The trye reclaimed rubber’s application introduction

1. Raw materials for reclaimed rubber production

Producing formula of reclaimed rubber is as follow, including trye rubber powder, softener and activator. Tyre rubber powder accouts for the maxium percentage, followed by softer and Activator, so the quality of rubber powder is important.

Designation	Tyre rubber powder	Softener (plant asphalt)	Activator
Mass fraction %	80~90	5~15	0.2~1

The tyre rubber powder must use the outer trye of truck trye. After physical crushing, the particle size of rubber powder is 20~40 mesh. The rubber composition of truck outer trye mainly is natural rubber (NR), mixed with little ratio of styrene butadiene rubber (SBR) and butadiene rubber (BR).Its filler system mainly is carbon black (CB), mixed with a certain proportion of white carbon black (WCB).According to the market research on the formula of truck trye, the general composition is as follows:

Classification	Ingredient	Content/%
Rubber type	NR	67
	SBR	19
	BR	14
Filler type	CB	52
	WCB	10
Anti-aging system	—	—
Vulcanization system	—	—

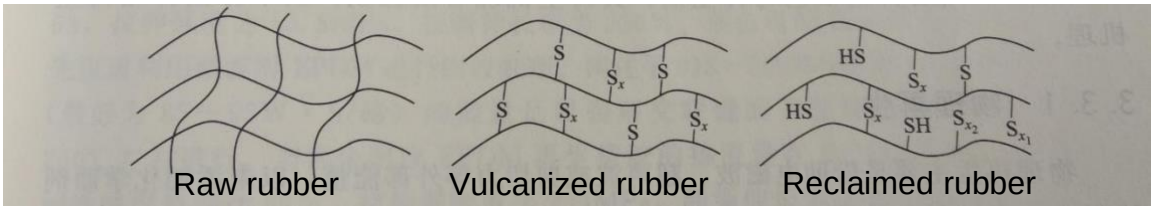
The softener is plant asphalt. The selection principle is good compatibility with rubber powder and suitable viscosity, and it complies with the relevant environmental protection regulations of EU Trye Labeling Law (EC1222/2009).

The activator is alkyl phenol disulfide and the addition amount is very small. It plays a role in promoting the break of polysulfide bond of rubber during the desulfurization process, and it don’t remain in the reclaimed rubber, not affecting good application of reclaimed rubber.

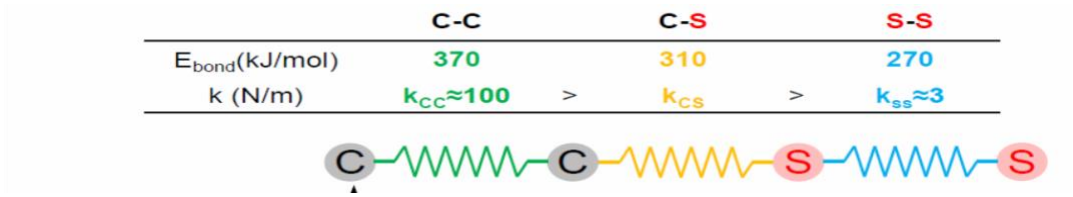
2. Production process of reclaimed rubber

In the process of trye production, the cross-linking point of the polysulfide bond is formed between the linear molecules of the raw rubber under the action of the vulcanization

system, which greatly increases the mechanical properties of rubber material. But it has became a thermosetting rubber product and cannot be reshaped.. The main purpose of production process of reclaimed rubber is to cut off the polysulfide bond between the rubber molecules, greatly increasing the processing plasticity of the rubber, and can form the cross-linking point of the polysulfide bond again which can ensure the certain mechanical properties of the recycled rubber.



The linear molecule chain of raw rubber is connected by carbon-carbon bond (c-c), and sulfur sulfur bond (s-s) is formed between linear molecule chains after sulfur vulcanization. However , the bond energy of S-S bond is much smaller than the bond energy of C-C bond, which is easily broken by thermochemical action to achieve plastic regeneration of rubber molecules. At the same time, since c-c with high bond energy is not subjected to excessive degradation and destruction, the prepared Reclaimed rubber still has high mechanical properties.



3. The reclaimed rubber's mechanical properties of tuck trye

Reclaimed rubber testing of mechanical properties is on the guide of <GB/T 13460-2016 Reclaimed rubber-General specification>, which lists the testing formula of truck trye's reclaimed rubber as follow.

Item	Reclaimed rubber	Vulcanization accelerator（TBBS）	Zinc Oxide（ZnO）	Stearic acid (SA)	Sulphur（S）
Mass/g	300	2.4	7.5	1	3.5

* Test the others using this formula, except the reclaimed rubber with special regulation.

The typical properties of truck tyre's reclaimed rubber is as below

Item	value
$ML_{(1+4)}$100℃	56
ML/dN.m	1.41
MH/dN.m	9.53
T10/min:s	1:32
T90/min:s	8:45
Shore A hardness	54
Tensile strength/MPa	9.2
Elongation/%	394
Vulcanization conditions ,145℃*10min	

This sample has good processing ability with viscosity 56, whereas tensile strength and hardness can maintain good value, 9.2MPa and 54 respectively. The viscosity can be adjusted by the needs of clients. Meanwhile, mechanical properties will change a little after adjustment.

4. The reclaimed rubber's applications

During rubber industry's development in China, reclaimed rubber has become the third category of rubber resources, in addition to nature rubber and synthetic rubber. Nowadays, reclaimed rubber in China can be distinguished among universal reclaimed rubber based on truck trye, butyl reclaimed rubber, nitrile reclaimed rubber and ethylene-propylene reclaimed rubber respectively. The technologies of rubber reclaiming also has been widespread in the United States, the United Kingdom, Japan, South Korea and other countries.

This article mainly introduces the applications of the universal reclaimed rubber. This reclaimed rubber belongs to complicated heterogeneous mixture. In addition to different amount of rubber hydrocarbon, it contains large amount of filler, such as carbon black or white carbon black, and other rubber additives. Its great plasticity can increase the mixing ability with raw rubber and additives, which enables the reclaimed rubber to replace or partially replace raw rubber for use. And the price is much lower than raw rubbers mixed with CB. Hence, reclaimed rubber becomes the significant raw material of rubber industry. Its usage amount account for up to 50% and some of low-grade rubber products completely use the reclaimed rubber, which can slash costs of rubber products. The rubber products based on NR or SBR, mixing with reclaimed rubber proportionally are widely applied in the rubber industry such as trye, cycle tyre, rubber overshoes, hose, slab rubber and many more.

4.1 The application in tyre flap

The tyre flap is a sort of annular belt made of rubber in order to protect the inner tube from wear and tear of the hub. It is mostly made by reclaimed rubber and compatibly used with the inner tube and the trye, including truck tyre, industrial tyre, off-the-road tyre, and agriculture tyre.

Reference of Formula:

Ingredient	1#	2#
NR	30	40
SBR	60	60
BR	10	—
Reclaimed rubber	150	100
Carbon black	60	30
Light calcium carbonate	50	85
Active agent	7	7
Aromatic oil	8	8
Sulfur and accelerant	7.3	4.3
Other fillers	6.5	6.5

Mechanical properties:

Project	1#	2#
Scorch time(120℃)/min	17.55	18.23
ML/dN.m	8.62	7.86
MH/dN.m	44.83	42.05
Ts2/min	4.80	5.58
T90/min	16.90	17.42
Density /(g/cm3)	1.26	1.31
Shore A hardness	65	63
Tensile stress at 300%/ MPa	6.7	5.8
Tensile strength/MPa	8.8	7.7
Elongation at break/%	366	395
Tear strength/(kN/m)	48	43
Air aging at 100℃, for 24h		
Tensile strength/MPa	7.6	6.9
Elongation at break/%	226	242
Tear strength/(kN/m)	39	34
Vulcanization conditions, 143℃* 25min		

Both formulas meet the needs of enterprises and national standard. No.1 formula is mixed with the part of BR and more usage of reclaimed rubber, that increases the mechanical properties and improves the functional performance of the finished cushion belts. Meanwhile this formula also decreases the cost of rubber materials, and obtains great economic and social benefits.

4.2 Reclaimed rubber application in shoemaking industry

According to its properties, reclaimed rubber is usually used for leather soles, rubber soles, sponge midsoles and hard midsoles. Its advantages are as follows: 1) good plasticity, easily mixing with raw rubber and chemical ingredients, reducing power consumption; 2) good fluidity, easily preparing model products; 3) good aging resistance, improving the aging resistance of whole rubber product, if reclaimed rubber is mixed in the rubber product. 4) fast vulcanization speed and good scorch resistance. But the reclaimed rubber has poor elasticity. It's a plastic material obtained by processing original elasticity vulcanizate, so it can not recover to its original elasticity level. Secondly, its flexion crack resistance and tear resistance are poor, so it can not used in thin upper parts which frequently bear larger bending deformation.

Sample test of reclaimed rubber in shoe formula:

Ingredient	**Original**	**20%RR**	**Performance**	**Original**	**20%RR**	**National standard**
NR	30	50	Tensile strength/MPa	12.4	11.4	≥9.3
BR	70	30	Elongation/%	467	446	≥360
Reclaimed rubber	-	20	Modulus 300%/MPa	7.5	7.4	—
Additives	170	170	Set after break /%	19	20	—

Total	270	270	Shore A Hardness	65	69	—
Gum content	37%	29.6%	Abrasion resistance/ （cm3/1.62km）	0.401	0.483	≤1.2

Vulcanization condition：134 x 16min

As shown in table, the properties of compound rubber mixed with part of reclaimed rubber, except for the slight decrease in tensile strength, are equal to the original formula, and all indexes meet the national standard.

4.3 The application in the aspect of hose

The rubber hose comprises the internal, external layer and framework layer materials. For common agriculture irrigation hose, its internal and external cover material mainly uses NR, SBR. The requirements of this hose's mechanical properties are generally low. Mostly it is used in static mode, so large amount of reclaimed rubber can be mixed into the products. The reclaimed rubber in the internal layer accounts for more than 80%. The external cover rubber needs better aging resistance, so the reclaimed rubber account for 30%~50% approximately.

Formula	**Internal cover rubber: dosage/g**
Reclaimed rubber	300

NR	50
ZnO	5
SA	2
Antioxidant	4
Softener	55
Carbon black	100
Inorganic fillers	200
Other fillers	23
Vulcanizing agent	12

Related test results:

Properties	**Standard**	**Sample**
Tensile strength(minimum)/Mpa	5.0MPa	5.4
Elongation at break (minimum)/%	200	373
hardness		68
Aging resistance (100℃*72h)：		
Rate of change in tensile strength(maximum)/%	±25	No data
Rate of change in elongation at break(maximum)/%	±50	
hardness		

Reclaimed rubber has many applications in many products and there are some simple examples which contains much percentage of reclaimed rubber.