Production of fuel oil from waste asphalt roof shingles in a sustainable manner

Satya Ganti and Tony Strouse Jr.
Email: sales@sarvabioremed.com
Road Gold Company, LLC, York, PA 17406, USA

Abstract

Asphalt roof shingles are used widely in the USA, Canada, and many countries in the European Union. Old roof shingles are replaced with new shingles and the old shingles are disposed of as waste. According to the available information, almost 11 million tons of waste roof shingles are produced every year in the USA. Currently, waste shingles are recycled into Hot Mix Asphalt (HMA). Shingles are first ground into fine particles after sorting and the recovered asphalt is mixed to produce Recycled Asphalt Shingles (RAS). RAS is then mixed in Hot Mix Asphalt (HMA) for application on the roadways. Both HMA and RAS are known to contribute to the emission of Polycyclic Aromatic Hydrocarbons (PAH) in the atmosphere. In the current paper, an environmentally safe method for recycling waste shingles is described. The current process follows the standard principles of Recycle, Reuse, and Reduce. Low sulfur fuel oil is produced during recycling that can be used directly in various industrial applications including low sulfur bunker fuel for ships without any further refining. Results of the bench-scale studies and those in a prototype unit show that the volume of fuel oil produced from waste shingles is very high due to the presence of almost 36% asphalt. At the end of the recycling, only a fiberglass sheet weighing about 5% of the total weight remains as a residue. Almost 95% of the weight of the shingles was asphalt that was converted into fuel oil. The present process utilizes the principles of "Circular Economy" by reusing the waste to produce energy. The patented process is safe and does not produce any emissions.

Introduction

A large volume of waste is created annually in connection with residential roofing products. Over 12 million tons of waste are created annually, with 11 million tons post-consumer tear-off debris and 1 million tons of manufacturers' waste. Contractors spend enormous amounts of money on waste hauling. This waste also is detrimental to the environment, as the asphalt shingles take up large spaces in the landfills and take a very long time to decompose. There is an urgent need in the industry for an effective recycling method of residential asphalt roofing products. (Horton, JD, and Clark, A. 2016) In the USA, different states have different protocols for recycling waste asphalt roofing shingles. The use of grounded recycled asphalt shingles (RAS) in hot mix asphalt (HMA) is by far the most popular method of recycling. In Europe, different countries have different methods of recycling waste roofing asphalt shingles as the volume of such waste is very large. It is reported that in the Netherlands alone, annually 70,000 tons of waste

shingles are disposed of every year. In Denmark, Tarpaper Recycling has been recycling the waste roof shingles since 2006. Royal Roofing Company in Canada has published a white paper providing comprehensive information regarding the technical, ethical, and commercial aspects of recycling asphalt including post-consumer bituminous roof tiles.

It can be seen that almost all the processes described so far propose recycling Asphalt Shingles as hot mix asphalt at high temperatures and thus contributing significantly to increases in methane emissions.

Circular Economy

It is proposed to introduce circular economy by employing the three R's of recycling namely, Recycle, Reuse, and Recover using the new patented process (Ganti, 2020). Currently, most processes for recycling asphalt shingles are harmful to the environment many directly contributing to pollution of the atmosphere.

The Road Gold Company, LLC has partnered with a group in Meridian, Mississippi, USA to register a new company Magna Gold Oil, LLC of the USA. The objective is to recycle waste asphalt roof singles implementing the patented cold water bioremediation process and produce low sulfur fuel oil. The proposal was submitted to Mississippi Economic Development Authority. Magna Gold Oil, LLC was awarded the Grant money of $ 7,500.00 to help develop this innovative technology in Mississippi and elsewhere.

Showing granular and asphalt surface

MS Development Authority Grant

Bench Scale studies:

Roof shingles are used in most of the USA, Canada, and many European countries. It is made of three components namely a) thin base fiberglass sheet; b) Asphalt

layer and c) colored stone granules. The granules offer external protection to the shingles and can be of many types. Some granules are colored to reflect light.

A strip of shingle measuring 2.5" x 2.0" and weighing 0.045 grams was placed in a beaker so that the asphalt side faces outside and the granule side faced the wall of the beaker. A light spray of diesel is sprayed on the asphalt surface and followed by a spray of VaporRemed®, a bioremediation product manufactured by Sarva Bio Remed, LLC of York, PA. This was followed by a spray of water to release oil produced from shingles in the water as seen in the images below. The process was continued for almost 2 days till the fiberglass base was seen clearly. The process was terminated and the oil was separated in a separating funnel. The volume of oil collected from the strip of roof shingles was then measured before sending it off to the laboratory for analysis.

The initial weight of strip (before): 12.47 grams
The final weight of fiberglass (after): 0.26 grams
Weight of asphalt: 12.21 grams.
Amount of oil produced 280 ml
1000 grams of shingles would produce: 22454 ml of oil or 22.454 Liters of oil
1 Ton would likely produce 22 tons of oil in the bench-scale study.

Oil released after first cycle

Almost 280 ml collected after 48 hours

The fiberglass surface was free from asphalt and both the granules and asphalt layer were removed in the process. The granules remained at the bottom of the beaker. Images of shingles before and after completing the process are given below.

Results of the Analysis of Oil:

Analysis of the oil produced from waste shingles was carried out using ASTM specification D 396 and the values are given below.

1. Total Sulfur: 291 ppm
2. Flashpoint: 67°C
3. Water content: 2.0%
4. Kinematic viscosity: 2.681 centistokes
5. Ash content: 0.019%

Based on the above values, the laboratory has classified the fuel as close to No. 4 Fuel Oil. No. 4 fuel oil is used for heating in many industrial applications. The fuel generated in this process is without any refining. The biggest market for this low sulfur fuel oil is ships where the current high sulfur 'Bunker Fuel' is being replaced by low sulfur fuel as per the International directive. The oil produced can be directly used onboard merchant marine ships.

Prototype Model 1 with Oil Water Separator and shingles.

Prototype showing Reaction vessel

Three waste shingles before.

Oil being produced after

Clean shingles after processing

The design shown in the photograph above is the basic design. It consists of a reaction vessel mounted on a stand. The central drain is connected to an oil-water separator (OWS). The OWS selected for the present design is distributed by Freytech Inc. in Florida. It meets the primary requirements of separating oil free from water and discharges water free from oil. It is proposed to recycle and reuse the discharged water into the system multiple times. The weights of the three shingles were determined before and after extraction of fuel oil in the above system

	Initial	Final	Wt of aphalt	% cent asphalt
Shingle 1:	77.71 gms	2.99 gms	74.72 gms	96.15%

Shingle 2	68.78 gms	2.68 gms	66.1 gms	96.10%
Shingle 3:	66.31 gms	3.90 gms.	62.41 gms	94.11%

The amount of oil produced from 3 shingles weighing 212.8 gms or 203.23 gms of asphalt coating was 2.82 kg or 6.217 pounds. According to this data 75.17 kg of shingles would produce 1000 kg of fuel oil.

Production of fuel oil from ground shingles:

On 10th March 2021, we visited Crushcrete Inc. near Bethlem, PA to check out their facility that receives waste shingles. We recorded the piles of waste shingles. The shingles are ground into fine powder for use with Hot Mix Asphalt (HMA). We brought two samples of the material one powdered to less than ¾ inch and the second less finely ground to a particle size of more than 3 inches.

Asphalt Shingles

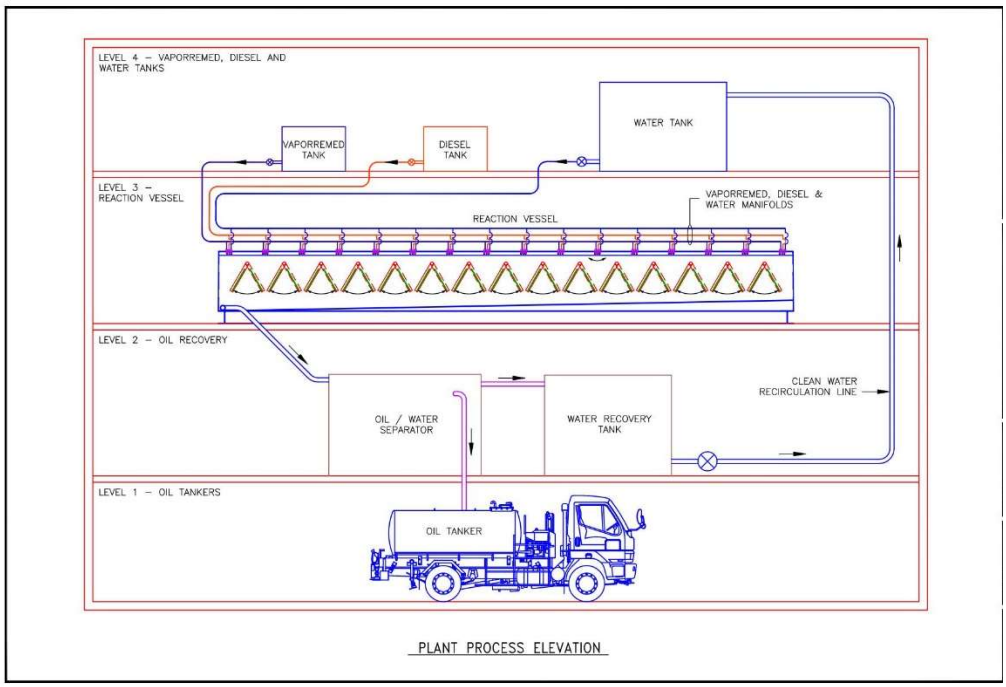
Ground asphalt shingles

Wt. of ground 3/4th Inch shingles: 10.00 gms
Amount of oil produced: 140.00 ml 110.5 gms
Wt. of the granules: 3.56 grams
1 ton of grounded shingles would yield: 11 tons of fuel oil

Proposed Design:

The proposed conceptual design is to study the oil produced by strips of shingles in large reaction tanks. In association with Magna Gold Oil, LLC, a working model is being developed to standardize all the parameters of spray application of each of the three products namely diesel, VaporRemed, and water. This will form the basis for a larger unit to produce fuel oil from larger volumes of shingles. The design will consider the lightweight nature of shingles and the large area occupied by the strips. The basic process involves the same as shown in the bench-scale study above. The larger commercial-scale system shown below will be installed in Meridian, MS to process the waste shingles generated in the nearby areas.

Interestingly, some of the landfills in the area were unable to accept fresh waste shingles as the area was full.



Conceptual plant design for recycling waste shingles

Based on the data collected above it is reasonably considered that 1 ton of waste shingles would produce 12 tons of Low Sulfur fuel oil. Magna Gold Oil, LLC is negotiating with a local oil dealer company for the collection and distribution of produced fuel oil.

Conclusions

1. Waste shingles of one house would produce 7 barrels of Low Sulfur fuel.
2. One oil well in the US produces 15 barrels of crude oil.
3. US Oil production is about 12 million barrels per day from 1,029,700 wells as per EIA report
4. The number of houses producing waste shingles could be higher than the number of oil wells
5. One barrel of crude oil produces 19½ gallons of gasoline, 9 gallons of fuel oil, 4 gallons of jet fuel, and 11 gallons of other products
6. One barrel of fuel oil produced by the current process compares with Low Sulfur Bunker fuel without any intermediate products.
7. The process is environment friendly with minimum emissions in the air.
8. The process is closest to a circular economy and generates revenue with minimum waste.

References:

1. Horton, JD, and Clark, A. (2016): "Method for progressive separation and extraction of raw materials from residential roofing products." US Patent **9,440,239**
2. Anonymous (2012): Asphalt shingles manufacturing & waste management in the northeast. Fact sheet
3. Anonymous: (2018): Economics and markets for recycling asphalt shingles.
4. Satyanarayana Ganti (2020): "Energy efficient method for recovering oil from asphalt waste utilizing bioremediation." US Patent No. 10,550,329 B.
5. Anonymous (2020): Oil from oil wells: EIA report.