KUFA JOURNAL OF ENGINEERING
ISSN 2071-5528
PRINTED IN IRAQ

Volume 4, Number 1 pp.125- 135, 2012

Study the Mechanical Properties of Polyethylene Reinforced by Metal Woven Fibers

Asst. Lect. Muayad Abdulhasan M.Ali
University of Kufa-College of Engineering
moayad_zahed@yahoo.com

Asst. Lect. AbbasAli Diwan
University of Kufa-College of Engineering
abbas1980@yahoo.com

(Received: 4/2/2012 ; Accepted :September/2012)

Abstract:

Strength and Durability of fiber reinforced polymer composites (FRP) are controlled by the durability of their constituents: reinforcement fibers, resin matrices, and the status of interfaces. A great deal of research has been focused on the relationship of fibers with matrix, on the other hand, the diameter of the fiber and properties of fiber-matrix composites. The present investigation aims to study the effects of adding steel woven fibers to polymer (polyethylene) on some mechanical properties for resulting composite materials.

This research tries to study the using of metal woven fibers as a reinforcement Material with Matrix from polyethylene grades (LDPE,LLDPE) as a composite material that was prepared using an injection molding process at 180- 200 Co and 60 rpm with different diameter (0.25- 1.0 mm).the results show that the tensile strength will slightly increase with percentage about (9%-18%) for the LLDPE and LDPE polymer composite respectively, and tensile modulus will significant increase about (80%- 190%) with woven metal fibers .The ductility is decrease with 68% for LDPE but it was 78% for LLDPE . The flexural strength will decrease with percentage about (36%-22%) for the LLDPE and LDPE polymer composite and impact strength with percentage about (78%-68%) and impact strength about (47%-40%) for the LLDPE and LDPE polymer composite respectively.

KEY WORDS: Composite Materials, LDPE, LLDPE, steel woven fiber, Mechanical properties.

دراسة الخواص الميكانيكية لمادة البولي ايثيلين المقواة بالياف المعادن المنسوجة

م.م. مؤيد عبد الحسن
جامعة الكوفة / كلية الهندسة

م.م.عباس علي ديوان
جامعة الكوفة / كلية الهندسة

الخلاصة:

إن مقاومة ومتانة المواد المتراكبة البوليمرية المقواة بالألياف (FRP) يتم التحكم بها من خلال المواد المكونة لها ،ألياف التقوية ، المادة الأساس البوليمرية وحالة السطح البيني . ان البحث يركز على علاقة الألياف بالمادة الأساس من جهة وقطر الليف من جهة أخرى وخواص متراكب الليف-الأساس . يهدف البحث الحالي إلى دراسة تأثيرإضافة ألياف الفولاذ إلى البوليمرات (البولي اثلين) على بعض الخواص الميكانيكية للمادة المركبة الناتجة.تم في هذا البحث دراسة استخدام ألياف معدنيةمحاكة كمادة تقوية مع أنواع مختلفة مادة الأساس من البولي اثلين(LDPE,LLDPE) وهذه المادة المتراكبة يتم إعدادها باستخدام طريقة القولبة بالحقن عند درجات حرارة بين ١٨٠-٢٠٠ درجة سيليزية وبسرعة دوران تساوي (٦٠) دورة بالدقيقة وبأقطار مختلفة تتراوح (0.25-1.0) ملم , حيث أظهرت النتائج بان قوة الشد تزداد بشكل قليل وبنسبة مئوية (9%-18%) للمادة المتراكبة من البولي اثلين الواطئ الكثافة والبولي اثلين بالتعاقب ،و معامل المرونة الشد قد ازدادت بشكل واضح وبنسبة مئوية (190% -80%)، بينما انخفضت كل من مقاومة الصدمة بنسبة(22%-36%)والمطيلية بنسبة (68%-78%) ومقاومة الصدمة بنسبة (40%-47%)للمادة المتراكبة من البولي اثلين الواطئ الكثافة والبولي اثلين بالتعاقب.

الكلمات الدلالية : المواد المركبة، البولي إثيلين المنخفض الكثافة، البولي اثلين المنخفض الكثافة الخطي، الحديد الألياف المنسوجة، الخواص الميكانيكية

Introduction

Many modern technologies require materials with unusual combinations of properties that cannot be met by the conventional metal alloys, ceramics, and polymeric materials. This is especially true for materials that are needed for aerospace, underwater, and transportation applications.

A composite is composed of two (or more) individual materials ,The design goal of a composite is to achieve a combination of properties that is not displayed by any single material, and also to incorporate the best characteristics of each of the component materials. A large number of composite types exist that are represented by different combinations of metals, ceramics, and polymers.[1]

Most packaging materials are based on polyolefin because they are low in price, versatile, and easy to process. Low-density polyethylene (LDPE) is especially valued for its flexibility and sealing properties. In the pharmaceutical industry [2].However, In the past decades, extensive research is proposed in prediction of mechanical properties of bi-directional fiber-reinforced composites. Several studies have been conducted for investigation the properties like tensile properties, modulus of elasticity, impact strength, compression strength ….etc.[3].A polymer composite was fabricated by mixing LDPE with different wt% of pigment (Fe_2O_3 and TiO_2) to obtain desirable properties in fabrication single screw-extruder was utilized , this mixing machine operated at a temperature between (150-170) C^o. some of mechanical properties, such as tensile, impact, hardness and bending test were determined at different weight fraction of composite materials. It was found that the addition of pigment (TiO_2 and Fe_2O_3) to the LDPE leads to increase the modulus of elasticity, tensile strength, elongation at break, shore hardness on other hand it decreases the % elongation at break, and for the impact strength.[4]

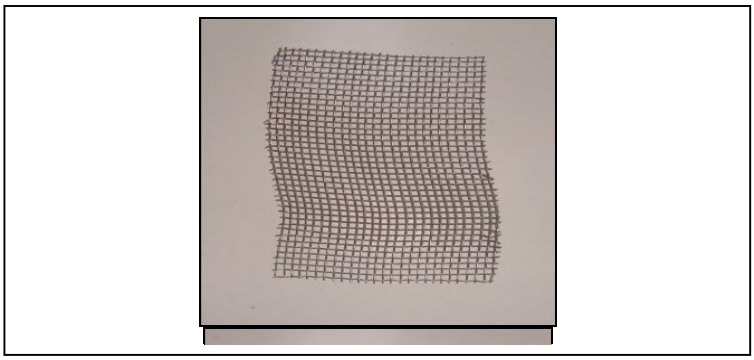
In this work LLDPE and LDPE are used as Matrices materials and steel woven fibers as reinforcement materials with different mesh to modify the tensile and bending properties of them. Apparently, study of literature review indicates that there are no reports related to mechanical properties of LDPE and LLDPE with both different diameter of steel fibers as mat .

Experimental:

Materials:

Two main types of materials were used Commercial LLDPE synthesized by SABIC Plastic Co. (SaudiArabia-type1311-21) with a density equal to (0.9235)gm/cm^3 and LDPE synthesized by SABIC Plastic Co. (Saudi Arabia) of density equal to 0.963gm/cm^3 . galvanized Woven steel wire

mesh (0- 90) was used as reinforcement materials with two types diameters (1.0 and 0.25)mm as shown in figure(1).



a ***b***

Fig.1: Types of wire mesh with diameters(a) 0.25mm (b) 1mm

Sample preparation:

The samples were produced by using the single-screw extrusion machine as shown in (fig.2) at temperatures ranging from 150 to 180 C^o and with thickness of approximately (3) mm. A sample with and without reinforcement by using wire meshes diameters are 0.25mm and1.0mm which processed under the same conditions from pressure and temperature . The LDPE and LLDPE formulations used in the present study are given in Table (1). From these formulations, samples of 140 x30 mm were which manufactured by mold, especially, for this process then the samples were prepare by machining process (cutting and grinding) for samples according to ASTM D638[5]. Most Mechanical measurements have been investigated by Microcomputer controlled universal testing machine electronic type (WDW) from time group Inc. at room temperature, as well as using the other instruments. Extruder machine was used to prepare samples shown in figure(2).

Fig.2: single-screw extruder machine

The reinforcement samples are prepared by hold the wire meshes between fixed and moving sides of mold during extruding process at same temperature of pure samples.

Table1. Formulation of composite materials:

No.	Matrix Material	Reinforcement	Specifications
1.	LDPE	Steel Woven Fibers	Mesh dia.=0.25 mm
2.	LDPE	Steel Woven Fibers	Mesh dia.=1.0 mm
3.	LLDPE	Steel Woven Fibers	Mesh dia.=0.25 mm
4.	LLDPE	Steel Woven Fibers	Mesh dia.=1.0 mm

Both types of pellets of LDPE and LLDPE were inserted to a single screw machine at temperature ranging from (150-170) C^0 and rotation increases from (0-60) R.P.M. The forming time involved was less than (5 min). After forming process was completed (i.e., the melt became homogenous), the homogenous mixture then pressed by the hydraulic press at applying temperature and 6MPa pressure on the same time the temperature applied to the fixed and moved sides of mold while the sample was still under the applied pressure about(6 MPa) and temperature ($180C^0$) for a (5min) to prepare the reinforcement samples the steel fibers (woven fibers) was set between two parts of mould and fixing by pins during the extruding process for each types of fibers(various diameter).

Mechanical Tests:

The Mechanical properties were carried out on the samples at room temp. at least five samples were examined for each test and take the average for each test, the test were carried out in this research as follow:

1-Tensile Test:

The tensile strength samples were prepared according to ASTM D638, and measuring speed about (10 mm/sec) the tensile tests were done on six types of samples:

A. Pure LDPE samples.

B. LDPE reinforced with (0.25mm) galvanized steel woven.

C. LDPE reinforced with (1mm) galvanized steel woven.

D. Pure LLDPE samples.

E. LDPE reinforced with (0.25mm) galvanized steel woven.

F. LLDPE reinforced with (1mm) galvanized steel woven.

Fig (3) shows the samples of Tensile before and after of testing

Fig.3: Samples of LDPE and LLDPE (a) before testing tensile sa[illegible] a , (b) after testing tensile samples

2- Flexure Test: *a*

The bending strength samples were prepared according to ASTM D790[6]. The Bending test procedure on samples were carried out at room temp. at measuring speed about 5mm/min Figure 4 shows bending samples before after testing.

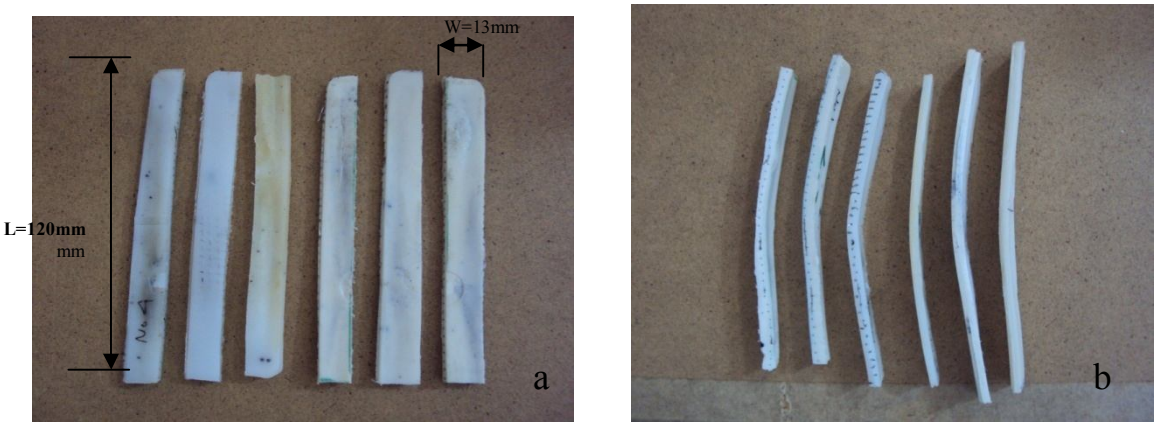


Fig.4: Bending samples of LDPE and LLDPE (a)before testing, (b) after testing

3- Impact Test:

The impact strength samples were prepared according to ASTM D4812[7]. The impact test procedure on samples was carried out at room temperature.

Figure 5 shows impact samples before and after testing

(a) (b)

Fig.5:Impact samples of LDPE and LLDPE (a)before testing, (b) after testing

Results and Discussion:

Figure 6 shows the relationship between the polymer material without and with reinforcement materials at diameter of steel woven fiber range between 0.25 to 1.0 mm.

The results show that the Tensile Strength of LDPE and LLDPE composites increases with reinforcement additives from 17 , 23 MPa to 20 , 25 MPa respectively .

The results of tensile Modulus are increase from 1.25 to 3.7 for LDPE and from 2.5 to 4.5 for LLDPE .The Ductility results are decrease from 7.4 to 2.4 for LDPE and from 6 to 1.3 for LLDPE as show in figure 7 and 8.

The results show obviously on increase in tensile modulus of LDPE and LLDPE Composites which consider as a logical result because increasing in tensile strength for this material according to Hooke's law[8]. which state that Modulus of Elasticity is directly proportional with magnitude of stress as a result to presence of steel woven fibers in material, and thereby ductility decrease according to this law as shown in fig 8 .

Figure 9 shows the variations in impact strength as a function to reinforcement type and decreasing in impact value because the fibers in the matrix material cannot support the impact loads that forced as rapidly loads on material as consider that the steel fibers is brittle materials which weak with impact forces.

Figure 10 shows the relationship of the reinforcement with flexure strength. There is slightly increase via this property by presence of fibers in polymer matrices but not sufficiently to improvement the flexure to enough limits.

The reason for the above result due to matrix and Fiber interface deboning and adhesion layers failure. So the failure mode changed due to low shear stress between them.[٩]

Conclusion:

Our study revolved that the tensile stress , tensile modules and flexural strength are increase proportionally with steel wire meshes diameters, on the other hands reducing accrue in some properties such as ductility, and impact strength and this refers that the fibers perhaps to strengthen the polymer durability in applications which demand more endurance to loads and reducing the plastic deformation then minimize the mechanical failure.

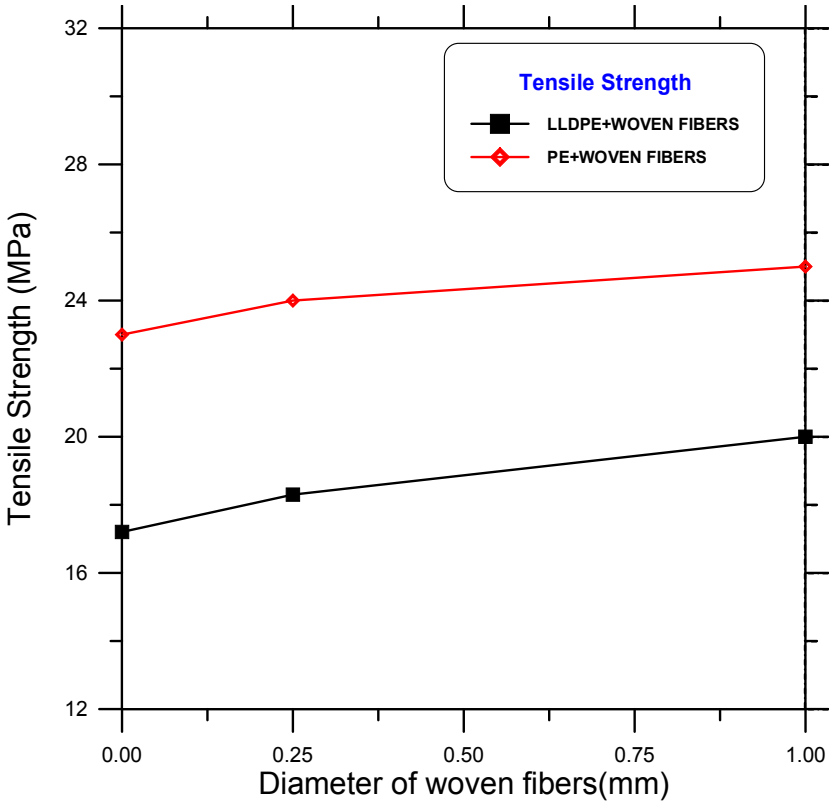


Fig.6: Tensile Strength versus diameter of LDPE and LLDPE fibers of Composites

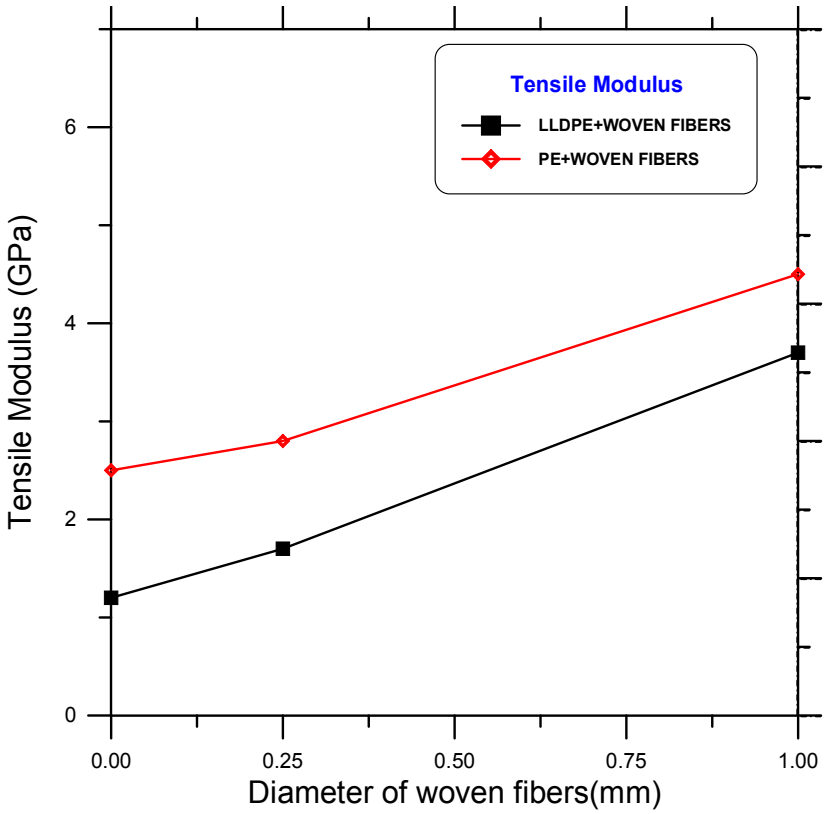


Fig.7:TensileModulus versus diameter of LDPE and LLDPE fibers of Composites

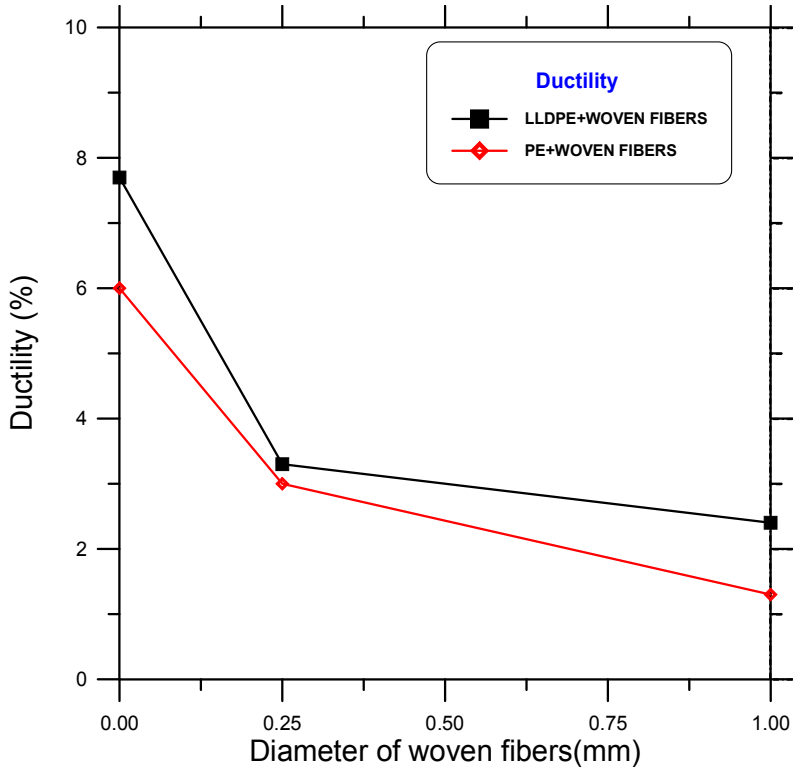


Fig.8:Ductility versus diameter of LDPE and LLDPE fibers of Composites

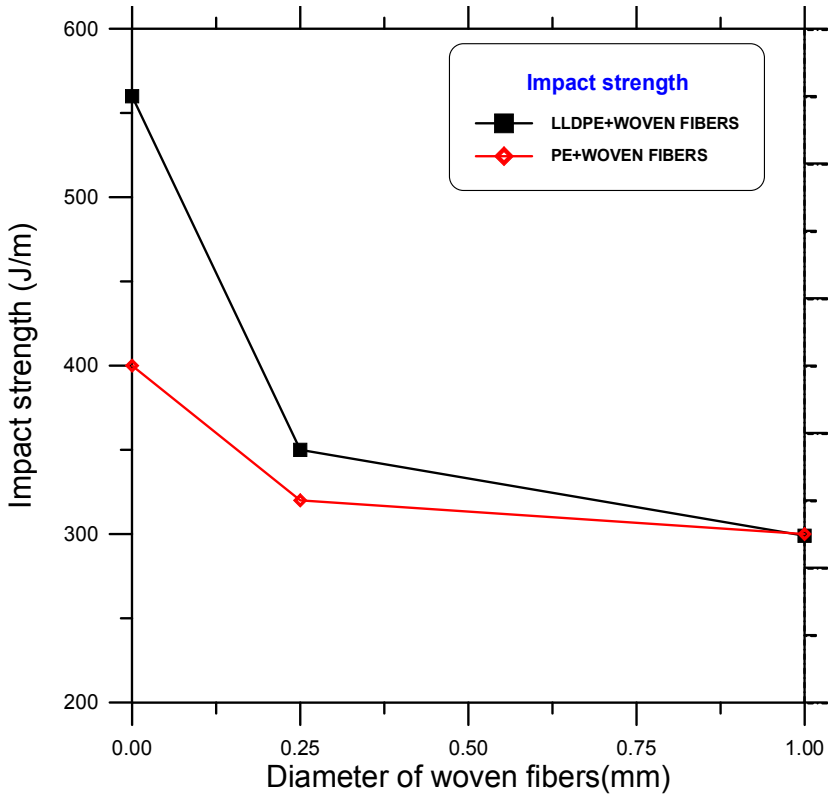


Fig.9:Impact Strength versus diameter of LDPE and LLDPE fibers of Composites

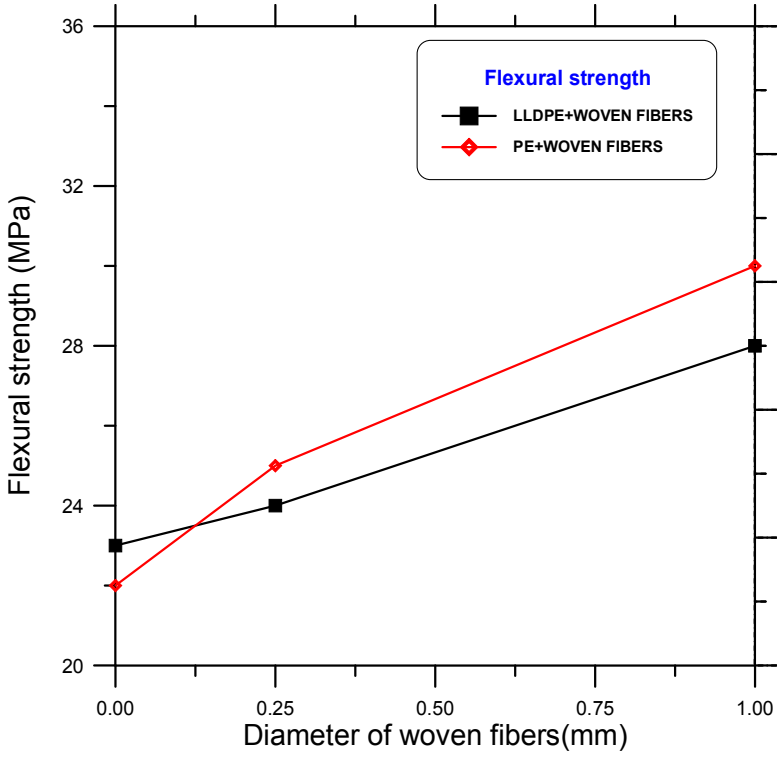


Fig.10: Flexure Strength versus diameter of LDPE and LLDPE fibers of Composites

Reference:

1.William D. Callister, Jr,"Materials Science and Engineering An Introduction" 7th edition, John Wiley & Sons, Inc. (2007)

2.Young Chang Nho, Jeong Kim, and Phil Hyun Kang " Mechanical Properties of LDPE/Ethylene-1-butene Copolymer Films Cross linked by Radiation" J. Ind. Eng. Chem., Vol. 12, No. 6, 888-892, (2006)

3.K. Sivaji Babua1, et al ," Prediction of Shear Module of Hybrid FRP Composite with Fiber-Matrix Interface Deboned", Int. J. of Mech. and Solids., pp. 147–156 ,2008.

4.Najat .J.saleh and ; Zanaib , Y.shnean" Improvement of Locally Produced Low- Density Polyethylene" Eng. & Tech. Vol. 26, No.9, 2008.

5. ASTM D638 - 03 "Standard Test Method For Tensile Properties Of Plastics " (2003) .

6. ASTM D790-03 “Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials”(2003).

7. ASTM D 4812 – 05 “Standard Test Method for un notched Cantilever Beam Impact Resistance of Plastics” (2005).

8. William A. Nash ” theory and problems in strength of materials “ Schaum’s outline series , McGraw-hill 4th edition (1998).

9. H.A.Al-Zubaidy, X.L.Zhao, R.Al-Mahaidi, "Effect of Impact Tensile Load on Strength of CFRP Bonded Steel Plate Joints",Procedia Engineering 14 ,PP.1312–1317(2011).