7.3 Double cantilever beam (DCB) test (experimental methodology):

This popular test (ASTM 3433) is used to obtain the mode I fracture energy of the

adhesive bonds, which is a measure of the fracture toughness of the adhesive in the

presence of flaws. Similar to a wedge test, a crack is initiated first by inserting a wedge.

The specimen is then loaded by pulling apart the two beams at a certain rate, this

increasing load resulting in increased deflection of two beams. At a certain critical load,

the crack begins to propagate resulting in a slight drop in the load (due to the increased

compliance). At this point, the beams are stopped from moving apart, thus keeping the

deflection constant. The drop in load (due to increasing crack length) and the crack

length are carefully followed. Following the equilibration of the crack, the specimen is

consecutively unloaded and then loaded. Ideally, the compliance of the fixture should

remain the same during these two cycles if there is no further propagation of the crack.

This overall procedure is repeated several times leading to total cleavage of the specimen.

The data finally collected at various times consists of load, deflection, crack length and

the compliance. This data can then be analyzed using several different approaches, two

of which are discussed next.

Bonding Conditions for the DCB tests:

While the bonding pressure and temperature were kept the same as above,

bonding time and cooling rate were varied for this study to understand the effect on the

fracture energy. The bonding times tried were 2 min, 20 min and 30 min respectively.

For the cooling cycle, in addition to cooling at 21°C/min, some specimens were quenched

directly to room temperature while some specimens were held at 365°C for 2.5 hours and

then cooled to room temperature. While all the above experiments utilized a Mn = 15,000

daltons polymer, some specimens were evaluated for a Mn = 30,000 daltons polyimide

(while keeping the bonded conditions same) to understand the effect of molecular weight

on the fracture energy. A higher molecular weight polymer is expected to demonstrate

increased toughness though it often requires higher bonding pressures to make a good

bond. In this regard, it was to be seen whether a low bonding pressure of 100 psi was

sufficient in adequately bonding the higher molecular weight (Mn = 30,000 daltons)

polyimide. Addit ionally, some specimens were made using both the molecular weight

versions (with the surface consisting of 15K polymer and the bulk core of 30KCHAPTER 7 229

polyimide) to see if improvements in fracture energies could be obtained. In this case,

the lower molecular weight polyimide was kept closer to the metal surface whereas the

higher molecular weight polyimide constituted the bulk of the polymer adhesive. The

reasoning behind such a design was that the lower molecular weight version would

facilitate adequate spreading to ensure a good adhesive interface while the bulk of the

adhesive would show increased toughness as it was constituted of the higher molecular

weight polyimide. However, it remained to be seen whether the low bonding pressure of

100 psi was sufficient in adequately mixing the two different molecular weight versions

of the polyimide.