Paul I. Anderson, Hanser Gardner Publications, Inc. (2007), ISBN-10: 1-56990-410-3.

The initial crack must be sharp enough that the values obtained would not be significantly altered by even the sharper crack. Typically, a razor blade is used to open a crack after matching a sharp notch. The fundamental test parameter advised 23 degrees Celsius and 10 mm per minute and it is advised that the speed greater than 0.1 meter per second and loading duration of less than 10 meter per second are likely to millisecond are likely to create dynamic errors. Additionally, ISO is developing a method for calculating the fracture toughness at fairly high loading rates and the basic loading rate is stated as 1 meter per second, but it is noted that the time to fracture has more significance than the loading rate.

The reason for using numerous test pieces with the different initial fracture lengths to acquire the GIC is largely due to the decreased accuracy anticipated at higher rates. A servo hydraulic testing machine for falling weight or a pendulum impact device or another method for applying the load can all be used under ASTM. The method is based on the multi test piece approach with each being loaded to a different displacement and producing one point on the JR curve and the test piece configuration like those LEFM are employed. tests on distinct unknown test piece are used to make corrections for non-fracture energy. So, dear friends, in this segment we discussed the various test protocols for testing of the polymeric materials and for your convenience we have enlisted several references as per your choice you can use all use these references. Thank you very much.