

# Research of Reclaimed Rubber for High Strength Conveyor Belt Used at High Temperature and Normal Pressure

Wei Feng Zhang<sup>1,a</sup>, Chuan Sheng Wang<sup>1,b</sup>, Fu Xia Zhang<sup>2,c</sup>

<sup>1</sup>Qingdao University of Science and Technology, Qingdao, Shandong China 266061

<sup>2</sup>Qindao College, Qingdao, Shandong, China

<sup>a</sup>sailor112@163.com, <sup>b</sup>wsc@qust.edu.cn, <sup>c</sup>fxhit@163.com

**Keywords:** Reclaimed Rubber, Waste Rubber, Desulfurization Technology

**Abstract.** Regeneration technology for waste rubber has been an important research subject in rubber industry for many years, but currently the enterprise mature reclaimed technology, mostly existence of high pollution, high energy consumption problem, can not meet the requirements of energy saving and environmental protection. This paper adopts the electromagnetic induction dynamic desulfurization technology, but do not add coal tar and other toxic additives, for the production of high strength reclaimed rubber to meet the requirements of high strength conveyor belt, which meets the tensile strength can reach 14MPa, the elongation at break up to 350%, Mooney viscosity 60-80 and other technical requirements.

## Introduction

The rapid development of rubber industry produces more and more waste rubber. Due to rubber's non biodegradable characteristics, it causes serious environmental pollution. Thus waste rubber recycling has been an increasing problem of global strategy. China is the biggest rubber products consuming country in the world, the annual consumption of 3700000 tons of rubber. At the same time, China is also a rubber resources deficient country, with 70% of natural rubber depended on imports. How to realize the waste rubber recycling, to fill China's lack of resources and solve the problem of environmental pollution, to realize the sustainable development of the economy of our country's requirements is of great significance<sup>[1][2]</sup>.

Waste rubber recycling of traditional production process is the use of desulfurization tank, equipment and the process is complex, investment is large. In the regeneration process, generally adding many additives such as coal tar, oil product, result in the reclaimed rubber very unpleasant odor, emissions of polluting very large, and also contain many toxic and carcinogenic chemicals. At present, our country has begun to limit contain toxic chemicals rubber products export and production. The traditional reclaimed rubber regeneration process time is generally about 3.5H, the steam pressure is about 1MPa, low efficiency and high energy consumption. The tensile strength of the traditional process reclaimed rubber is low, generally in the 8 - 12MPa. The adoption of new technology to develop environmentally friendly high strength regenerated rubber is now an urgent need for rubber industry regeneration work[3][4]. This paper uses engineering tire tread rubber powder as raw material, adopts a new environmental protection equipment, to change the regenerated rubber production process, and study physical and mechanical properties of rubber regeneration in different regenerating conditions, to research the reclaimed rubber used in high strength belt, and then find a waste rubber regeneration method with the direction of industrialization.

## Test portion

### Test material

- a. 40-mesh rubber powder of engineering tire-tread.
- b. New regenerated activating agent(Independent research).
- c. Rubber modifier: Indopol, phenolic resin, KH570.

d. Curing system Additive: Stearic acid, Sulfur, ZnO.

e. Plasticizer: SI—69.

f. Mooney viscosity stabilizer.

#### Instrument and equipment

a. Electromagnetic induction heating rubber powder Desulfurization plasticizing machine: Jinshan rubber plant , Dongping Town, Tai'an City, Shandong, provence.

b. Four roller refining machine: JL-4-400 mode(Independent research).

c. Plate vulcanizing machine: QLB—D400×400×2.

d. Tensile testing machine: Taiwan High-speed Rail Polytron Technologies Inc.

e. Mooney viscosity tester: GT-7080-SZ, Taiwan High-speed Rail Polytron Technologies Inc.

f. LX-A Rubber hardness tester

#### Principle of desulfurization process

Desulfurization is a key link of reclaimed rubber production process and one of the key processes of reclaimed rubber product quality. Desulfurization is not to pick up the sulfur from the rubber, but through heating, oxidation and regeneration agent, makes the vulcanization of C-S-C crosslink scission, degradation, to cause the rubber from elastic state to the plastic state, and to achieve the purpose that facilitate the later period processing. The traditional reclaimed rubber methods require high temperature and high pressure conditions, the desulfurization process will produce gas leakage (such as gas and low molecular volatile), serious pollution of the environment<sup>[5]</sup>. Now the state actively attaches importance to energy-saving emission reduction, so the traditional regeneration of high energy consumption, high pollution, has been far from meeting the energy-saving emission reduction. And green machining method should have been eliminated. In accordance with the requirements the rubber powder and the regeneration agent mixed evenly , and then sent to the double screw conveyor in a horizontal layers, the conveyor with a jacket and a far infrared heating device, glue to uniform heating far infrared ray in the conveying process, to achieve the desired effects of regeneration. In the production process, do not add coal tar state environmental protection prohibited high pollution additives, no waste water exhausts emissions, energy consumption is relatively low, and has no environmental pollution, is one regeneration method, which in accordance with the national circular economy requirement.

#### Reclaimed Rubber Production Technology.

In the reclaimed rubber production process, the desulfurization in all production processes is the mainly environmental pollution process. This technique of environment-friendly normal high temperature rubber desulfurization equipment, costs much less with an energy-saving emission reduction and low-carbon method. With the low cost, high quality, and high efficiency, it has high research significance and market value. The fig.1 is process of reclaimed rubber production technology.

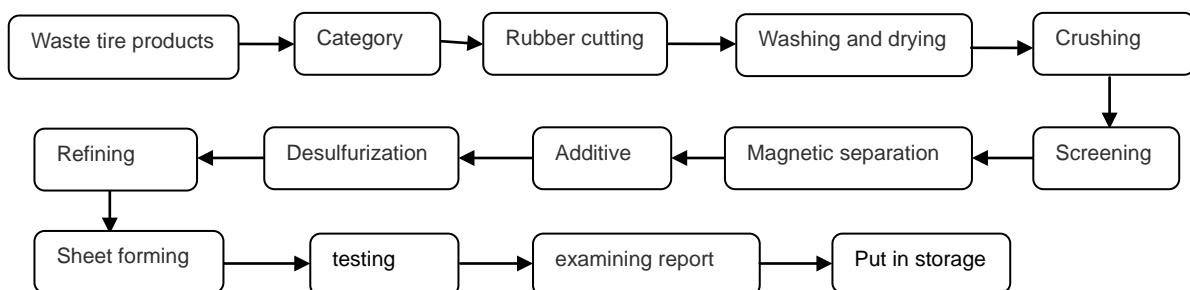


Fig.1 reclaimed rubber production process flow chart.

#### Experimental results and analysis

The experiment using the environmentally friendly desulfurization equipment and new additive formulation, change desulfurization time and temperature, to implement multi - group experiments, gets the test data of desulfurization time and the physical properties of reclaimed rubber relationship, desulfurization temperature and the physical properties of reclaimed rubber relationship, reclaiming

agent and the physical properties of reclaimed rubber relationship, and further improves the physical properties and mass production of the reclaimed rubber.

### Main factors affecting the physical and mechanical properties of reclaimed Rubber.

#### 1) Effect of regeneration temperature on the physical mechanical properties of reclaimed rubber.

In a certain range, reclaimed rubber physical properties increases with the regeneration temperature, but if too high a temperature will lead to the decrease of mechanical properties, and the activity of the regenerated catalyst will reduce. Based on the comprehensive analysis of the various performance parameters, we set the reclaimed rubber regeneration temperature range as 230 -270 °C, for 10 minutes. When we desulfurization in 230 °C, due to fracture of the rubber molecular is not enough, tensile strength is lower than 14MPa; at 245 °C, the tensile strength is more than 14MPa the desulfurization rubber powder, other comprehensive performances also are good, but when at the temperature of 260 DEG C, the desulfurization rubber powder tensile strength decreased, which is mainly due to the polymer molecular transition fault, the tensile strength is lower than 14MPa, and existence sticking phenomenon is serious in refinement. Therefore when we desulfurization, we should maintain the temperature in appropriate range to ensure the physical and mechanical properties of reclaimed rubber. The relationship of the physical mechanical properties and regeneration temperature as shown in Fig.2(a-d).

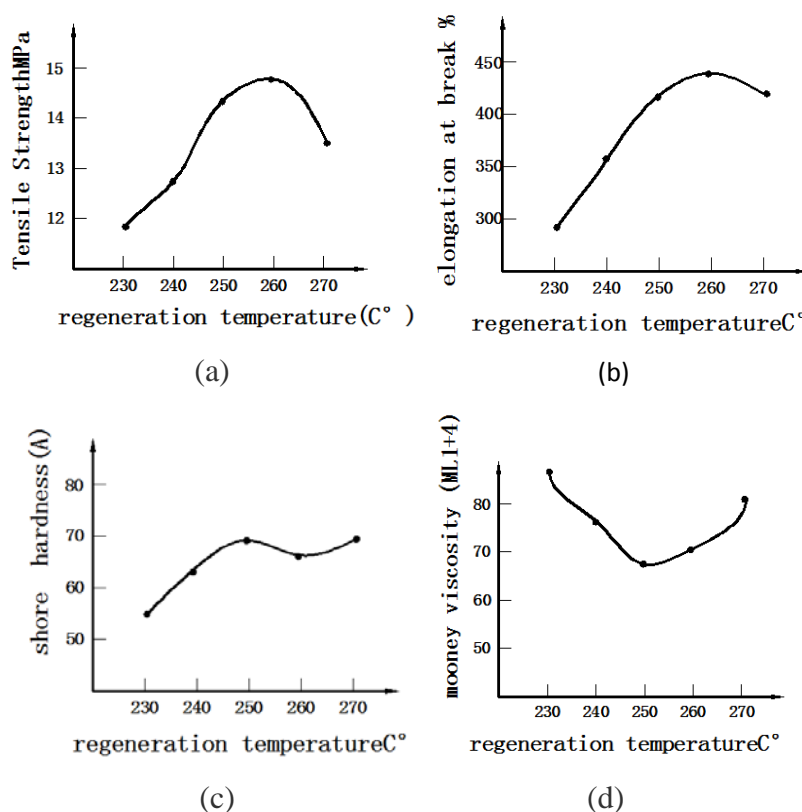


Fig.2 Effect of regeneration temperature on the mechanical properties of reclaimed rubber physical

#### 2) Effect of new reclaiming agent on the physical mechanical properties of reclaimed rubber

In the desulfurization process, using the activating agent can greatly shorten the desulfurization time, and improve process performance of desulfurization and product quality of reclaimed rubber, in high temperature the free radicals of activating agent and rubber molecules can combine together to prevent the cracked free radical polymerization of rubber molecular combine again, to speed up the degradation. From the theoretical analysis, the content of the active agent is insufficient, the degradation is not sufficient, resulting in regenerated rubber physical mechanical performance is not

high, the addition of excess, activating agent residue will affect the curing of reclaimed rubber, which leads to the decrease of mechanical properties. By 3, 3.5 respectively, 4, 4.5, 5 copies of regeneration agent. In the experiment that other conditions are the same with performance shown in Table.1 and fig. 3.

Table.1 Effect of reclaiming agent on the physical mechanical properties of reclaimed rubber

Uselevel	Tensile strength MPa	Elongation at break /%	Tear strength /MPa	Mooney viscosity (ML1+4)	Shore hardness (A)
3	11.733	279.818	26.86	88	63
3.5	12.538	329.412	32.62	79	80
4	14.485	386.445	38.55	68	68
4.5	13.622	321.620	28.12	74	78
5	12.385	285.806	23.67	72	74

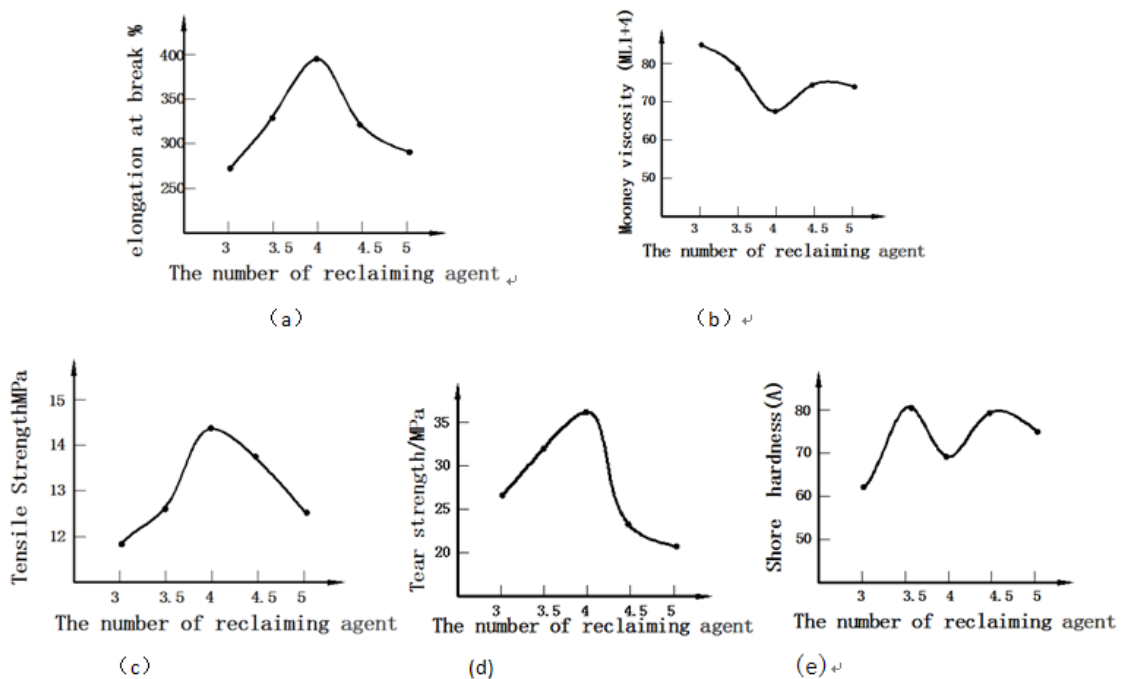


Fig.3 Effect of reclaiming agent on the physical mechanical properties of reclaimed rubber

From the test data we know, when the reclaiming agent use level gradual increased from 3 to 4 copies, probability of molecular chain cleavage and cracking gradually increases, molecular chain mesh more uniform, mechanical properties gradually increases, and tensile strength and elongation increased with the dosage of recycling agent increasing, when the reclaiming agent more than 4 copies, the degree of chain scission is serious and the reclaiming agent residues effect further vulcanized, the tensile strength and elongation decrease with the increasing of recycling agent dosage. The test results are agreeable with the theoretical analysis.

#### Comprehensive performance index of reclaimed rubber.

According to the high tenacity belt requirements, we carry out the comprehensive detection for the reclaimed rubber, and the test data shown as table.2. The test data show that compared with the traditional method, the reclaimed rubber physical machinery performance has greatly improved in this experiment, comprehensive performance is better than ever and better meet the requirements of the use of high-strength conveyor belt, basically can replace natural rubber, reduce the cost of raw materials.

#### Summary

From test of the reclaimed rubber formulation and process equipment under normal pressure and high temperature conditions, we draw the following conclusions:

Table.2 Comprehensive performance index of reclaimed rubber

Performance standard	GB/T13460—2008				
Test project	Unit	test result	standard	Eligible or not	Remarks
tensile strength	Mpa	14.4	Strength one more than 14.0MPa, elongation at break is greater than 400%	Eligible	
Elongation at break	%	402		Eligible	
tensile strength	Mpa	14.1		Eligible	
Elongation at break	%	425		Eligible	
tensile strength	Mpa	13.9		not	
Elongation at break	%	418		Eligible	
Mooney viscosity	ML100°C 1+4	74.1	≤90	Eligible	
moisture	%	0.74	≤1.0	Eligible	
ash content		6.65	≤10	Eligible	
acetone extract	%	15.06	≤20	Eligible	

1. Compared with the conventional vulcanization reclaimed rubber production, using electromagnetic induction heating rubber processing equipment and regeneration process in the production process, shorten the desulfurization time, and reduce device power consumption.

2. Eliminate the pollution of coal tar and other additives to the environment, no waste gas waste emissions, in line with the current energy-saving emission reduction and the development of green environmental protection requirements.

3. he production of reclaimed rubber tensile strength can reach 14MPa, Mooney viscosity is 60-80, can be directly used for high-strength conveyor belt use, saves the cost of raw materials.

## References

- [1] Fukumori K, Recycling technology of tire rubber [J]. SAE Review, 2002 , (23) :259~264.
- [2] Yanhao Zhou. Method of waste vulcanized rubber regeneration desulfurization mechanism. China rubber industry[J ] ,2003 ,50 (80) :453~456.
- [3] Chuanmin Wang, Zian Li. Determine the Mooney viscosity of High strength recycled rubber. Rubber & Plastics Resources Utilization. 2011, 1: 13~14.
- [4] Chuansheng Wang, Qingkun Liu, Lei Guo, Chao Yang. Experimental Study on the regeneration methods of waste treads rubber. Technical Exchange[J]. 2012, 12:25-32.
- [5] Yanqiu Wang, LiXue Zhou, Delun Xie, Jing Kou, Liang Yao. Study on microwave radiation process of environmental protection and high-strength reclaimed rubber. Applied Chemical Industry [J ]. 2012, 419(12), 287-290.