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Application of Ground Scarp Tyre in Asphalt Pavement

N.Tamizharasan* S.Raghuraman#,
*M.E. Student, #Assistant professor, Department of Civil Engineering, Adithya Institute of Technology, Coimbatore – 641 107, India
E-mail: *tamilrajancivil@gmail.com, #raghuraman_s@adithyatech.com

Abstract—**Now a days rubber tire wastes are causing major problem in the environmental pollution not only in our country but also in the whole world. So we have to rectify the problem by using rubber as a base material in the construction. The necessity of utilizing the crumb rubber bitumen is stressed in the future development of the road in our country and also to reduce the financial problem of the government and also reduce the maintained cost of the roads. The bitumen is flexible in nature with particular temperature. But cost wise it will be more. The crumb rubber as the same property like bitumen so we have to use with proper proportion crumb rubber with bitumen in different ratio the property and workability will not affect road and also rectify the cracks in road.**

Keywords— **Waste scrap tyre, Flexible pavement, Aggregate, Bitumen.**

I. Introduction

The purpose of rubber modified bitumen and asphalt is to achieve desired engineering properties such as increase modules and reduce plastic flow at higher temperature and / or increase resistance to thermal fracture at low temperature.

Rubber Tire –disposal are ground scrap tire, crumb tire are cheap cost and for only one purpose. So it is used and throws into the streets anywhere. Burning is the only one way to safe disposal of these rubber tire wastes. But it should cause more environmental air pollution. So there is one way need to reuse the rubber tire wastes. There is one way invented to reuse wastes in the roadwork. It is used in the roadwork like binding material.

Asphalt is known as brittle and hard in cold environments and soft in hot environments. As a pavement material, it is characterized with a number of failures represented by the low temperature cracking, fatigue cracking, and the rutting (or permanent deformation) at high temperature, causing its quality and performance in pavement of roads to decrease. Though, it has been historically the most popular paving material for roadways. Any improvement in service life of road pavements will be off course of a great economical advantage and any modifications of asphalt are attempts to extend the service life and improve the performance of asphalt pavements. The global problem with landfill disposal of automobile tires and plastics can only be solved by the feasible option left, and that is recycling and utilization of the recycled products. It is thought that the application of recycled automobile tires and plastics will not only solve the environmental of these industrial solid wastes problem but also act as very promising modifiers for the improvement of asphalt pavement material has investigated the utilization of waste rubber tires and waste plastics in pavement of flexible highway, as a result he has concluded that the project is not only to improve the engineering properties of asphalt, but also allows us to collect modifier raw materials (scrap or crumb rubber) at low costs and provide a solution to the ecological menace imposed by the increase disposal of waste tires .

II.METHODOLOGY

2.1 Processes of Asphalt Mix with Rubber Tires

Reduction of asphalt mixtures with tire rubber in form of CR is usually established by mainly one of two common ways; the first one is called the wet process where rubber particles are mixed with asphalt at elevated temperature prior to mixing with the hot aggregates. The second type is called dry process, where rubber particles replace a small portion of the mineral aggregate in the asphalt mix before the addition of the asphalt. The main differences between these processes include size of rubber; in the dry process rubber is much coarser than wet process rubber, amount of rubber; the dry process uses rubber 2 to 4 times as much as the wet process, function of rubber; in the dry process the rubber acts more like an aggregate but in the wet process it acts more like the binder, and finally the ease of incorporation into the mix; in the dry process no special equipment is required while in the wet process special mixing chambers, reaction and blending tanks, and oversized pumps are required.

2.2WET PROCESS

The Wet Process The binder produced from wet process, or the McDonald Process, is called asphalt rubber. It has been defined by American Society for Testing and Materials (ASTM) as “A blend of asphalt cement, reclaimed tire rubber, and certain additives in which the rubber component is at least 15% by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles”. In wet process, asphalt is blended with a crumb rubber modifier (CRM) in a specialized blending unit at elevated temperatures (190 - 225°C) for a minimum of 45 min to promote the chemical bonding of the components. During the blending process, CR swells and softens with the asphalt. This reaction is influenced by the blending temperature, the time the temperature remains elevated, the type and amount of mechanical mixing, the size and texture of CR, and the aromatic component of the asphalt. CRM typically ranges from 18 to 22% by weight of the asphalt. Extender oils are sometimes used to reduce viscosity and promote workability of the asphalt rubber as well as to increase the compatibility between the asphalt and CR. The diagram in Figure 1 shows production of asphalt rubber mixes using the wet process. Asphalt rubber mix is used primarily in open graded and gap graded HMA. It is also used in spray applications for seal coats and pavement interlayers and as a crack sealant.

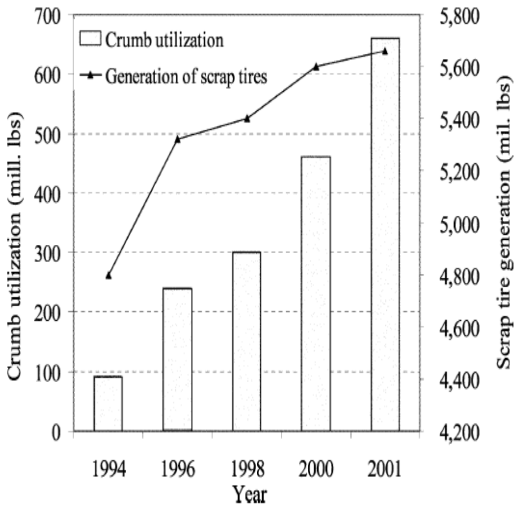


Fig.1 Scrap tire utilization alternatives

2.3DRY PROCESS

The Dry Process As aforementioned, in the dry process, CR is added to the aggregate in a hot mix plant operation prior to adding the asphalt. There is relatively little reaction between the asphalt and CR in the dry process. In essence, CR replaces a portion of the aggregate. The dry process can be used in dense graded, open graded, or gap graded HMA. The most commonly used dry process was developed and patented in the late 1960s in Sweden and in 1978 in USA. The performance of pavements using this process has met with mixed reviews and, as a result, the dry process is not widely used for modifying asphalt pavements.

2.4 CRUMB RUBBER TIRES (CRT)

Crumb rubber tires CR is usually defined as rubber having a particle size of 9.5 mm (3/8 inch) or less. They can be classified into four groups as follows: coarse, 9.5– 6.3 mm; mid-range, 2 – 1 mm; fine, 0.4 - 0.2 mm; and superfine, 0.15 - 0.075 mm. CR is commonly obtained by using either of these processes.

2.5 HOT-MIX AND WARM-MIX TECHNIQUES

It was reported that about 299 million scrap tires are generated every year in the USA. And many state regulations penalize landfill disposal of these materials. The incorporation of the scrap tires in the asphalt binder is established by converting the scrap tire to CR. As mentioned previously, this CR will be added to asphalt before adding the asphalt to aggregate using the common wet process to produce HMA. A. Case Studies There has been a steady and increasing interest in using of crumb rubberized binders in HMA pavements in the Unites States and other countries, due to the conclusions drawn by some investigation studies which have indicated that rubberized binders could produce asphalt pavements with a decreased traffic noise, reduced maintenance costs and improved resistance to rutting and cracking fig.1

However, the increase of rubber content unfortunately produces an increase in flexibility, and the incorporation of the rubber itself to the virgin asphalt binders can reduce the indirect tensile strength of modified mixtures. Production of HMA at high temperatures can result in undesirable high energy consumption, greenhouse gas (GHG) emissions, fumes and odours deteriorating inhabitant's locations. In addition, the high temperature requirement results in shorter paving seasons, and longer cooling periods. Alternatively, introducing warm mix asphalt (WMA) is known to provide decreased optimum mixing and compaction temperatures of the rubberized mixes and expected to be comparable to those of conventional mixes. WMA was first originated in Europe in the mid-90s. WMA is mixed and compacted at temperatures lower than these of conventional HMA. Typically, the mixing and compaction temperatures of WMA range from 100 to 140°C in comparison to 150 to 180°C for HMA It has been proven that WMA techniques can provide a number of benefits due to the lowered production temperatures. Although benefits can vary depending on the specific warm mix additive being used.

2.6 Flexible Pavement

Flexible pavements are those, which on the whole have low or negligible flexural strength and are rather flexible in their structural action under the loads. The flexible pavement layers reflect the deformation of the lower layer on-to the surface of the layer. Thus if the lower layer of the pavement or the soil sub-grade is undulated, the flexible surface also gets undulated.

2.7 Environmental and safety issues

Fire causes tires to break down into hazardous compounds including gases, oil and heavy metals. Tire fires are characterized by incomplete combustion, producing thick clouds of toxic black smoke and a highly flammable oily residue. 202 The average passenger car tire is estimated to produce about eight litres of oily residue when burned. 203 For every million tires consumed by fire, about 208,000 litres of runoff oil containing dangerous chemicals is produced, which can leach into soil, ground and surface water unless effectively contained

III.RESULTS

3. CHARACTERISTICS OF PLASTIC AND RUBBER COATED AGGREGATE

3.1 Moisture Absorption and Void Measurement

Hot stone aggregate (1500c) is mixed with hot bitumen (170 0c). The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS coding. The bitumen is chosen on the basis of its binding Property, Penetration value and viscos-elastic property. The aggregate, when coated with plastics and rubber improved its quality with respect to voids, moisture absorption and soundness. The coating of plastic and rubber decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.
It is to be noted here that stones with < 2% porosity only allowed by the specification.

3.2 Soundness Test

Soundness test is intended to study the resistance of aggregate to weathering action. The weight losss attributed to the poor quality of the aggregate. The plastic and rubber coated aggregate, did not show any weight loss, thus conforming the improvement in the quality of the aggregate.

3.3 Aggregate Impact Value

A study on the effect of plastic and rubber coating was extended to study on the aggregate impact value. Aggregate was coated with 1% & 2% plastics and rubber by weight (splitted in 0.5% & 1%) and then was submitted to Aggregate Impact Value test and the values were compared with values for non-coated aggregate. For each % of waste, the tests were conducted twice to get the better results.

TABLE I
Aggregate Impact Value

Percentage of Plastics (%)	Percentage of rubber (%)	Aggregate Impact value (%)	Conventional value (%)
0.5	0.5	9.23	12.63
0.5	0.5	8.73	12.16
1	1	8.73	12.14
1	1	8.10	12.63

3.4 Aggregate crushing Value

A study on the effect of plastic and rubber coating was extended to study on the aggregate crushing value. Aggregate was coated with 1% & 2% plastics and rubber by weight (split in 0.5% & 1%) and then was submitted to aggregate crushing Value test and the values were compared with values for non-coated aggregate. For each % of waste, the tests were conducted twice to get the better result.

TABLE II
Aggregate crushing value

Percentage of Plastics (%)	**Percentage of rubber (%)**	**Aggregate crushing value** (%)	**Conventional value** (%)
0.5	0.5	11.41	23.66
0.5	0.5	12.27	22.37
1	1	11.30	23.70
1	1	11.32	23.86

3.5 Los Angel’s Abrasion Test

The repeated movement of the vehicle with iron wheeled or rubber tire will produce some wear and tear over the surface of the pavement. This wear and tear percentage of an aggregate is determined with the help of los Angeles abrasion study. Under this study the percentage of wear and tear values of the 1% & 2% plastic & rubber coated aggregate is found to be in decreasing order with respect to the conventional values. This wear and tear percentage of an aggregate is determined with the help of Los Angeles abrasion study.

TABLE III
Los Angeles abrasion value

Percentage of Plastics (%)	**Percentage of rubber (%)**	**Los Angeles value (%)**	**Conventional value (%)**
0.5	**0.5**	**14.64**	**17.51**
0.5	**0.5**	**14.72**	**17.42**
1	**1**	**13.77**	**17.46**
1	**1**	**13.85**	**17.43**

When the Los Angeles abrasion value of plain aggregate value is compared with the Plastic and rubber coated aggregate the values are less for conventional aggregates as compared to polymer and rubber coated aggregates.

3.6 CHARACTERISTICS OF POLYMER AND CRUMBBED RUBBER MODIFIED BITUMEN

An alternate use of plastic and rubber waste is also under study where plastics and rubber is mixed with bitumen and used for preparing the mix. The waste tires are made into powder by grinding into some special type of grinders. The powder is collected and it is used for modification of bitumen. The bitumen is heated to 120-140 degree Celsius and the powdered crumb rubber and plastic is added to the bitumen by its weight and stirred well with help of mechanical stirrer. The mix was used to study the basic properties of bitumen like softening point, penetration point and ductility. Here 10% & 20% plastics & crumbed rubber (split in 5% & 10%) is taken in proportion by weight. For each %

of waste, the tests were conducted twice to get the better results.

3.7 Conventional Value

TABLE IV

Bitumen(gms)	Ductility (mm)	Softening point ºC	Penetration (mm)
37	89	34	91
38	93	35	93
39	91	37.52	89
40	88	36	90

3.8 Polymer and Crumbed rubber modified value

TABLE V

% plastics	**% crumbed rubber**	**Ductility (mm)**	**Softening point ºC**	**Penetration (mm)**
5	5	62	48.5	70
5	5	60	47.5	68
10	10	58	45	59
10	10	56	42	54

Above values were compared with the conventional value & was found better. Thus by using waste plastics & waste rubbers can increase the durability & life of the road material substantially.

IV. MARSHALL STABILITY TEST

4.1 Marshall Stability:

This test is carried out to determine the stability of bituminous mix i.e. resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface at 60 degree Celsius. Here we have designed the Dense Bituminous Macadam.

There are two major feature of Marshall Stability test to design the mix:
i) Density-void analysis,
ii) Stability-Flow analysis.

4.2 Combined Gradation

TABLE VI

Sieve analy-sis	Required gradation	M20 coarse 30%	M10 fine 50%	Grit 20%	Combined gradation
26.5	100	30	50	20	100
19	90-100	25	50	25	100
13.5	56-88	3.65	40	30	73.65
4.75	16-36	0.10	0.85	18.7	19.70
2.36	4-19	0	0.15	16.9	17.05
0.3	2-10	0	0.05	6.69	6.74
0.075	0-8	0	0	4.96	4.96

Preparing 3 gradations of each bitumen content for making the block and allowing for Marshall Stability. In conventional mix design, 15 samples are prepared; each 3 samples have constant bitumen percentage from 3.5, 4.0, 4.5 & 5.0. Percentage is increased by 0.5% and so on till 5% bitumen content.

4.3 Marshall Apparatus:

a) Mould assembly (10cm dia, 15cm height) with base plate and collar extension.
b) Sample extractor,
c) Compaction pedestal and hammer,
d) Breaking head,
e) Loading machine @ 5cm per minute,
f) Flow meter with least count of 0.025mm

The test is applicable to hot mix designs using bitumen and aggregates up to a maximum size of 25mm. In this method, the resistance to plastic deformation of cylindrical specimen of. Bituminous mixture is measured when the same is loaded at periphery at 5 cm per min. This test procedure is used in designing and evaluating bituminous paving mixes.

Marshall Stability plays a very important role in the testing of road materials. Hence the values obtained by the Marshall Stability test shows the actual strength and load carrying capacity of the road materials.

4.4 Preparation of the conventional mix:

1) 1200 Gms of mix taken. Thickness should be 63.5mm.
2) Approximately 1200gms of aggregate and filler is heated at temperature 180-200 degree Celsius.

3) The compaction mould assembly and rammer is pre-heated at 100-145 degree Celsius.
4) Bitumen is heated at 130-140 degree Celsius and it is added in the aggregate ay the appropriate percentage.
5) 80/100 bitumen is heated at 160-180 degree Celsius.
6) In this way, preparing the other samples of the mix and allowing the block for the testing.

4.5 Preparation of the mix by adding Polymer & Crumbed Rubber:

1) 1200 Gms of mix taken. Thickness should be 63.5mm. TABLE VII values of conventional bituminous mix.
2) Approximately 1200 Gms of aggregate and filler is heated at temperature 180-200 degree Celsius.
3) The compaction mould assembly and rammer is pre-heated at 100-145 degree Celsius.
4) Bitumen is heated at 130-140 degree Celsius and it is added in the aggregate ay the appropriate percentage.
5) Similarly, polymer and crumbed rubber is added to the bitumen in the proportion of 8% i.e. 4% polymer and 4% crumbed rubber by weight of each bitumen content.
6) 80/100 bitumen is heated at 160-180 ºc.
7) In this way, preparing the other samples of the mix and allowing the block for the testing.

Preparing 3 gradations of each bitumen content for making the block and allowing for Marshall Stability. In conventional mix design, 15 samples are prepared; each 3 samples have constant bitumen percentage.

Marshall Stability test is carried out to determine the stability of bituminous mix i.e. resistance to plastic flow of cylindrical specimens of a bituminous mixture loaded on the lateral surface at 60 degree Celsius. Here we will design the Dense Bituminous Macadam.

Values of conventional bituminous mix. TABLE VIII values of polymer and crumbed rubber mix TABLE NO VI shows the values of conventional bituminous mix.

TABLE NO VII shows the values of polymer and crumbed rubber modified bituminous mix.

Where,

Gmb = Density of the bitumen,
Gt = Maximum theoretical density of bitumen,
Vb = Volume of bitumen, cm3
Av = air Voids, %
VMA = voids of mineral aggregates, %
VFB = voids filled by bitumen, %.

TABLE VII
Values of conventional bituminous mix.

Bitumen	Sample Wt. gm	Marshall stability kg	Flow mm	Gmb gm/cm3	Gt gm/cm3	Vb %	AV %	VMA %	VFB%
3.5	1120	871.12	3.1	2.101	2.31	7.3	9.24	16.59	44.30
4.0	1122	940.75	3.0	2.114	2.30	8.4	8.12	16.58	50.99
4.5	1100	892.70	2.9	2.155	2.25	9.4	6.49	15.94	60.26
5.0	1167	882.90	3.0	2.252	2.23	9.6	5.35	14.97	68.94

TABLE VIII
Values of polymer and crumbed rubber mix.

% Bitumen	Sample Wt. gm	Marshall stability kg	Flow mm	Gmb gm/cm3	Gt gm/cm3	Vb %	AV %	VMA%	VFB%
3.22	1046	689.71	3.0	2.120	2.49	6.5	18.9	25.44	25.51
3.68	1089	885.79	3.5	2.167	2.47	7.9	12.3	20.24	39.39
4.14	1106	1095.50	3.3	2.210	2.43	9.1	9.05	18.20	50.27
4.6	1120	1289.75	3.5	2.298	2.39	10	3.85	14.41	73.35

V. GRAPH

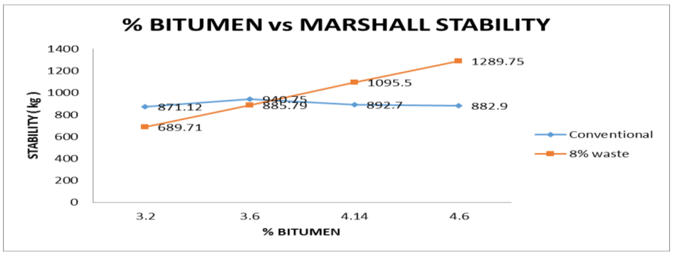
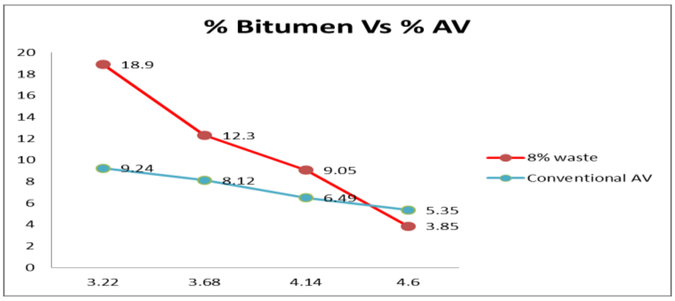


Fig No. 2 Graph of % Bitumen Vs Marshall Stability



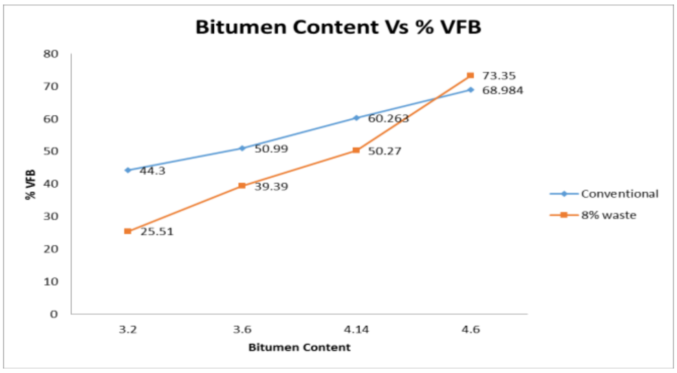


Fig No. 3 Graph Of % Bitumen Vs Vfb

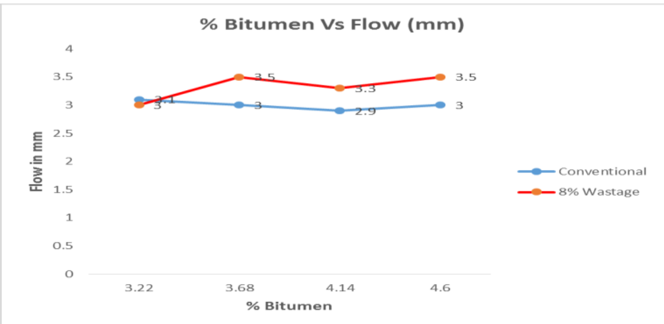


Fig No. 4 Graph of % Bitumen Vs Flow

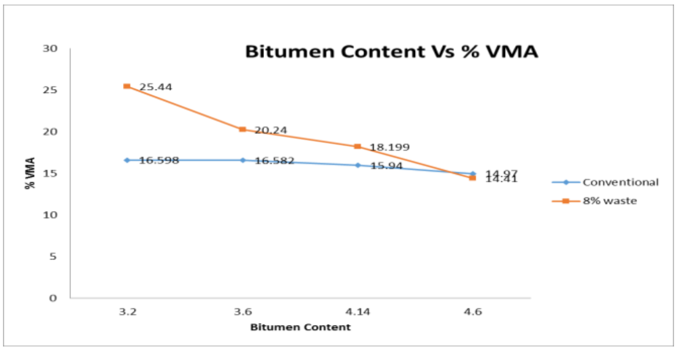


Fig No. 5 Graph of % Bitumen Vs VMA

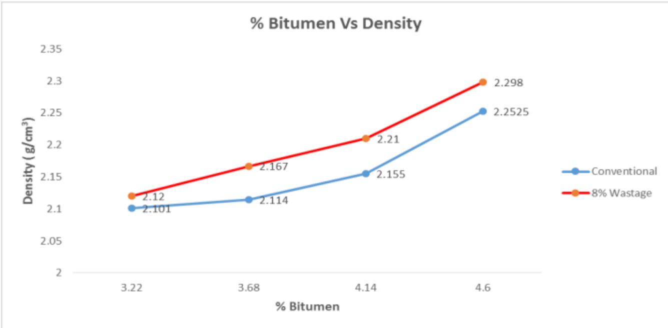


Fig No. 6 Graph of % Bitumen Vs Flow

IX. FIELD APPLICATIONS

More than 1000kms length of Plastic tar road was laid by Tamil Nadu government during 2004-2006. Test road were laid at Mumbai, Pondicherry and Trivandrum. These roads are functioning well without pothole, raveling and rutting. The process requires only 30 seconds for mixing 10% of plastics and rubber. The plastic available in the nearby area can be used.

X. CONCLUSION

As seen the above results and graphs, when 8% polymer and crumbed rubber is blended in the mix, the values of the Marshall tests viz.Marshall Stability (kg), Flow (mm), Gmb (gm/cm3), AV (%), VMA (%), VFB (%) goes on increasing as compared to the conventional mix. This shows and proves that by adding certain amount of waste in the bitumen, it gains strength and thus becomes more durable and tough. Stone aggregate is coated with the molten waste plastics

& rubber powders. The coating of plastics & rubber reduces the porosity, absorption of moisture and improves soundness. Hence the use of waste plastics & rubber tyres in the form of powder for flexible pavement material is one of the best methods for easy disposal of wastes. The use of polymer & crumbed rubber coated aggregate is better than the use of conventional aggregates in many respects. As shown in the table, it is clearly shown that there is a huge difference in the values of the mix when compared with the conventional value. In India more than 3.3 million km of road is available. If they are constructed as plastic-rubber tar road, there will be less waste plastic & waste tyres available on the road. The process is eco-friendly.

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