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RESEARCH ARTICLE

Effect of mixture of Reclaimed tire and Carbon Black Percent on the Mechanical properties of SBR/NR blends

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Abstract

This article explores the possibility of using mix of reclaim powder and carbon black as reinforcement in natural rubber/styrene–butadiene rubber (NR/SBR).

Mix of reclaim and Carbon Black materials used in this research to enhancement some of the mechanical properties of SBR/NR blends as additives or fillers. 16 different compound was prepared from SBR(100,80,60.50)pphr ,NR (0,20,40,50) and 4 loading level from C.B (10,20,30,40) pphr ,Reclaim (10,20,30,40)pphr in series while the hardness ,tensile strength, tear résistance, elongation, elastic modulus, fatigue ,and specific gravity have been studied in this research. We found that some of these properties are increasing with the increment of mix of C.B, reclaim loading , such as hardness ,specific gravity ,tensile strength ,tear resistance ,elastic modulus from other hand fatigue, elongation , were decreased with increment C.B, reclaim loading %.

INTRODUCTION

Reclaiming is a procedure in which the scrap tire rubber or vulcanized rubber waste is converted, using mechanical and thermal energy and chemicals, into a state in which it can be mixed, processed, and vulcanized again. The principle of the process is devulcanization. In vulcanization, it is assumed that the cleavage of intermolecular bonds of the chemical network such as carbon–sulfur and/or sulfur–sulfur bonds, takes place, with further shortening of the chains occurring .Many different reclaiming processes have been applied through the years in an attempt to solve the problem of rubber recycling. Generally, ground rubber scrap is, in most cases, the feedstock for the devulcanization step.

Reclaiming is the most important process in rubber recycling. Many different reclaiming processes have been used through the year depending on scrap characteristics and economics. Generally, ground rubber scrap is, in most cases, the feedstock for the reclaiming. The pan process digester process (either wet or dry), and mechanical or reclaimator processes are currently the common processes used for reclaiming[1].

High elastic polymer composites are very important in the applications of rubber industries, such as tires transportation belts, pipes for fluids and fender.
Damping and support parts in the mobiles as well as diaphragm as mentioned above
Rubber composite materials with different type of rubber are used in dampers and.
supports application [3] Therefore it is occupied a wide field studies ,because rubber has good characterization in the high elastic strain damping which is obtained from
suddenly impact loading because of different acceleration of the system ,therefore a

different modification of new type of rubber composite for loading resistance in addition to the interference of the usages conditions with the mechanical loads such as environment effects at high temperatures in the presence of oils and friction result in creation of blended polymers such as (NBR , SBR , NR , CR ,..etc) [4].
Also a new type of polymers which is supported by thermosetting polymers type is developed for heat resistance purposes ,also different types of blended rubbers for improved by supporting methods such as by using particles and fibers for dynamic properties improvement for high loads purposes[5]

Rubbers can be divided broadly into two types: thermosets and thermoplastics thermosets are three-dimensional molecular networks, with the long molecules held together by chemical bonds. They absorb solvent and swell, but do not dissolve; furthermore, they cannot be reprocessed simply by heating. The molecules of thermoplastic rubbers, on the other hand, are not connected by primary chemical bonds. Instead, they are joined by the physical aggregation of parts of the molecules into hard domains [6]..[
Hence, thermoplastic rubbers dissolve unsuitable solvents and soften on heating, so that they can be processed repeatedly. In many cases thermoplastic and thermoset rubbers may be used interchangeably. However, in demanding uses, such as in tires, engine mounts, and springs, thermoset elastomers are used exclusively because of their better elasticity, resistance to set, and durability. The addition of various the chemicals to raw rubber to impart desirable properties is termed rubber compounding or formulation [7]..
Typical ingredients include crosslinking agents (also called curatives reinforcements, anti-degradants, process aids, extenders, and specialty additives, such as tackifiers, blowing agents, and colorants. Because thermoplastic rubbers contain hard domains that interconnect the molecules and impact strength and elasticity, they do not require crosslinking agents or reinforcing fillers.
This article study some of the mechanical properties such as tensile set and specific gravity and fatigue ,specific gravity tests were carried out by Densitron according to Archimedes principle. it was weighed in air and in water. The specific gravity is calculated by the following equation:-

$$\text{Specific gravity} = \frac{\text{Weight in air}}{\text{Weight in air} - \text{weight in water}} * \text{specific gravity of water}$$

So, we can calculate the tensile strength by the equation ;

$$T.S = F/A$$

Where F is the observed force required to break the specimen .

Young's modulus was reported as the slope of the initial linear region of the stress–strain. Actual experimental values were reported as stress–strain curves. The stress and strain are described by the following expression [24,25] ;

$$\text{Stress } \sigma = \frac{\text{Force or load F}}{\text{Cross sectional area A}}$$

$$\text{Strain } \varepsilon = \frac{(L - Lo)}{Lo}$$

Thus, Young's modulus in a tensile test is given by ;

$$E = \frac{\Delta\sigma}{\Delta\varepsilon}$$

Therefore the ultimate elongation is mathematically calculated by the relation;

$$E = [(L-Lo)/Lo]*100\%$$

where Lo=initial thickness ,L=final thickness.

with respect to the tear strength or the tear resistance in rubber, it may be described as the resistance for growing a neck or cut when the tension is applied on the specimen and it depends upon the width and thickness of the test piece and the test results as the load necessary to tear specimen of standard width and thickness .

Tear .S = F*t1/t2

where F=maximum force ,t1=thickness of standard piece,t2=the measured thickness of the specimen tested.

Fatigue may be defined as the change in properties that occur in a material after prolonged period action of stress or strain. The fatigue failure process involves a period during which cracks nucleate in regions that were initially free of observed cracks. Many factors influence fatigue nucleation [27].

1- Type of rubber , the type and degree of cross- linking , additives such as protective agents , reinforcement phase such as filler (type , volume fraction) and fibers (type , aspect ratio , orientation) which control the basic crack growth characteristics and the size of the flaws that are present initially .

2- Mechanical considerations such as, the shape and size of the article, the nature and magnitude of the deformations and the frequency and the form of the cycling.

The two widely used fatigue life parameters which are reported in point (2) for crack nucleation prediction in rubber are maximum principle strain (or stretch); minimum strain; and strain energy density, Our study is focused on maximum strain. Strain is a natural choice because it can be directly determined from displacements X which can be readily measured in rubber. Another factor is the R – ratio which is defined in the following equation:

$$R = \frac{\sigma_{\min}}{\sigma_{\max}} \quad \text{Or} \quad R = \frac{\varepsilon_{\min}}{\varepsilon_{\max}}$$

Where $\sigma_{\min}$, is minimum stress ; $\sigma_{\max}$ is the maximum load stress , $\varepsilon_{\min}$ is minimum strain ; and $\varepsilon_{\max}$ is the maximum strain . The R – ratio of strain cycle has a significant effect on fatigue life [26].

Experimental part

Materials

The NR ,SBR were reinforced by different volume fractions of carbon black and reclaim powder (supplied by the Babylon tire company)..

NR used in this study was of SMR20, supplied by the Perlis, Malaysia. The compositions of NR are listed in Table (1).

The SBR used is SBR–1502 with 23.5% styrene content (made by the emulsion process), Supplied by the Petkim, Turkey. The Properties of SBR are listed in Table (2). The properties of N375 are listed in Table (3).

Zinc oxide (97%) and stearic acid (99.4%) were supplied by Durham, U.K. The 6PPD [N- (1,3 – Dimethyl butyl) – N – Phenyl – Para – Phenylenediamine] (98%) was supplied by Flexsys , Belgium MBS [N-oxydiethylenebenzothiazole 2- sulfonamide] (98.2%) is supplied by ITT , India . Paraphenic oil was supplied by the South Patrol Company. Sulfur was supplied by the Durham, U.K.

Equipment and Instruments

Laboratory mill

Baby mill was used in this research contain two roll having provisions for passing cold water. These rolls are cylindrical in shape and of 150mm diameter and 300mm length. The roll speed is 20 r.p.m.

Equipment for Specific gravity measurement

Mansanto – Densitron equipment was used to measure the specific gravity . It . The operating of equipment according to Archimedes principle the sample prepared was weighed in air then in water the resulting data were given to the compile which was linked to the equipment.

Equipment for the measurement of Tensile Strength, Tear resistance, Elongation and Modulus of elasticity .

Tests are carried out on samples which were prepared mill laboratory according to ASTM D412. Monsanto T10 tensometer was used . The test sample which is movable at speed of 500 mm/min for all except tear resistance at 50 mm/min.

Equipment for Fatigue measurement

Tests are carried out on prepared samples and according to ASTM D430 by using the Wallace tester.

Equipment for Hardness (IRHD) measurement

The International Hardness test is used in measurement of the penetration of rigid ball (according to Brinall method) into the rubber specimen Test was carried out according to ASTM D1415 specifications.

Moulds preparation

The necessary moulds were manufactured for test samples to study their mechanical properties according to British standard (BS).

Mould for Testing hardness, and specific gravity

For preparing samples for hardness, impact, and density tests , the mould in the laboratories of Tyre Company was used The mould consists of three parts ,the middle part in a dimension of 200*180*6.5mm which contains (9) circular equivolume open with 65mm diameter and 5 mm thickness while one of other two parts is bottom base and the other is a cover for the purpose of samples thickness regulation .They have a dimension of 150*150*10mm .

Mould for preparing samples for tensile, elongation, and modulus tests

For preparing samples for the above tests, slice from each recipe with a dimension of 150*150*2.5mm was prepared by using mould which consists of three parts, the middle one in a dimension of 395*158*2.5mm contains six sections with 150*150*2.5mm dimension fixed on base of 395*160*10mm and covered with a cover of the same dimension as that of the base for regulation of thickness.

Mould for Fatigue Test Samples

For preparing fatigue test samples with dimensions contain half circular middle notch with a radius of 2.5mm The mould consists of three parts ,the middle part with a dimension of 282*222*6mm contains on 6 empty spaces with (153*62mm)dimension a circular middle notch with a radius of 2.5mm divided the part and the 6 vacant.

Results and Discussion

We can show from figure (1) that the hardness increasing linearly with increment C.B and reclaim loading this attributed to the physical cross- linking that it is happen between the rubber chains and this lead to increase hardness, this behaviors is agree with [19,23] . So that the hardness was incraesed when NR ratio is increased at 20% then starting to decrease with NR ratio increase.

Table (1) Compositions and properties of NR.

Composition and Properties	
Rubber (SMR20) purity	94.3%
Protein	1%
Organic matter	2%
Nitrogen content	0.2%
Volatile matter	0.5%
Ash	1%
slag	0.2%
Water	0.8%
Density (gm/cm^3)	0.9
Plasticity	39-48

Table (2) Composition and Properties of SBR 1502.

Properties	
Density (g/cm^3)	0.95
Bound styrene	23.5 ± % max.
Volatile matter	0.75% max.
Ash	1.5% max.
Soap	0.5% max.
Organic acid	4.7 – 7.2%

Table (3) Properties of Carbon black N375.

properties	**N375**
Density (g/cm^3)	1.8
Specific surface areas(Iodine number) m^2/g	92±5
DBP absorption number ml/100g	114±5
Particle size (µm)	75
Loss at 105 °C	1%
Ash content	0.75%

Preparations of batches.

The batches are prepared by mill laboratory as shown in the table(4);

Table (4)

Compounding gradients%	**Recipe 1**	**Recipe 2**	**Recipe 3**	**Recipe 4**
SBR 1502	**100**	**80**	**60**	**50**
NR SMR 20	**0**	**20**	**40**	**50**
ZINC OXID	**5**	**5**	**5**	**5**
STEARIC ACID	**2**	**2**	**2**	**2**
PARAPHINIC OIL	**2**	**2**	**2**	**2**
CARBON BLACK	**Variable(10,20,30,40)**	**Variable (10,20,30,40)**	**Variable (10,20,30,40)**	**variable(10,20,30,40)**
RECLAIM	**Variable (10,20,30,40)**	**Variable (10,20,30,40)**	**Variable (10,20,30,40)**	**variable(10,20,30,40)**
6PPD	**0.5**	**0.5**	**0.5**	**0.5**
MBS	**1**	**1**	**1**	**1**
SULFUR	**1.5**	**1.5**	**1.5**	**1.5**

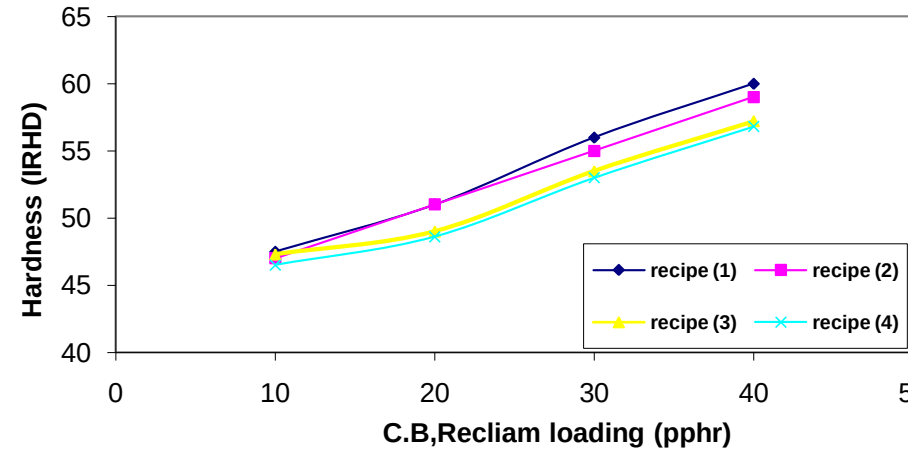

Figure (1)Relation between C.B,Recliam loading and hardness for different batches

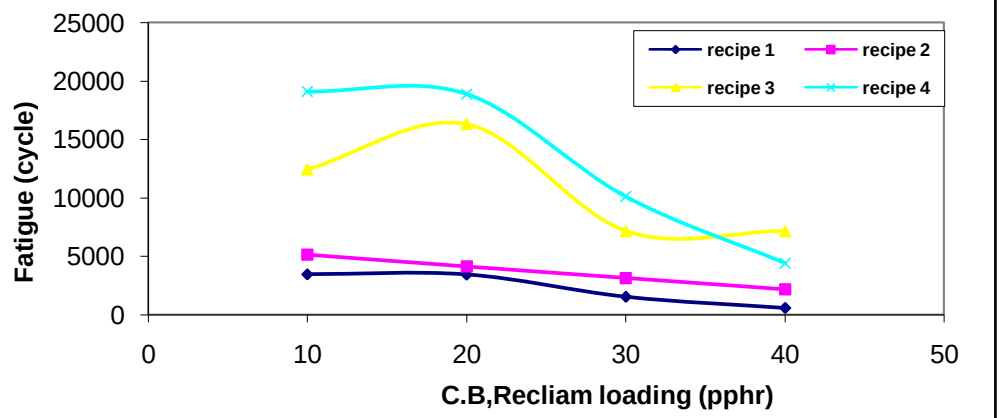

Figure (2)Relation between C.B,Recliam loading and fatigue for different batches

Figures (2) show decreasing in the flexibility or fatigue as C.B&reclaim mix loading increases. This is due to increasing of the contact area with the rubber .This will result in increasing stress surface which causes (fault). This result agrees with that of other workers [19,20].

With respect the specific gravity that is directly proportion with increasing C.B, reclaim loading because the increment of C.B and reclaim mix molecules in the volume unit leads to increase the specific gravity, so if the SBR density is approximately equal NR density therefore ;the variation of SBR,NR ratio was not effect on specific gravity .show fig(3).

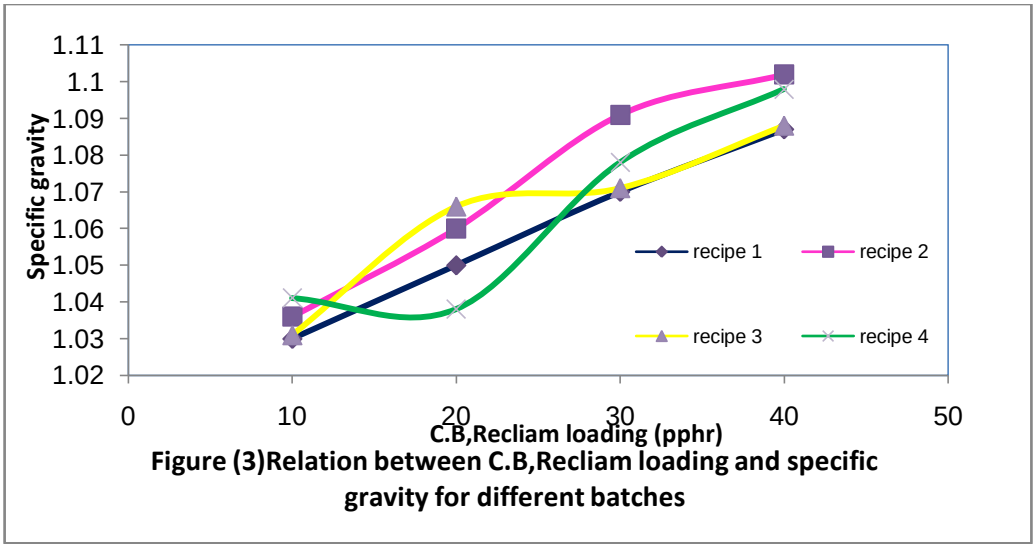

Figure (3)Relation between C.B,Recliam loading and specific gravity for different batches

Figure (4), Figure (6) shows the increasing in the tensile strength ,tear resistance as C.B& reclaim loading increases because of this increasing the interaction of C.B &reclaim with the rubber blends chain resulting in more physical bonds and an increase in surface activity which give high tensile strength ,high rear resistance and. This result agrees with that of other worker [19,23]. and the relation between loading and tensile strength is non-linearly since the value of tensile is starting decrease with high loading .

So we can shows that the tensile strength and tear resistance and are increasing with NR ratio increase since pure NR rubber had tensile strength more than SBR rubber.

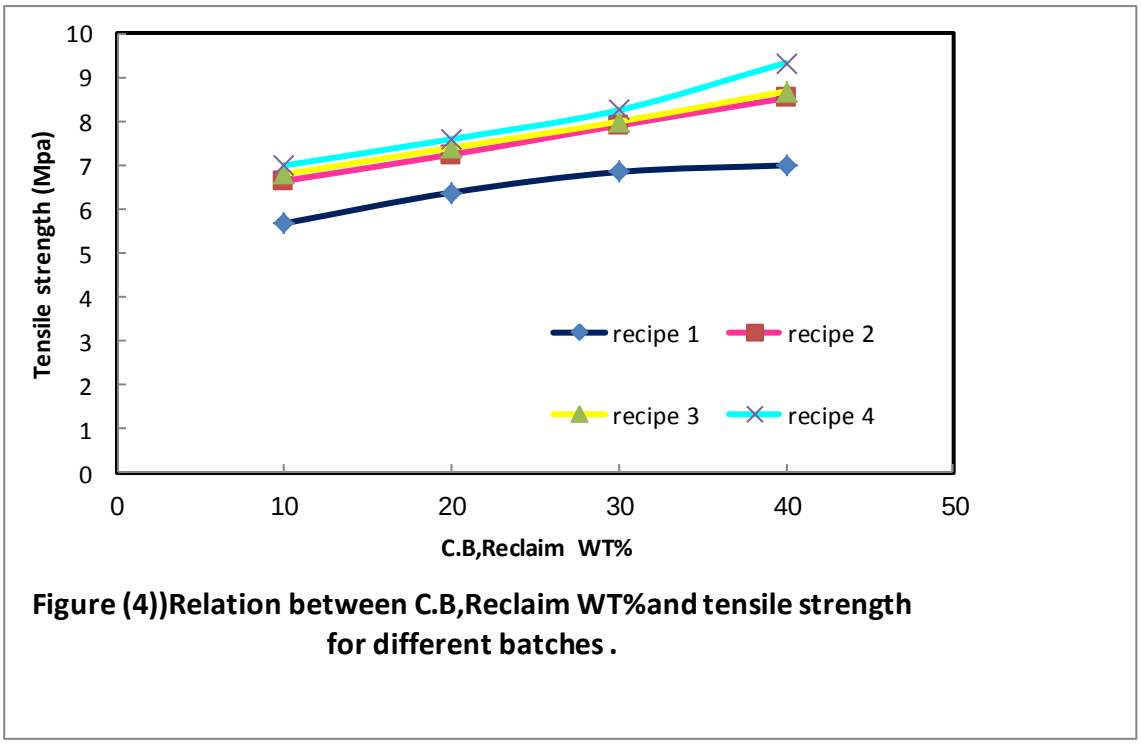

Figure (4))Relation between C.B,Reclaim WT%and tensile strength for different batches .

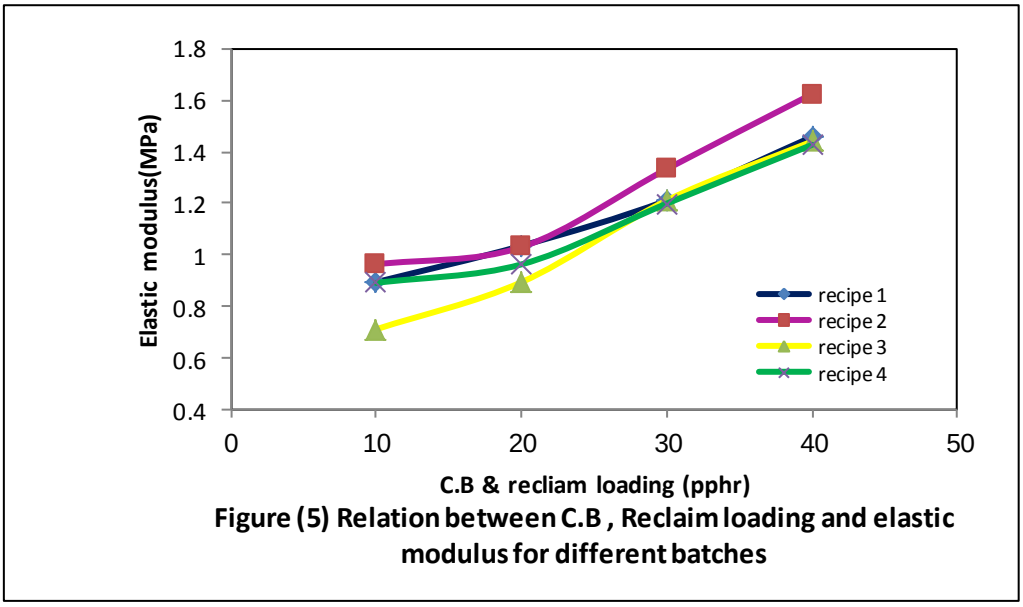

Figure (5) Relation between C.B , Reclaim loading and elastic modulus for different batches

Fig (5) show the modulus at 100% of all vulcanizates increase with increasing C.B,Reclaim content due to the presence of carbon black and active crosslink sites in the reclaimed rubber [13].

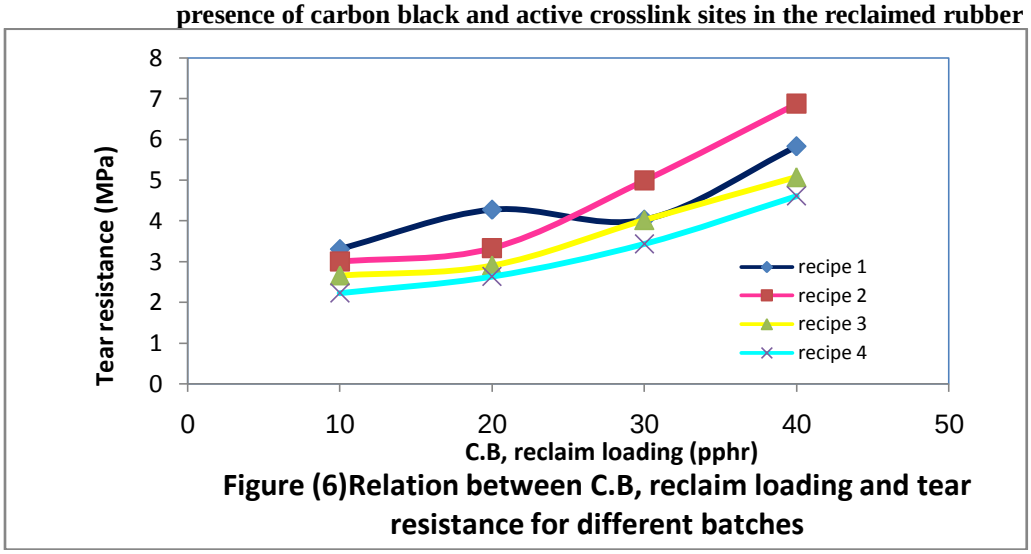

Figure (6)Relation between C.B, reclaim loading and tear resistance for different batches

With respect to figure (7) we indicated that the elongation% was decreased with increasing C.B,cement waste loading level this attributed to the elongation property was due to cohesive of polymer chains .So we can show that the elongation decrease with increasing NR content .

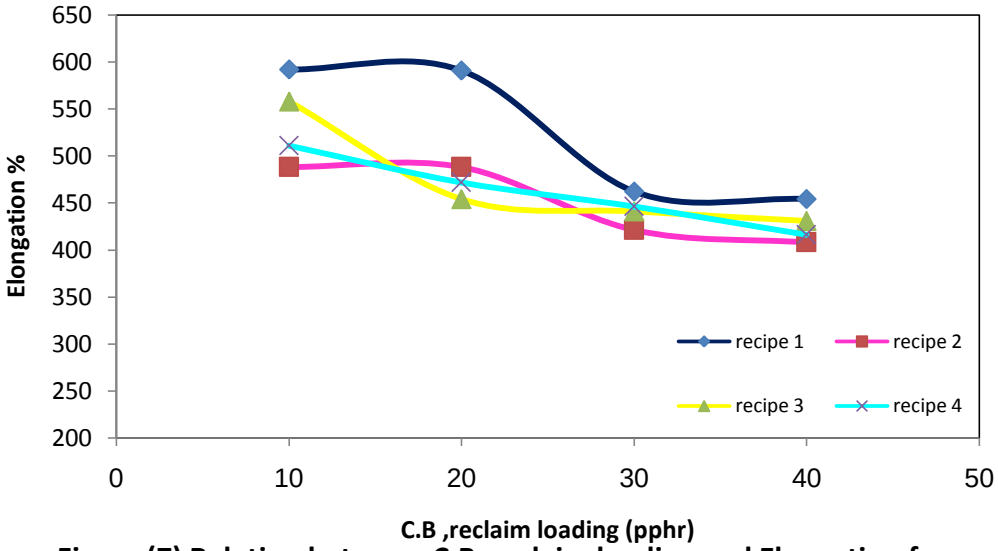

Figure (7) Relation between C.B, reclaim loading and Elongation for different batches

CONCLUSIONS

1) Mechanical properties are improved or increase as mix of C.B and reclaim percent increases such as hardness ,tensile strength, tear resistance ,modulus and specific gravity except fatigue and elongation which gradually decrease.
2)Improvement in mechanical properties has advantages and disadvantages according to the engineering uses such as fenders in the port.
3)The tensile strength started with decrement after 50(pphr) or at high loading level.

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