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THE EFFECT OF ANGLE REINFORCING OF COMPOSITE MATERIAL BARS (POLYMER) BY CELLULOSE ACETATE FIBER ON ITS STRENGTH FOR FATIGUE STRESS

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Abstract:

Study on oblique angle of composite material bar by reinforcing with acetate fiber was conducted to estimate the stress strength at fatigue test, by using rotary bending tester. The specimens were used with 130mm length and 10mm diameter, which consist the basic material (Resin) and harder with oblique angles of (0°, 30°, 45°, 60°, and 90°), the cellulose acetate fiber has used with elastic mechanical properties. The results were converged with practical and theoretical result for the number of failure and the values of correction factor, as well as the values of fatigue strength were between (28-100 Mpa) and had directly proportional with vertical compounds material, while the maximum value of oblique angle was equal to zero.

تاثير تعزيز زاوية قضبان المواد المركبة بواسطة دعمها بالياف السيليلوز على قوتها عند اجهاد الفشل

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الخلاصة:

أجريت الدراسة على زاوية مائلة من شريط المواد المركبة عن طريق تعزيزها بالياف خلات السيليلوز لتقدير قوة التحمل في اختبار الكلال، وباستخدام جهاز اختبار الانحناء الدوار. استخدمت عينات بطول 130 ملم و قطر 10ملم ، والتي تتكون من المواد الأساسية (الراتنج) والمقواة بالياف مائلة بزوايا (0° ، 30 ° ، 45° 60° ، 90°) ، وقد استخدمت ألياف خلات السليلوز مع الخواص الميكانيكية المرنة. وقد تقاربت النتائج مع نتائج العملية والنظرية لعدد من الفشل وقيم معامل التصحيح، فضلا عن قيم مقاومة الكلال كانت بين (28 – 100 ميجا باسكال)، وكان يتناسب طرديا مع المركبات العمودية، في حين بلغت القيمة القصوى لزاوية ميل الالياف الصفر .

INTRODUCTION :

The composite materials are used widely in industrial sphere, whereas the mechanical parts exposed to static and dynamic loads. Therefore those parts manufactured from polymeric material armed with cellulose fiber or steel wire to resist these loads. Many studies found that the reinforcing angle have a significant impact on the load resistance of fatigue.

The designers and engineers at the present time had focus on active role of various material produced by industrial fields, which have multiple successive operations according to the structures design and construction fit with the functionality as well as the performance analysis of the failure (D.R. Askeland 1984-1) . Complexes of supported layers are represented as type of well-known and popular since ancient time, so it had used in the manufacturing of different materials such as swords, which gives the material form and unmatched overlap (V. Raghavan 1979-2), These materials possess many applications, including coatings and surface protection minute packing thick (W. Bolton -1998-3), and complex structures such as high sandwiches which used in the manufacturing of aircraft and spacecraft. Also the glass protection considered one of the complexes of supported layer, which consists a layer polymer between two layers of ordinary glass (Sada – Lime glass), as well as protective clothing lead (L. Holliday 1966-4).

These compounds consist layers in successive series and these layers have of two or more different materials in terms of shape and directionality, which are associated with each other (V. Raghavan 1979-2).

The properties of layer parts of complexes tend to be anisotropic, and the properties of these complexes have federation a characteristic of materials, which gives the properties not available in each subject individually and hence produces unrivaled properties (L. Holliday 1966-4). These properties include the stiffness resistance, light weight, corrosion resistance and wear to best sound insulation, thermal insulation and cost of low (5) . Since 1920, (Bakelite and John) had added alpha cellulose; it has adde to plastic ivory powder material (CelluLoid) (Hyatt) (R.M. Jones 1975- 6). The main purpose of these plastic additives to increased flexibility while polymer resistance tensile and bending has been decreasing (R.B. Seymour 1990-7) .

1. Behavior of composite materials:

Representation breaking separation under the influence of specific stress is the most important external major causes fracture so the impact of slow or fast external loads and continuous application of dynamic strain repeated Fatigue, while the internal stresses, such as heat stress which is caused by variation of the coefficient values of expansion warming or the difference in temperature in the article, the effects of environmental conditions (when corrosion cracking, hydrogen embrittlement).

It has been assumed researcher (Griffith) condition, which is based on the energy balance of thermodynamics, which showed a couple of things that occur when growth is a notch:

1. Elastic strain energy will be liberated in the volume of material.
2. Create surfaces and cracks, which represent the surface energy.

The located fissure will spread if the elastic strain energy liberalization by the work, which is larger than the surface energy that is created from the surfaces of the new cracks, when the incision is spread Strain energy liberated as the slit becomes fixed when balanced energy compounds with each other (G. Lubin 1969-8). The mechanical surface fracture is the result of virtual materials overlapped depends on the characteristics of the fracture of the material foundation and material consolidation and the effect of bonding between articles, it gets breakage in the material consolidation and thus moving to the material basis that suffer from failure (P.A. Thernton & V.J. Colangelo 1985-9) and must take into account the two basic concepts of fracture (cracked fatigue), namely:

1. Response of materials to high localized stresses (where the rate is greater than the stress of the cross section).
2. Field grooves gaps, cracks and other defects that lead to the generation of very high localized stresses in the material. (Efunda.com 2004-10)

It uses the term durability (Toughness), which is the work necessary for the spread of cracks within the article which is a property of the material properties, accounting for the energy absorbed in the work unit area slit and in some cases the rate of liberation Strain energy embarrassment (Critical Strain Energy Release Rate) and unity ($J.m^{-2}$), where high durability means it's hard to make slit spreads.

Characterized polymers durability medium and its durability break and sessile (Low Fracture Toughness) because the transactions flexibility is low either material overlapped its durability breaking high, where the materials are overlapped over the durability of polymers normal, so durability included materials such as epoxy resin ($G_c = 0.1 - 0.3KJm^{-2}$) or polycarbonate resin ester could grow dramatically this is reinforced fiber or carbon fiber, glass fiber will operate like obstacles to slit (Crack Stoppers) (M.A. Meyers and K.K. Chawla 1999-11).

Durability of overlapped materials depends on the following factors:

1. foundation of Composition Material.
2. Type, size and directional reinforcement materials (M.M. Schwartz 1984-12).

Called the phenomenon of reducing the strength of materials at the impact loads alternating fatigue of materials and a lot of cases of breakage that occurs in real life are attributable primarily the basis of the fatigue and the seriousness of this phenomenon managed in the absence of any indication prior article warns of occurrence of breakage and cracks that lead to fracture very subtle and difficult to define, but you grow and spread quickly through the material to cause breakage and in a relatively short time, and usually start the cracks of the surface and rapidly progressing to the internal structure of the material. (J.w. Phillips 1997-13).

When they grow incision through the material basis fragile towards the fiber while up notch to fiber lies in the area of stress in front slit completely separated material foundation for the fiber over a small area and the process is called schizophrenia (Debonding) and notch then expands very large so that the movement stops natural. That this Only if grown vertically slit ills fiber, an important reason in the fact that a very short fibrous complexes in engineering design is a high-durability and high stiffnesses.

Some compositions always contain cracks and it is that the length of these cracks will be less than a certain length (length, which can reveal reasonably well when we check him or examine compositions) and guess-old secretary of the structures and we need to know that any number of courses that can endure the installation before it grows into one of those cracks length which has expanded tremendously.

Occurrence of cracking of fatigue as a failure of pounding caused by stresses cycle and then generate a cycle tensile zone, elastic and which make the head slit open by elongation generator there surface new, either cycle compression press the edges of the incision and will involve a new surface when provided extensive incision, in the cycle of tension following the same thing happens again and slit slowly progressing forward. Plasticity region consist gaps and communicate with each other and with the head of notch.

In the case of non-cracked parts, which are subject to fatigue with a few laps so roughening the surface quickly and there consists incision along the expansive first level and then slide the mechanism we have described perpendicular to the tensile axis. (M.A. Meyers and K.K. Chawla 1999-11), (J.w. Phillips 1997-13).

2 - The search materials

Cellulose Fibers are recognized with some features such as transparency, slow combustion, and possibility of excellent molding, durability, a good ability to run and scratch resistance. Such as of their important specification, which includes the specific weight (1.23 – 1.5), tensile strength (20 - 55 MPa), shock resistance (Izod Number) (1 – 5.4 J), water absorbency = (20 – 60 ml) and Top working temperature (60 - 125℃) (R.A. Flinn & P.K. Trojan 1990-14).

Also cellulose fibers are used to increase the shock resistance, increase the flow of plastic materials under pressure and enhance the insulating properties (Abu-Farsakh G. A 2000-15).

3- Search theory

Depending on the law of the bending stress threshold installed by one (ثامر 2007)

$$\sigma_b = \frac{M.C}{I} \text{.......................} (1)$$

Where:

σ_b = Bending stress threshold

C = d/2 (Distance of the top of mounting stress from zero to the greatest value)

I = Moment of inertia of the section of the ring hard ($\frac{\pi}{64} d^4$)

Through the foregoing be above the law:

$$\sigma_b = \frac{32F\ell}{\pi d^3} \quad \text{.........................(2)}$$

And the application of practical values for model checking and fatigue following dimensions (ℓ=100mm, d=8mm).

With the values of the exerted force out to the two cases, the law can be applied to model the behavior of fatigue testing under stress alternating stress and the average value is zero.) Khurmi .RS 2005-17).

$$\sigma_r^a * N_f = k \quad \text{..........................(3)}$$

Where:

σ_r = Over the cycle of stress.

N_f = The number of cycles of failure.

k&a **=** Material constants to model checking fatigue.

Can be applied to equation (3) for the two studies case to extract two values of constant coefficients of the polymer material of the armed Cellulose and more than one site, then the transaction were used to extract the number of cycles to failure theory loads corresponding to the loads process.

4- Practical field

The manufacturing molds tubular had cut into halves to make it easier to open, and after placing cellulose fibers inside the mold and at different angles with the longitudinal axis of the template (0, 30, 45, 60, 90) and then put the base material and the surrounding tempered fiber, and use your checking fatigue rotor under the influence of stress bending at the free end of the screening model as in Figure 1, and the polymer with the following specifications (Hammood .A.S 2011). When testing the range of previous models in bath by hanging load value on the edge of the model and increase the number of courses, and models with the same specifications with the change of the pregnancy value to get the data that has been painted forms (2.3, 4.5 0.6), while (Fig. 7) was concluded the shapes of the angle between the reported arming cellulose fiber and the amount of load.

RESULTS AND DISCUSSION :

When applying equation (3) for each group models, according to the angle of reinforcing fibers, cellulose and appoint two cases of stress hanging over models can calculate the values of coefficients of material specifications (a & k) for each case of arming and reapply the equation for the highest stress value can be borne by the models calculated the number of cycles of failure theory, and the values of process cycles of failure can be calculated by correction factor.

$$N_{mean} = \frac{\sum N_{\exp.}}{N} = \frac{23249}{5} = 4649 rev.$$

$$(Correction Factor) R^2 = \frac{\sum (N_{th.-} N_{mean})^2}{\sum (N_{\exp.} - N_{mean})^2} = 0.9$$

The results show that the theoretical and practical is installed, the following observations:

1 - Data presented in figure (2) revealed that can be increase the number of courses at decreasing pregnancy hanging bow, when its initial stress (149.283N/mm^2) the number of cycles (2000 cycle), but when the final stress (99.522N/mm^2) the number of cycles (17500 cycle).

2 **–** The results shown in figure 7 demo start when a fixed amount of (50N) after the value of angle rebar (60º) start growing, the number of cycles of failure to reach the corner (90º) almost (11000 cycles).

3 - When the value of loading at least (20 N), the number of cycles of failure upper corner reinforcement (90°) of what appeared in the form (7), to load (50N) and the angle of arming (0°) be the number of cycles of failure top (17500 cycle).

4 - The value of the correction factor (0.9) shows best congruence between the approximate theoretical and practical results.

CONCLUSIONS :

1- That the value of fatigue resistance for composite materials used in the research lies in the range (28-100 MPa) and in different situations on the angle of reinforcement with the longitudinal axis of the column of the polymer and the maximum value of the resistance when the angle of reinforcement is zero.

2 - The value of the fatigue resistance of composite materials increases with increasing resistance to the vertical composite material.

3 - The difference between the thermal expansion coefficient of the material polymeric (Epoxy) and cellulose fibers (Fiber) must be less than what can be, and this is not always possible, can work cover (Flex) fibers are used to reduce the difference in thermal expansion coefficient between the polymer and fiber, but that situation probably article increase the cost of the vehicles.

Table (1) shows the specifications of the polymer

Test method	Typical results
Compressive strength (BS 6319)	70.0 N/mm^2@ 20^{o}C 93.0 N/mm^2@ 35^{o}C
Tensile strength (BS 6319)	26.0 N/mm^2@ 35^{o}C
Flexural strength (BS 6319)	63.0 N/mm^2@ 35^{o}C
Youngs modulus in compression	16 Gpa
Pot life	90 minutes @ 20^{o}C 40 minutes @ 35^{o}C
Specific gravity	1.04
Mixed viscosity	1.0 poise @ 35^{o}C

Table (2) values of failure process cycles

No.	Angle (deg.)	n	logK	Stress (σ) N/mm^2	Nf exp. (rev.)	Nf the. (rev.)	ΔN (rev.)
1	0º	9.59	80	149.283	2362	1905	455
2	30º	8.71	70.8	99.522	17023	16595	426
3	45º	9.98	79.526	99.522	1775	1584	190
4	60º	85.4	77.34	99.522	735	630	104
5	90º	8.2	64.13	99.522	1354	1174	178
SUM	---	--	--		23249	21888	1353

Fig. (1) shows the testing device for fatigue bending rotor technology used in the practical field of search

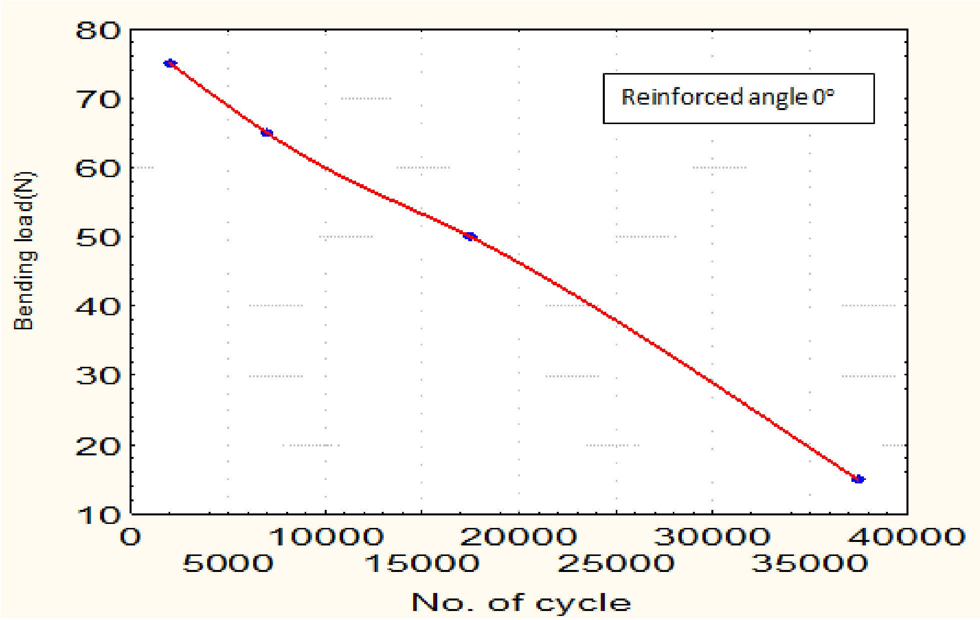

Fig. (2) Shows the fatigue test results for four models reinforced polymer cellulose angle (0 °) and parallel to the longitudinal axis of the model

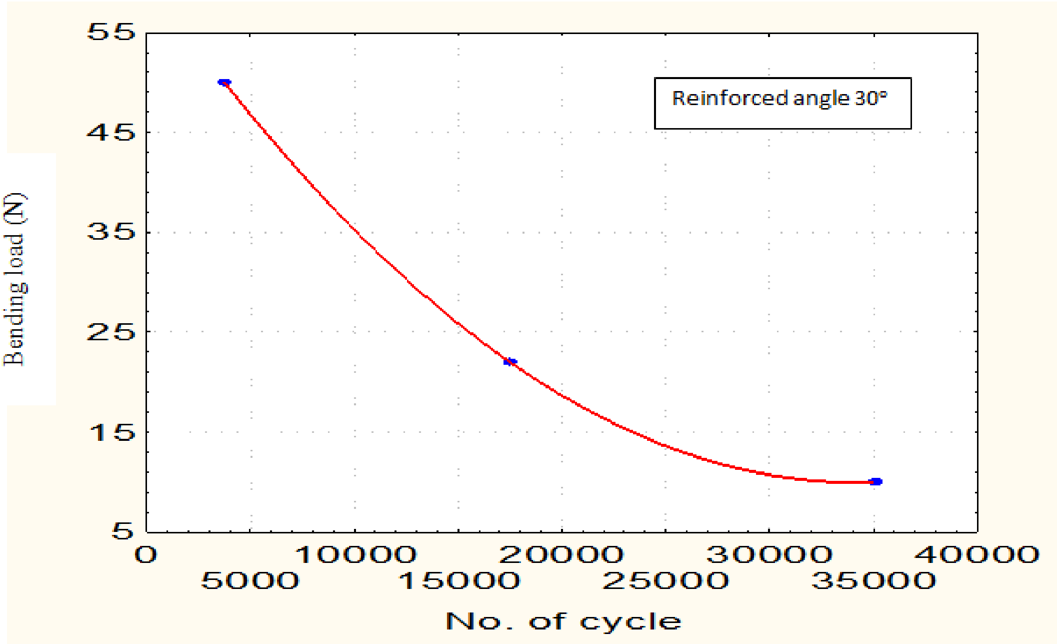

Fig. (3) Shows the fatigue test results of three models of polymer reinforced Cellulose and angle (30 °) with the longitudinal axis of the model

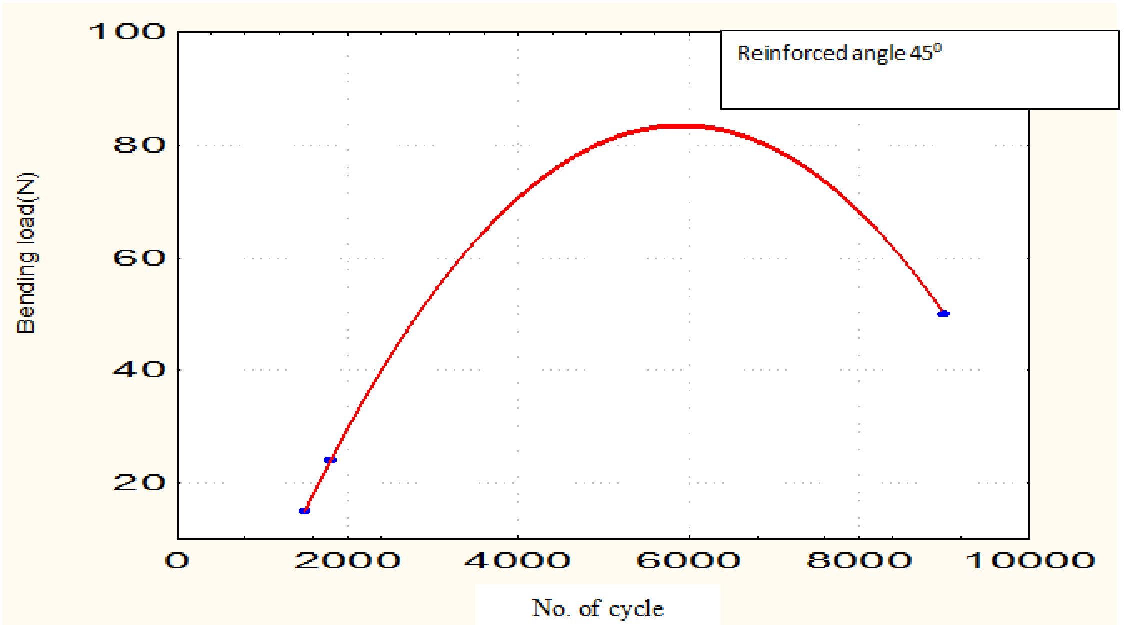

Fig. (4) Shows the fatigue test results of three models of polymer reinforced Cellulose and angle (45 °) with the longitudinal axis of the model

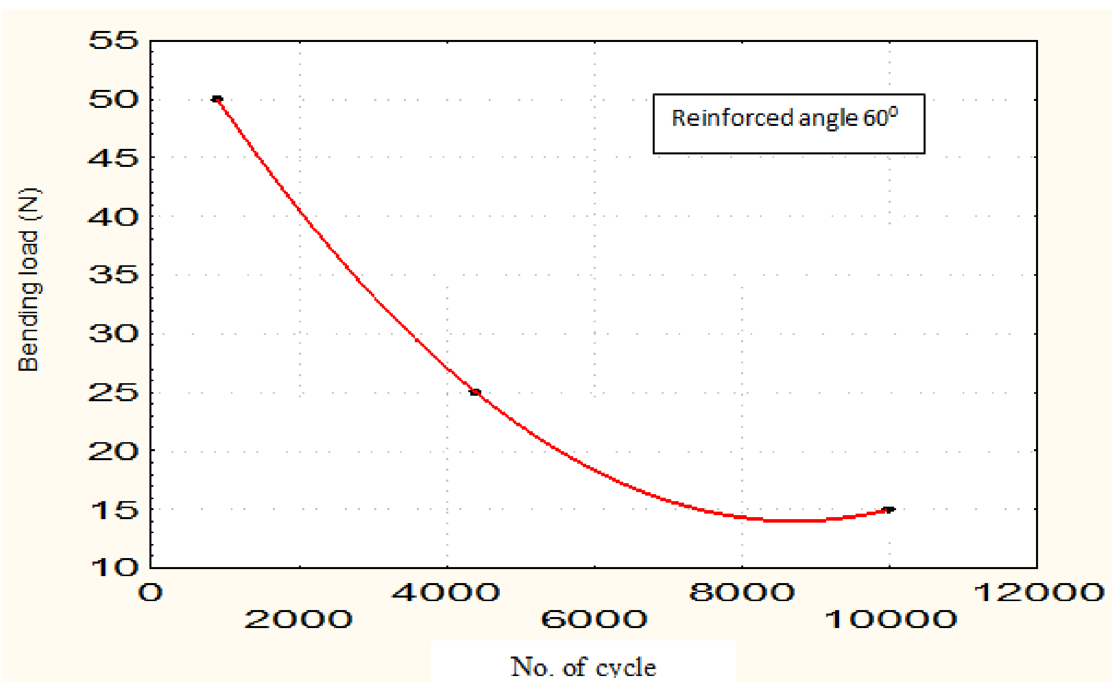

Fig. (5) Shows the fatigue test results of three models of polymer reinforced Cellulose and angle (60 °) with the longitudinal axis of the model

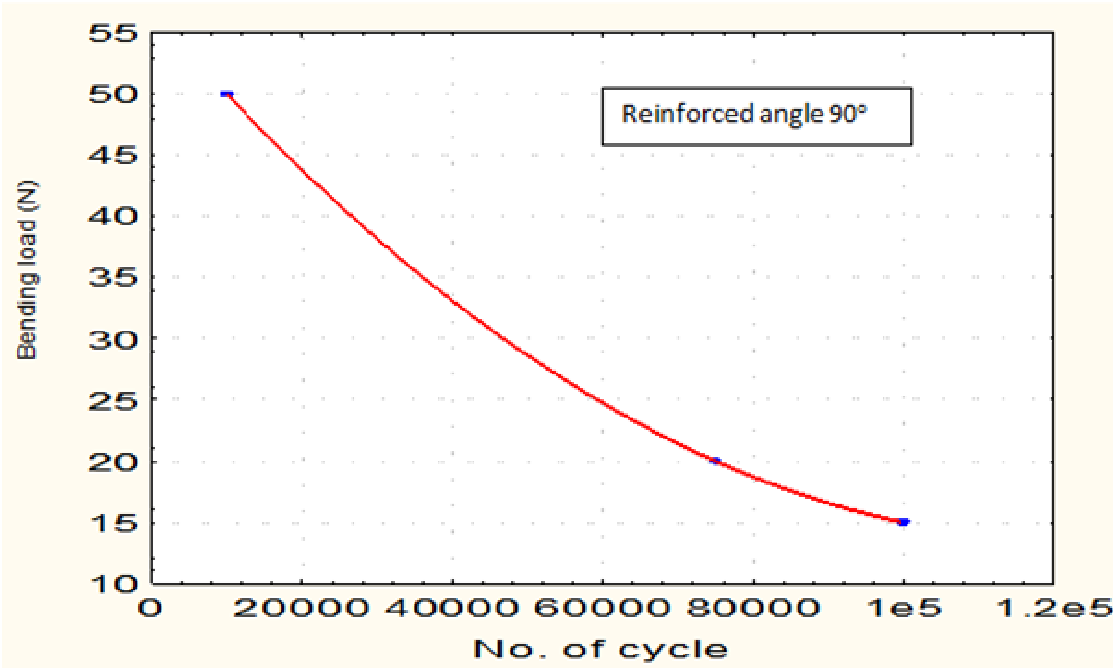

Fig. (6) Shows the fatigue test results of three models of polymer reinforced Cellulose and angle (90 º) with the longitudinal axis of the model

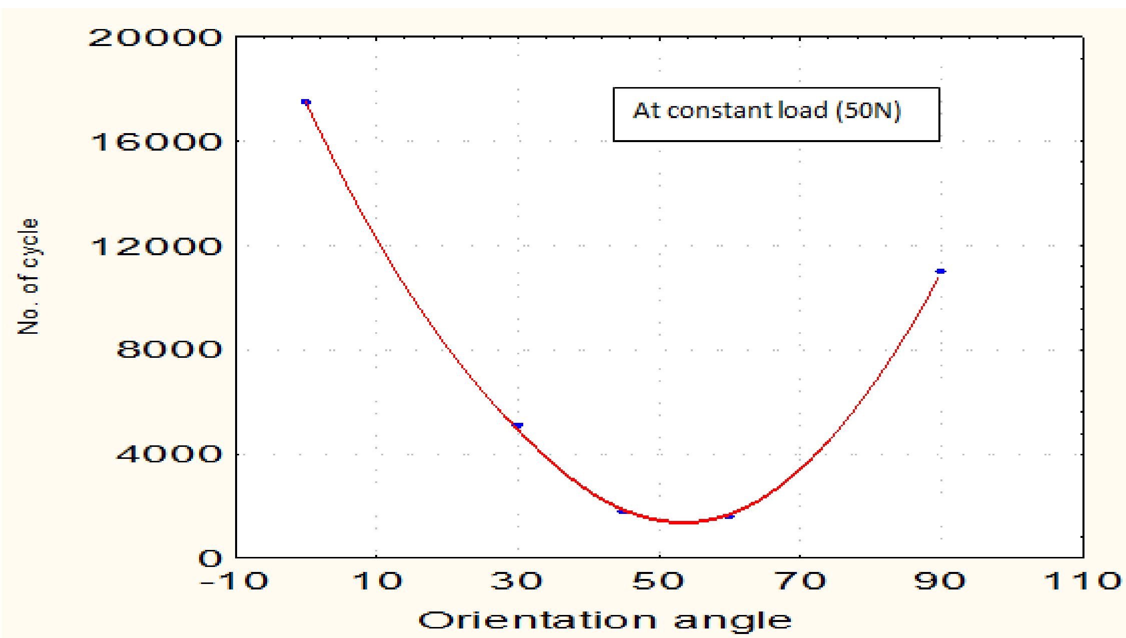

Fig. (7) Illustrates the relationship angle arming polymer cellulose fibers with sessions examining fatigue strength under static load

REFERENCES :

Abu-Farsakh G. A.”Micromechanical characterization of Tensile strength Of fiber composit material” 2000,Taylor & Francis ,Jordan University.

D.R. Askeland, “The Science & Engineering of Materials”, Wadsworth, Inc., California, (1984).

Efunda.com/ formulae/ Solid-mechanics/ Composites “Introductionto Composite Materials”, (2004).

G. Lubin, “Hand Book of fiber glass & Advanced Plastics Composites”, Litton Educational Company, New York, (1969) .

Hammood .A.S "Effect of fiber Orintation on fatigue of glass-fiber reinforcement Epoxy composite material"The Iraqi Journal of mechanical & material Engineer -ing ,2011.

J.w. Phillips, “Behavior of Engineering Materials”, The Board of Trustees of the university of Illinois at Urbana- Champaign, (1997).

Kurmi .R .S.”Machine Design “ 2005.

L. Holliday, “Composite Materials”, Elsevier Publishing Company, London, (1966).

M.A. Meyers, K.K. Chawla, “Mechanical Behavior of Materials”, Prentice- Hall, Inc New Jersey, (1999).

M.M. Schwartz, “Composite Materials Hand Book”, Mc Graw- Hill Company, New York, (1984).

P.A. Thernton & V.J. Colangelo, “Fundamentals of Engineering Materials”, Prentice- Hall, Inc., (1985).

R.A. Flinn & P.K. Trojan, “Engineering Materials & their Applications”, Houghton Mifflin Company, Boston, (1990).

R.B. Seymour, “Polymeric Composites”, Alden Press, London (1990).

R.M. Jones, “Mechanics of Composite Materials”, Scripta Book Company, New York (1975).

V. Raghavan, “Materials Science & Engineering- Afirst Course”, 2nd.ed, Prentice- Hall of India Private Limited, New Delhi, (1979).

W. Bolton, “Engineering Materials Technology”, 3rd ed., a Member of Reed Elsevier Group, (1998).

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