The Iraqi Journal For Mechanical And Material Engineering, Vol.13, No.2, 2013

EFFECTS OF RICE HUSK FILLER ON THE MECHANICAL AND RHEOGICAL PROPERTIES OF RUBBER COMPOUNDS BASED ON NATURAL RUBBER

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ABSTRACT:-

This research tries to study the using of rice husk (**RH**) as a filler with rubber compound based on Natural rubber (NR) that was prepared using an mixing mill about 80℃ and 50 rpm with different weight fraction **(part per hundred Rubber)** as (0-5-15-25**pphr**)with particle size between (250-500) µm , the results show the tensile strength and viscosity decreased with RH loadings in the matrix, while the tensile modulus and hardness showed an opposite trend. The weak filler -matrix interaction, resulting in poor filler dispersion and large agglomerated particles size, caused those properties to decrease. However, some mechanical properties of the rubber compound can be slightly improved with the addition of **(RH)** into the matrix while other properties decrease weather the overall rheology properties for all samples almost being little change.

Key Word: PE, Mechanical properties, Rice Husk, Natural Rubber, Tensile strength, dispersion, agglomeration.

دراسة تأثير مالئ قشة الأرز على الخواص الميكانيكية والريولوجية لمركبات مطاطية ذات أساس من المطاط الطبيعي

الخلاصة:

تم في البحث الحالي المحاولة في دراسة استخدام قشة الارز(Rice Husk) كمضاف على مركب مطاطي ذو اساس من المطاط الطبيعي (Natural Rubber)،يعد هذا الخليط باستخدام عصارة مختبرية بدرجة حرارة مقدارها 80 ℃ وسرعة دوران تساوي (50 r.p.m.) مع نسبة اوزان مختلفة (جزء لكل مئة جزء مطاط) وبنسب (0-5-15-25pphr) وحجم دقائق تتراوح ما بين µm (250-500) . حيث اظهرت النتائج بان كل من قوة الشد واللزوجة قلت بزيادة نسبة (RH) فى العجنة المطاطية بينما اظهرت ان معامل مرونة الشد والصلادة تزداد بزيادة نسبة (RH). ان ضعف التفاعل بين الماة المالئة و العجنة المطاطية ناتجاً من الضعف في انتشار المالئ والتكتل الكبير للدقائق كونها ذات حجم كبير مؤدياً ذلك الى الانحراف النسبي في هذه الخواص،على اي حال بعض الخواص الميكانيكية لمركب المطاط يمكن ان تحسن بشكل لا باس به مع اضافة (RH) للاساس المطاطي بينما تقل الخواص الاخرى فيما كانت خواص الانسيابية بشكل عام لجميع النماذج ذو تغير قليل جداً.

INTRODUCTION:

In recent years, bio-filler-filled thermoplastic polymer composites have been widely studied for the application and development of environmentally friendly materials in the world. Rice husk is an agro-waste material which is produced in about 100 million of tons. Approximately, 20 Kg of rice husk are obtained for 100 Kg of rice. Rice husks contain organic substances and 20% of inorganic material.[Mauro M. Tashima, and et.al2004, Hee-Soo Kim and et.al 2007]

The new Biomaterials filler rubber compounds (BFRC) is a blend of rubber compound based natural rubber (NR) and a Biomaterials , such as rice husk because it is a good abrasion properties [Hee-Soo Kim and et.al 2007]. The strength of composite materials depends not only on the substrate strength but also on the interface strength. The blending of polymers was undertaken for three main reasons: improving the technical properties of the original polymer, achieving good processing behavior, and lowering the material costs [D. S. Campbell ,1978] .

The incorporation of various types of filler into a polymer matrix was carried out with the aim of improving the specified physical and mechanical properties of polymer composites. The main factors governing reinforcement of a matrix, apart from filler loading, are filler-particle size or specific surface area, filler structure, and specific surface activity [B. B. Boonstraand et.al,1987]. These fillers can be categorized into many aspects according to their applications, such as inorganic and organic. Recently, investigations into the use of fillers derived from agricultural-based materials such as hemp, jute, bamboo, and rice husk (RH) as alternatives to inorganic fillers in rubber had been widely reported [R. G. Raj and et.al.1991, H. Ismail and et.al.,2001] .

Rice husk (RH), among several cellulose products, is biodegradable, inexpensive, low density, abundant, and causes no damage due to abrasion to the processing machinery

The major limitation of using RH for reinforcement is the difficulty in dispersing particles in the rubber matrix due to the poor interfacial adhesion between the polar hydrophilic RH particles and the non-polar-hydrophobic rubber chains [M. Y. A. Fuad and et.al.1995].
One of the problems identified with using a high content of RH in thermoplastics is the agglomeration of fillers as a result of insufficient dispersion.

The study of materials whose mechanical properties have characteristics of both solid and fluid materials. Viscoelasticity is a term often used by those whose primary interest is solid mechanics while rheology is a term often used by those whose primary interest is fluid mechanics. The term also implies that mechanical properties are a function of time due to the intrinsic nature of a material and that the material possesses a memory (fading) of past events. The latter separates such materials from those with time dependent properties due primarily to changing environments or corrosion. All polymers (fluid or solid) have time or temperature domains in which they are viscoelastic.

In this paper, We investigated the effects of filler loading on some mechanical properties of rubber compound based on natural rubber (NR).

EXPERIMENTAL:

Materials:

The Natural rubber (NR) in this study was (SVR -5L) from Vietnam Rubber standard, which used as a compound with other additives. RH, supplied by local farm area, Najaf, was grind and sieved by using lab crusher and screening through a sieve Type (Micro plant Grinding-FZ102) to obtain rice husk as flour with a particle size between (150-250 μm) and then drying for (24 h at 100 °C) before mixing with Rubber compound.

Sample preparation

The Sample were prepared with blending process in a Laboratory Mixing mill type (comerio Ercole Busto Avsiz), at (80 °C and 50 r.p.m). Matrixes were prepared with compositions as shown in Table (1). The compounds were curing by heating press at (145 °C for 45 min). with (3.5 MPa) to made thin sheet according to (ASTM-D3182), and then cutting by use hand press for preparing to tensile tests, as well as use special mold to prepare the other samples for the other properties .

Table 1: Compound rubber blends formulations

Material type	Composition (pphr)			
NR	100			
Reclaim	28			
Renacit	0.15			
Zinc Oxide	4			
Stearic Acid	2			
Carbon 660	58			
Process Oil	6			
Novolak	2			
Sulphur	2.64			
CTP-100	0.44			
MBS	0.77			
Rice Husk (RH)	0	5	15	25

Rheology studies:

The rheology studies were made using a (Rheometer ODR-2000).Samples with circular shape with (0-5-15-25 pphr) of (RH) and dimensions (diameter =50mm, thickness=6mm) by special cutter from compound as shown in the figure (1-a). The test will conduct with temperature at (185 C^o for 6 min).

Mechanical testing:

The tensile properties were measured using a Universal Testing Instrument (Monsanto T-10) according to (ASTM D638). Also elongation and modulus of Elasticity for the samples can be examined by the same instrument. The shape of the samples as shown in the figure (1-b).

The hardness of the rubber compound (IRHD) was measured using a Durometer, according to (ASTM D2240).The specific gravity also measured by (Monsanto- Densitron) according to the Archimedean principle.

RESULTS AND DISCUSSION:

Figure 2 shows the variation of tensile strength with RH loadings in different RH ratio (0-5-15-25 pphr) for rubber compound matrixes. The tensile strengths of the compound with and without RH are in the order as follows:

A clearly decreasing of tensile strength is observed when RH is added into the rubber compound matrix as a result to poor dispersion and agglomeration for RH particles in NR matrix. However, the incorporation of RH into the matrixes NR compound causes the drop in tensile strengths to decrease.

The (NR) and (RH) phases are not compatible and so it is need to improve the interfacial interactions between the RH and plastic phases by sophistical ways and, thereby, increases the homogeneity of the compound [I. Hanafi and et.al.1999, P. Sae-Oui and et.al 2001]. The coupling agents may be increase the interfacial adhesion, like silane, is expected to react with the polyisoprene of (NR), and causes the (NR) phase to be partially cured, also the rubber molecule should adsorb the reinforcement particle surface physical adsorption or chemically or wettability between surface of RH and rubber molecule chain as term surface tension between them for that, there is no reinforcement effect if there is no interaction of the particulate surface and rubber molecule even if the addition ratio of the particle is increased [Sae-Oui and et.al 2001, Yoshihiro Yamashita2002]. Table 1. show the result by universal testing machine(monesanto –T10).

The tensile strength of samples decreases with (RH) loadings [B. B. Boonstra1987]. The effect is drastic at the (25%) loading, especially for the (NR) matrix. Further addition of RH results in a proportionate decrease in tensile strength. The trend shows that the RH filler is non-reinforcing and being very prominent the reduction in the strength may also be due to the highly porous structure and agglomeration of filler particles in the matrix to form a domain that acts like a foreign body, or simply the result of physical contact between adjacent aggregates. This poor interfacial bonding creates partially separated microspaces between the filler and the polymer matrix, which obstruct stress propagation when tensile stress is loaded and induces increased weakness for the material. A further increase in filler (RH) loading would eventually reach a level whereby almost all filler particles or aggregates are no longer adequately separated or wetted by the matrix phases, which causes the inability of the filler to support stresses transferred from the Rubber matrix.

The tensile modulus increases with filler loadings at different ratio of strain (100%200% and 300%), as shown in Figure 3,4 and 5. The composite system of (RH) and (NR) has the highest

tensile modulus. The addition of fillers (RH) is expected to increase the tensile modulus resulting from the inclusion of rigid filler particles in the soft matrix and the better value at (15 pphr) of (RH), but the Modulus at (300%) strain drop suddenly because the failure occur before the strain reach to (300%) . This observation indicates that the incorporation of filler into the thermoplastic matrix improves the stiffness of the BFRC.
The elongation also decreases with (RH) loading as a result for the same reason above, elongation as show in the figure 6.
Hardness is an indication of the other mechanical properties. The filler is capable of obstacle for the local movement of rubber chains to resist the loads if the filler matrix interaction is strong enough. The result, in Figure 7.

Figure 8 shows the Specific gravity of (RH/NR) composites with (RH) loading, which show increasing in density resulting for increasing Rice Husk percentage. The variation of hardness of composites with filler loadings which depends on the distribution of filler particles in the matrix seems to increase with increasing filler loadings. Incorporation of filler particles into the rubber or plastic phases reduces the elasticity or flexibility of polymer chains to a more rigid composite. The presence of a more flexible (NR) in the blend causes the material to exhibit lower hardness properties.

Table2. Shows the result by Rheometer (ODR-2000) with (RH) loading. However, the viscosity also decreases slightly with (RH) loading for all samples, as in figure 9, also the relationship between Max. Torque and time of curing with (RH) loading shown in figure 10 and 11 respectively.

In Figure 12 shows the result of rheology for all samples with different loading of (RH) as relationship between torque and time .It is observed that there are slightly variations in rheology of rubber composites, this is due to the restriction of mobility and deformability of the matrix with the introduction of mechanical restraint [Chayanoot Sangwichien, 2008].

CONCLUSION:

The main objective of this study is to investigate the mechanical properties of rice husk (RH) as natural filler in rubber compounds matrixes. It is obvious that natural rubber/rice husk (NR/RH) compounds have the moderate mechanical properties, which is due to the incorporation of filler that depends on the distribution and homogeneity in rubber compounds and the (RH)-rubber matrix interaction. The (NR/RH) compound has the moderate mechanical properties, which is due to agglomeration and poor interfacial bonding that will increase the interfacial tension of the filler-matrix blend. Tensile strength and rheology properties of the blend drop dramatically with (RH) loadings, due to large particles size, agglomeration, and low interaction between the inert filler and polymer matrix. However, the increase in modulus and hardness is attributable to the rigid filler particles, causing a drop in elasticity or flexibility of the soft matrix.

Fig.1(a): Rheology samples

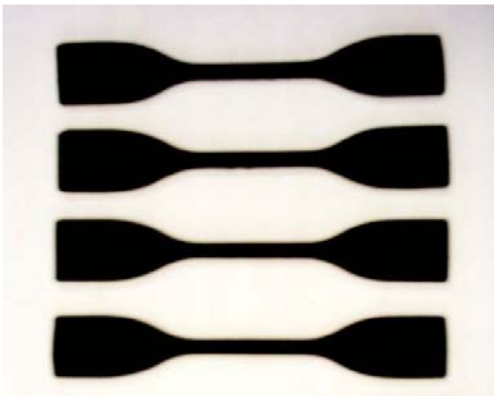

Fig.1(b): Tensile samples

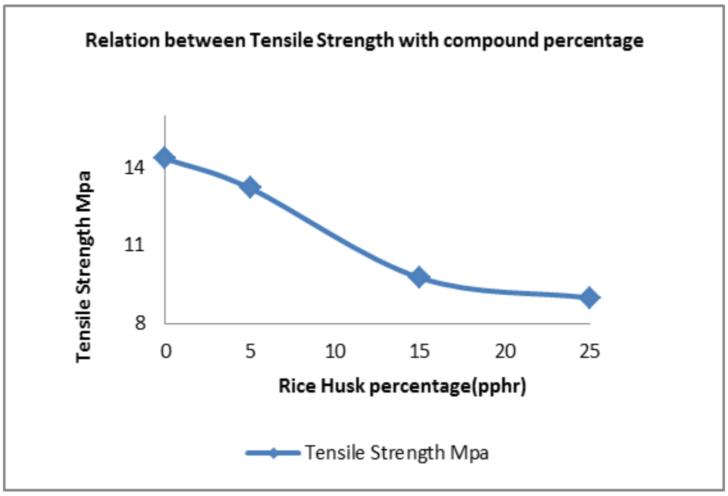

Fig.2: Tensile strength of NR/RH compounds

Table 2: Results from Universal Testing Machine

No	RH%	Tensile strength Mpa	Elongation at Break %	Mudulus at 100% Mpa	Mudulus at 200% Mpa	Mudulus at 300% Mpa
1	0	14.35	375	2.57	6.17	10.88
2	5	13.2	354	2.9	6.5	11.12
3	15	9.75	273	3.13	6.81	-
4	25	8.98	283	2.95	5.99	-

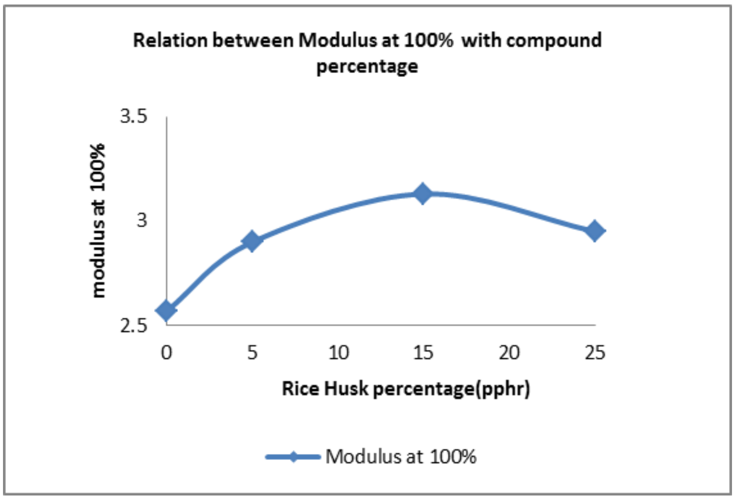

Fig.3: Tensile Modulus of NR/RH compounds

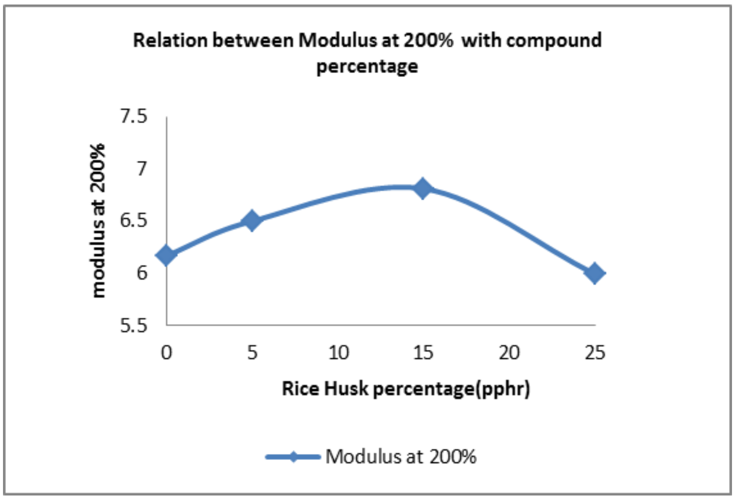

Fig.4: Tensile Modulus of NR/RH compounds

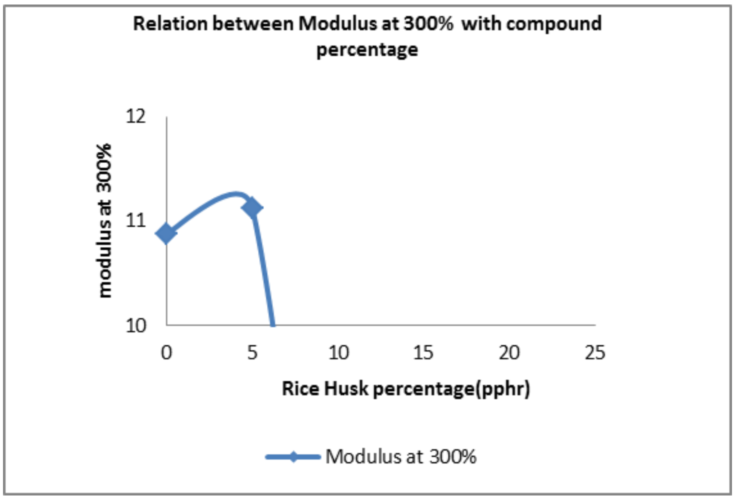

Fig.5: Tensile Modulus of NR/RH compounds

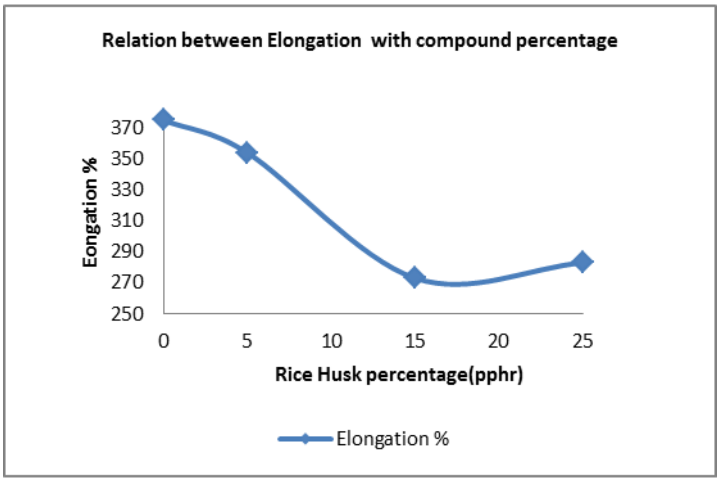

Fig.6:Elongation of NR/RH compounds

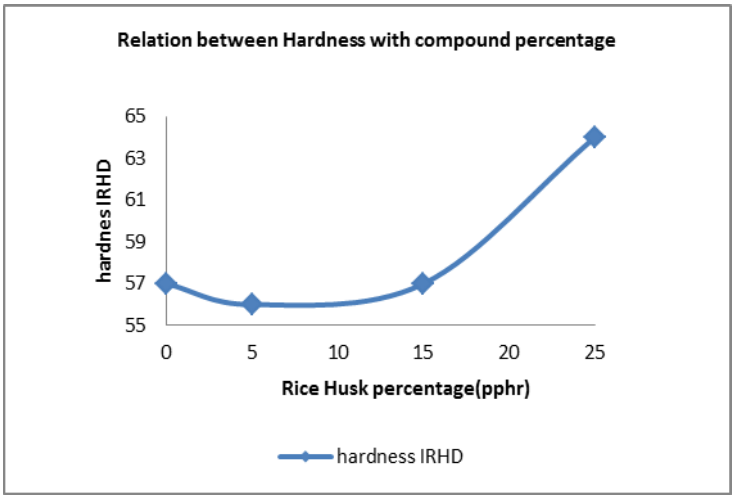

Fig.7:Hardness of NR/RH compounds

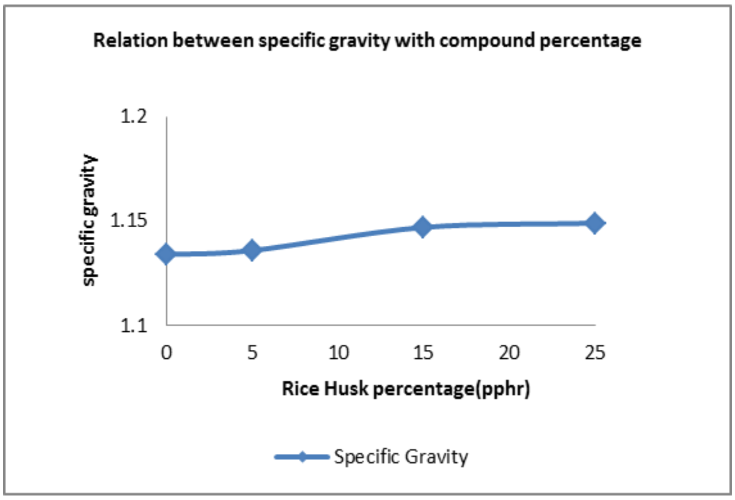

Fig.8: Specific gravity of NR/RH compounds

Table 3: Results from Rheometer Testing Machine

No	RH%	Cure time t90 (m.m)	Scorch time ts2(m.m)	Viscosity MU	Max. Torque lb-in	Min.Torque lb-in	Specific Gravity	Hardness (IRHD)
1	0	2.37	1.35	9	27	3.24	1.134	57
2	5	2.49	1.41	7	26.49	2.59	1.136	56
3	15	2.4	1.36	7	27.1	2.74	1.147	57
4	25	2.32	1.33	6	27.82	2.15	1.149	64

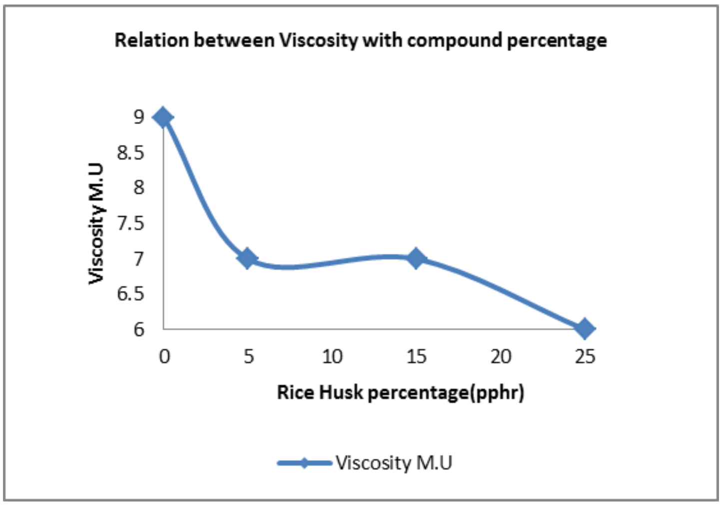

Fig.9: Viscosity of NR/RH compounds

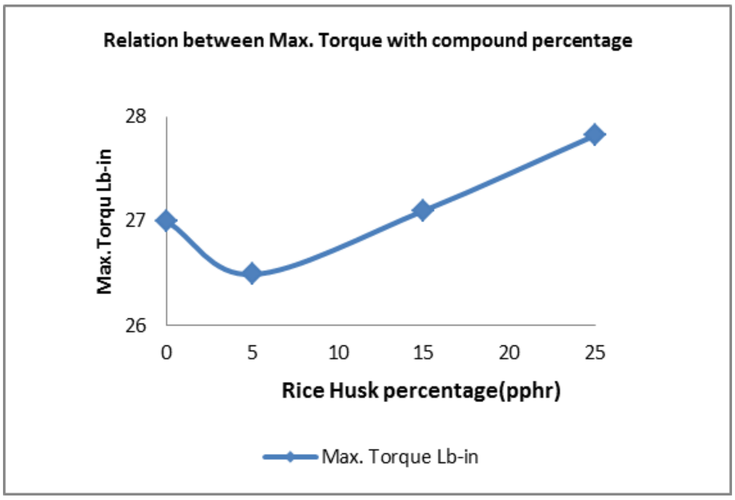

Fig.10: Max. Torque of NR/RH compounds

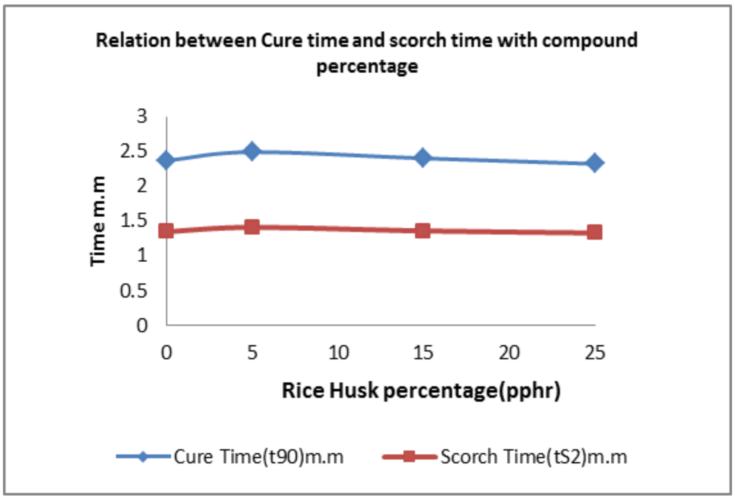

Fig.11: Time of curing of NR/RH compounds

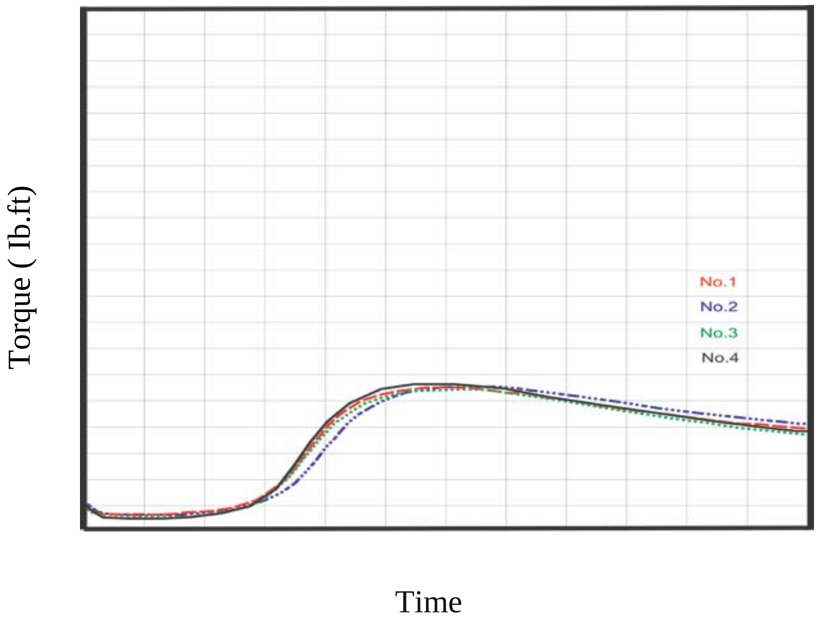

Fig.12: overall rheology of NR/RH compounds

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