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Research Article

LOW VELOCITY IMPACT ANALYSIS ON COMPOSITE MATERIAL

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ABSTRACT:

This project aims at experimentally studying low velocity impact on fiber reinforced glass sheets. An experimental setupis fabricated, wherein a dart of known mass with accelerometer inbuilt in it made to fall on specimens of fiber reinforced glasssheets.The damageof thesheets of various thicknesses for various kinetic energies ofdart is studied.The kinetic energy isvaried by altering the height of the dart above the specimen sheet. The amount of energy transferred from the dart to the sheet ismeasured by the accelerometer output. The kinetic energy of the dart just before the moment it strikes the sheet is calculated bysimple formula. The energyabsorbed by thesheetis proportional to the thickness,material characteristics and the kineticenergy of the dart during collision. The dart is made fall free on the sheet; therefore, the acceleration is constant and is equal tothe acceleration due to gravity constant (9.8 m sec^{-2}). Since the height of the dart above the sheet does not exceed three meters,the velocity during collision is comparatively low. A tabulation of velocities of dart, thickness of sheets and obtained. Theaccelerometer's electrical output is signal conditioned and is displayed in a computed using appropriate software. The goal ofthis project is to get a complete knowledge of the low velocity impact on the glass reinforced fiber sheets and to conclude howfeasibleitcanbeforvariousapplications.

Keywords: Lowvelocity,Collision,kineticenergy,acceleration,voltage.

Theexperimentsaredesignedtoachieveacontrolledplane-

1. INTRODUCTION:

Impact tests are used to study dynamic deformationandfailuremodesofmaterials.Low-velocityimpacttechniques can be classified as plate-on-plate, rod-on-plate,plate-on-rod,orrod-on-rodexperiments.Lowvelocityimpact material testing is significant because the defects ordamagescausedduringsuchacollisionaremostlyunnoticed.Thisisarod-on-platetypeexperiment.Theresponse of structural composites to impactis studied.Acomposite material is a macroscopic combination of two ormoredistinctmaterials,havingrecognizableinterfacebetween them. Composite laminate is a combination of fiberand resin mixed in proper form. One of the unique propertiesof composite laminate is that it has high specific strength.Compositesarebeingutilizedasviablealternativestometallicmaterialsinstructureswhereweightisamajorconsideration, e.g., aerospace structures, high speed boatsandtrains.

Plate impact experiments are used to generate suchplane waves. These experiments provide controlled extremestress-stateloadingconditions,involvingone-dimensionalstress-pulsepropagation.Therecoveryconfigurationsinplate-on-plate impactexperiments are performed with theobjective of examining the micro structural changes in thespecimen after it is subjected to loading under a uniaxialstraincondition.wave loading of the specimens. In practice, this is limited bythe finite size of the plates employed, which generate radialreleasewaves.

This has the potential for significant contribution tothe damage processes by introducing causes other than theuniaxial straining of the material. Hence, this aspect of theplate impact experiment has been a subject of considerableresearchinthepast.Theplateimpactexperimentsareperformed in two main modes: normal impact and pressure-shear, or oblique, impact. Both modes have been specializedto several new configurations to achieve different aspects ofcontrol over the imposed loading. In these experiments, thetime histories of the stress waves are recorded and used toinfertheresponseofthespecimenwiththegoalofconstitutive modeling. To enable the formulation of correctconstitutive behavior for the considered material, knowledgeof the micro mechanisms of deformation that occur duringthepassageofthestresswavesisnecessary.Suchknowledge is also necessary for damage-evolution studies.Hence, it is important that the specimen is recovered after itis subjected to a well-characterized loading pulse so that itcanbeanalyzedforanychangesinitsmicrostructure.Thisis achieved in the normal plate impact mode by using animpedance-matched momentum trap behind the specimen.Ideally, the momentum-trap plate captures the momentum ofthe loading pulse and flies away, leaving the specimenatrest.

Figure1Carbon FiberMaterial

2. THEBASICEXPERIMENTALSETUP:

The experimental setup consists of a freefalling dartofknownmasswithaccelerometerfixedintoitandprovision to make the dart collide head-on with the centre ofspecimen sheets. The accelerometer is wired and connectedto a data acquisition system (DAS). The DAS gives it outputto a computer with the appropriate software installed in it,whichdynamicallydisplaystheaccelerationistotimeoutputinX-Yaxis.

Thedartheadarrangement

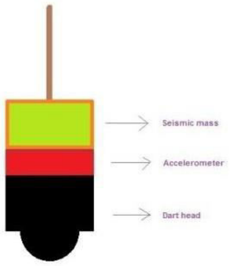

Figure2:ASchematicDiagramoftheDartusedforCollision

Thedartarrangementconsistsofadarthead,whichisthepartthatisgoingtocollidehead-onwiththespecimensheet.Thedarttipisthereforenotsharpbutmadeblunttosuchanextentthatthereisnodamageincurredonthesheetduetoapointedtip.Thebluntareawhichisgoingtocomeincontactwiththesheetisalreadymeasured.Theenergywhichisgoingtobetransferredtothesheetduringthecollision can be calculated only if the dimension and the areaof the region of contact are known.

The accelerometer is the most important part of thisentire setup. The entire next chapter is dedicated to it. Theaccelerometer is sandwiched between the dart head and theseismic mass.Itis the only directmeasuring unitof theentiresetup.Itconvertsthemechanicalenergyintocorresponding electrical output. It is robust and protected tohandle well around the entire range of shock that can happenduringtheexperiment.

The output and suspension mechanismthe accelerometer has wired output. This wire is providedlong enough so that the free fall of the dart setup is notaffected at all. No drag is there due to the wire because ofsufficientlength.Theseismicmassislocatedabovetheaccelerometer. The purpose of the mass is to add weight tothe dart setup. It is arranged in such a way that it does nothavedirectphysicalcontactwiththetopsurfaceoftheaccelerometer.Themassprovidessufficientweightforthedart setup to have the necessary force to hit the specimensheet due to free fall. The thread suspending the entire setupis strong. It is not rigid in shape because if it is rigid, it willaffectthefreefall.Itisrolledinapulleywhichisfrictionless. The height of the fall of dart is adjustable byincreasing and decreasing the entire pulley setup which isfixed moveably overaverticalstand of the experimentalsetup. A scale is providedonthe vertical stand to measuretheheightfromabovewhichthedartisfalling.

3. ACCELROMETER:

Basicsof accelerometer:

An accelerometer is a device that measures properacceleration.Thisisnotnecessarilythesameasthecoordinate acceleration (change of velocity of the device inspace), but is rather the type of acceleration associated withthe phenomenon of weight experienced by a test mass thatresides in the frame of reference of the accelerometer device.Foran example of where these types of acceleration differ,an accelerometer will measure a value when sitting on theground,because masses there have weights,eventhoughthey do not change velocity. However, an accelerometer ingravitational free falltoward the centre of the Earthwillmeasure a value of zero because, even though its speed isincreasing,itisinaframeofreferenceinwhichitisweightless. An accelerometer thus measures the change inacceleration.Anotherwayofstatingthisisthatbymeasuringweight,anaccelerometermeasurestheaccelerationofthefree-fallreferenceframe(inertialreferenceframe)relativetoitself(theaccelerometer).

Theaccelerometer model:

TheADXL335isasmall,thin,lowpower,complete3-axisaccelerometerwithsignalconditionedvoltage outputs. The product measures acceleration with aminimum full-scale range of ±3 g. It can measure the staticacceleration of gravity in tilt-sensing applications, as well asdynamicaccelerationresultingfrommotion,shock,orvibration.Theuserselectsthebandwidthoftheaccelerometer using the CX, CY, and CZ capacitors at theXOUT, YOUT, and ZOUT pins. Bandwidths can be selectedto suit the application, with a range of 0.5 Hz to 1600 Hz forthe X and Y axes, and a range of 0.5 Hz to 550 Hz for the Zaxis

The ADXL335is available inasmall, low profile,4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chipscalepackage(LFCSP_LQ).

4. WORKINGPRINCIPLE:

Thebasicworkingprincipleinvolvedhereiscalculation of the energy absorbed by the specimen sheet byexploiting the concept of conservation of energy. When thedart hits the specimen, a part of the kinetic energy of the dartis transferred to the specimen. The specimen breaks and thedart penetrate it. The kinetic energy of the dart afterthebreakingofthespecimenisequivalenttothedifference betweenthekineticenergyithadjustbeforethecollisionandtheenergythatwasabsorbedbythespecimen.

Thebelowequationisgoverningequationtocalculate the energy that is being imparted to the specimen.$E_{bc}=E_{ac}+E_{as}$
E_{bc}-Energyofdartbeforecollision
E_{ac}-Energyofdartaftercollision
E_{as}-Energyabsorbedbythespecimen

$E_{bc}=m*g*h$
E_{ac}iscalculatedashalfoftheproductofmassandthesquareofthevelocity.
$E_{ac}=(1/2)*m*v^2$
m-massofthedart
g-accelerationduetogravity
h-heightofthedartabovetheground
v -velocity of the dart just after the collisionE_{as} istheobtainedbysubtractingE_{ac}fromE_{bc}.

The velocity “v” needed to calculate E_{ac} is obtainedby the acceleration output obtained from the dart. When it isintegrated withrespecttotimeonce,velocityisobtained. Thevoltageoutputoftheaccelerometerislinearlyproportionatetoacceleration.TheintegratingsoftwareisMATLAB .Thevoltageoutputobtainedisplottedcontinuously with time and a graph is obtained. The velocityis to time output is obtained by performing a single point topoint integrationof the values in the previous mentionedgraph.

The output from the DAQ is obtained by a simpleRS 232 connection. The baud rate and other specificationsprerequisitetoreceivethedataaredoneandasimpleMATLABcodeiswrittentoreceivethevoltagedata. TheMATLABprogrammeispresented below:

```
sa=serial('COM9','BaudRate',9600);fopen(sa);
b=[];
%sum=0;
%d(0)=0;i=10;
forj=1:i
      pause(0.5);tic    ;
a=fgetl(sa);b=a;disp(b);time=toc;disp(time);
%d(j)=time+sum;
%sum=d(j);endfclose(sa);clear('sa');
%plot(d,c);
```

The baud rate can be adjusted for different kind ofDAQs. The COM port may differ from PC to PC. The timeinterval for which the DAQ should continuously acquire thedata is programed. Precaution must be taken to see that thetime interval to acquire data is in synchronisation with thetimetakentotransmitthedata.Ifthetimeintervalofacquisitionis considerably smallerthan the time takenforthe RS 232 system to transmit the data to the PC, then anumber of readings of the data will be missed or the systemwillthrowanerrortoshowthetimingsarenotinsync.

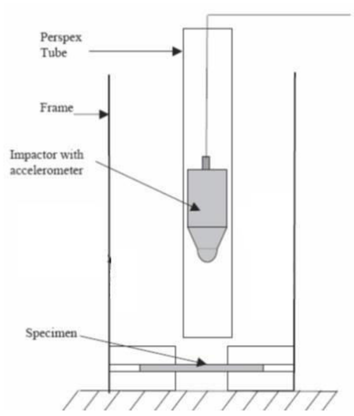

Figure3ASchematicDiagramoftheDartusedforCollision

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