

COMPRESSION MODULUS IMPROVEMENT OF HDPE USING SCRAP STAINLESS STEEL POWDER AS A FILLER COMPARING WITH WOOD FLOUR AND BOVINE BONE POWDER

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Abstract:

This paper presents study on the effect of addition of different types of fillers such as (wood flour, Bovine bone powder, and fine powder of scrap stainless steel 302) on compression modulus of HDPE. Fine sieving treatment has been used for the fillers before mixing; composites were made at (5%, 10%, 20 %) by weight filler contents, each filler was added separately to HDPE material.

Results indicated that the addition of scrap stainless steel powder gave positive improvement in the compression modulus of HDPE and the improvement increased with increasing stainless steel contents and maximum percentage of improvement was (30%). The addition of bovine bones flour and wood flour decreased the improvement in compression modulus of HDPE in all percents used of Fillers.

الخلاصة

يقدم هذا البحث دراسة عن تأثير إضافة مسحوق العظام والخشب و مسحوق معدن الفولاذ الغير قابل للصدأ كحشوات إلى مادة البولي اثلين عالي الكثافة على معامل الانضغاط. تم تنظيف هذه المواد وتحويلها إلى مسحوق وتم خلطها قبل خلطها مع البولي اثلين العالي الكثافة. تم خلط كل مسحوق بشكل منفرد مع البولي اثلين وبالنسب الوزنيه ألتاليه (5% ، 10% و 20%) . أوضحت النتائج بان مسحوق معدن الفولاذ الغير قابل للصدأ (المجهز من مخلفات الورش الميكانيكية في الحي الصناعي في الحلة) الذي أضيف إلى البولي اثلين عالي الكثافة قد حسن معامل الانضغاط من خلال ارتفاع معامل انضغاطه بشكل كبير وان هذا التحسن ازداد مع زيادة كمية الفولاذ الغير قابل للصدأ المضافة وان أعلى نسبة تحسن تم الحصول عليها (30%). بينما أدت إضافة مسحوق العظام ومسحوق نشارة الخشب إلى انخفاض معامل انضغاط البولي اثلين عالي الكثافة مقارنة مع قيمه في أحواله النقيه.

Introduction:

High density polyethylene (HDPE) consumption continues to grow annually, with product and potential new applications increasing volume sales growth. The Pipes segment is seen as one area, which will enjoy higher than average growth, HDPE substitution into the juice and milk packaging market is likely to continue as high density bottles replace glass and tetra-pack bricks. The potential for replacing metal in automotive fuel tanks, metal cans, large containers and house hold fuel tank is also likely to support HDPE demand in the coming years [1].

Many efforts have been made to improve the mechanical properties of HDPE by adding fillers and reinforcements, such as wood flour, recycled urea-formaldehyde grit, glass bed calcium carbonate, and clay.

Behzad etal [2], have been studied the effect of maleic anhydride polyethylene as the compatibilizer on the mechanical properties of wood flour polyethylene composites using Dynamic Mechanical Analysis (DMA). Results indicated improvements in the mechanical properties.

Bliznakov et al [3], have been found that the tensile modulus of the ionomer treated blends was raised to three times the modulus of virgin HDPE. Urea-formaldehyde grit was used as recycled thermosetting filler.

Calcium carbonate as an inorganic material was used to modify the mechanical properties and morphology of the polymers [4].

The low creativity of HDPE prevents a good bond between the filler and matrix, some researchers have used compatibilizers [5,6] others techniques have used are very fine sieving treatments for fillers before mixing to improve the filling ability and well distribution of fillers in matrix [7]. Proper mixing and dispersion of mineral into the polymer matrix is a critical factor in the optimization of product properties and performance [8]. The nature of the filler and filler loading has dramatic effect on the mechanical properties [9].

The objectives of this research are to study the effect of addition of different types of fillers such as (wood flour, Bovine bone powder, and fine powder of stainless steel 302) on compression modulus of HDPE. Fine sieving treatment has been used for the fillers before mixing. Composites were made at (5%, 10%, and 20 %) by weight filler contents.

Materials:

1. Virgin HDPE (Sabic company-kingdom of Saudi Arabia P-UP 6015-12, had a melt index 25g/10 min was used as the polymer matrix.
2. Fine powder of stainless steel (302) was prepared from machining scrap of Hilla Industrial Area. The scrap stainless steel powder was treated by dilute hydrochloric acid and sodium hydroxide, then washed by distilled water and finally dried before mixing.
3. Bovine bones powder was prepared from clean bovine bones were treated by dilute hydrochloric acid and sodium hydroxide, then washed by distilled water and finally dried. The bones crushed well and fine sieving treatment by 40 mesh sieve have been used before mixing.
4. Wood flour was prepared from machining waste of furniture manufacturing workshop, Russian origin. The 40 mesh wood flour has been dried from moisture before mixing.

Composites Properties:

Polymer, stainless steel 302 powder, Bovine bones powder and wood flour were initially weighed and bagged according to the various filler contents as shown in table (1). The HDPE mixed well with filler together under heating and molded to prepare the testing samples, for each type of test, four samples were molded.

Table 1
Composition of tested samples

Formulation	ADPE content (%)	Filler content (%)
1	100	0
2	95	5
3	90	10
4	80	20

Compression test:

The compression test was performed using (WP 300 universal material tested [Gunt-Hambury] which is interfaced to Pc computer in the mechanical department laboratory of Kufa University.

Results and discussion:

The compression behavior of HDPE was examined without any fillers addition as shown in figure (1). The maximum load reached was (500000 KN/m²), it was considered in this study as maximum reference load.

Figure (2) shows the effect of bone fine powder filler with weight fraction (5%, 10%, 20%) without compatibilizer on HDPE. The maximum load reached at 5% filler content about (375000 KN/m²), this addition decreased the improvement in compression modulus to (25%). (340000 KN/m²) maximum load was reached at (10%) bone fine powder filler content and the decreasing in compression modulus about (32%). (20%) filler content decreased the compression modulus of HDPE to 25%, that is mean there is no significant change in compression modulus of HDPE comparing with 10 % filler content . Generally the addition of bovine bone fine powder as filler to HDPE had a negative effect on compression modulus. Another point noticed that for all percents of filler addition of bone fine powder, the maximum load reached less than the reference load of pure HDPE.

Figure (3) shows the effect of addition of wood flour with weight fraction (5%, 10%, and 20 %) as filler on HDPE compression behavior, the addition of (5%) filler reduced the maximum load to (240000 KN/m²), leading to reduce the compression improvement to (52%). For (10%) wood flour addition there is no improvement noticed, the maximum load reached was near above (230000 KN/m²) and the percent of reducing about (54%). There was significantly improvement with (20%) filler content, the load reached about (380000 KN/m²) and the reducing in compression modulus become (24%) which is better than (5% and 10%) filler content .

However the addition of wood flour as filler without compatibilizer also had a negative effect on compression modulus of HDPE since the maximum load reached largely less than the reference load of pure HDPE.

Stainless steel 302 powder had significant positive effects on the compression behavior of HDPE as shown in figure (4), increased stainless steel powder content increased compression modulus. At (5%) filler content the load reached (620000 KN/m²) which is higher than the maximum load of virgin HDPE. At both stainless steel contents (10%) and (20%) an improvement in the compression modulus values was observed due to the filler addition. Positive increasing in load value (630000 KN/m²) was reached with (10%) filler, when increasing stainless steel powder content to (20%) there was no change in load value, but composite ductility decreased compared with (5%) content.

It was found that all stainless steel reinforcement investigated in this study exhibited very significant positive change on compression modulus of HDPE. The percents of increasing in the improvement of compression modulus are (28%), (30%) and (30 %) for filler addition contents (5%), (10%) and (20%) respectively because of strong interaction between the filler and the polymer matrix.

Conclusion:

Stainless steel powder had a very significant effect on the compression modulus of HDPE. The compression modulus increased with an increase in stainless steel contents , maximum percentage of improvement was (30%), when compared with the other two

filler contents used (bone fine powder and wood flour). The addition of bone fine powder and wood flour decreased the improvement in compression modulus in all percents used of fillers.

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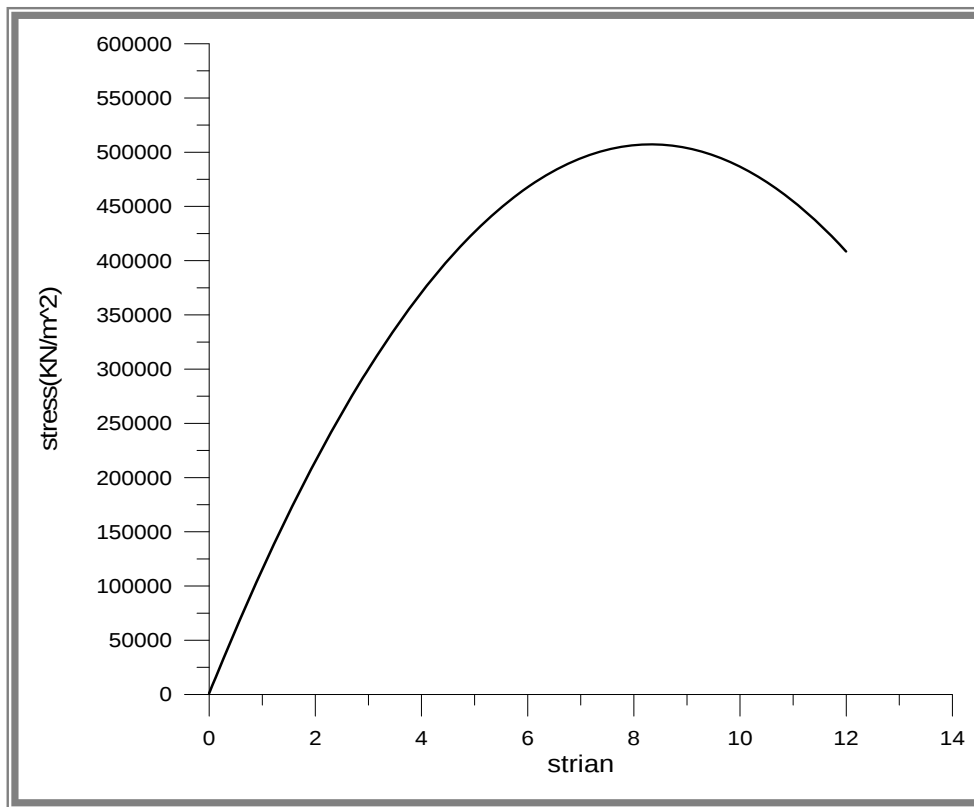


Fig. 1. Relationship between force and elongation for pure % HDPE

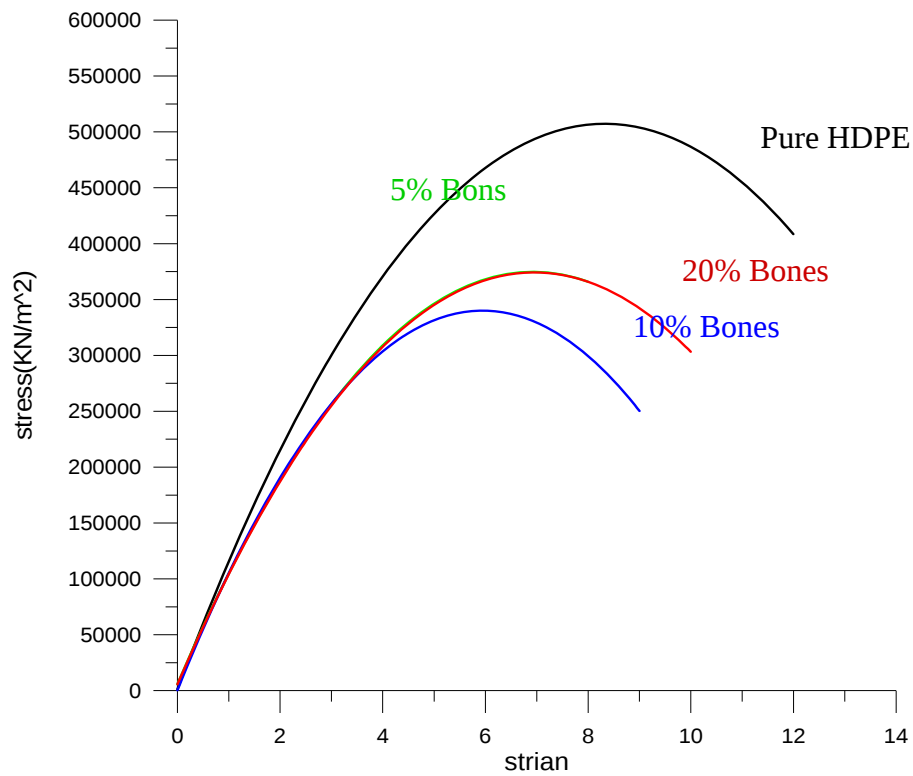


Fig. 2. Effect of bone powder on the compression modulus of HDPE

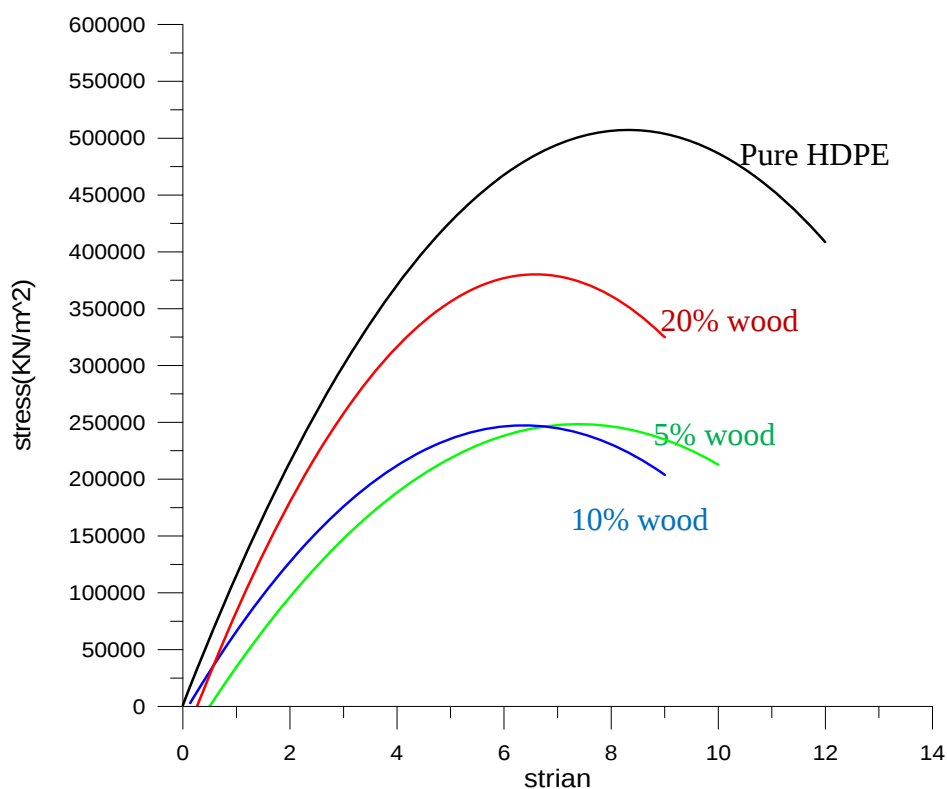


Fig.3. Effect of wood flour on the compression modulus of HDPE

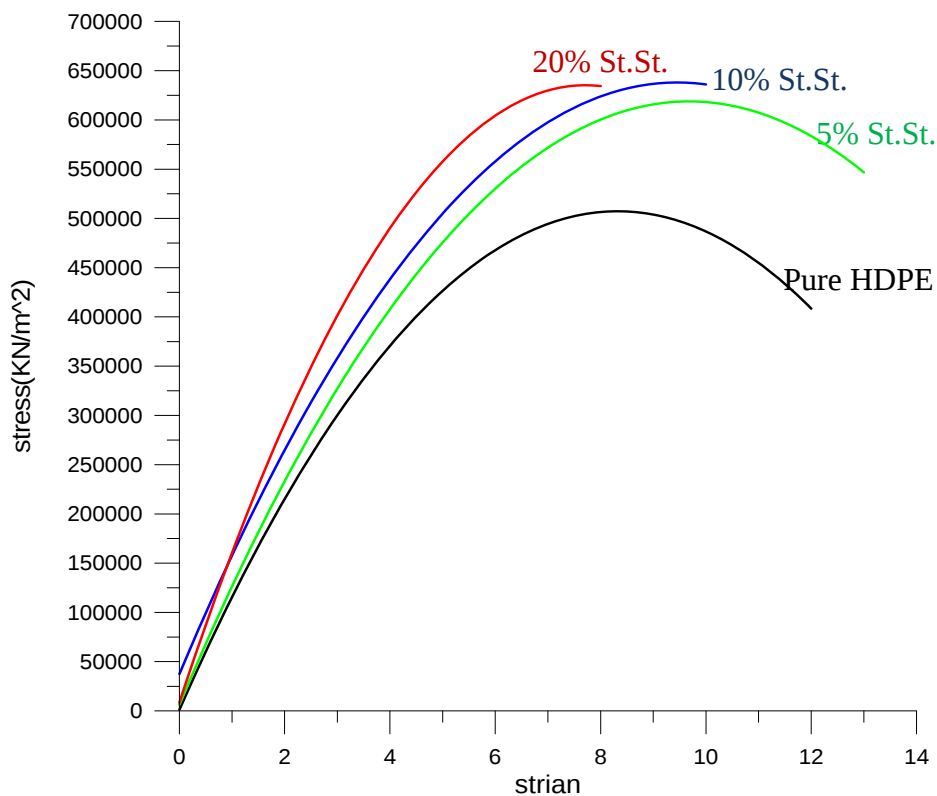


Fig.4. Effect of stainless steel powder on the compression modulus of HDPE