Turn Post Consumers Shingles into a Circular Model

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Abstract:

Approximately thirteen million tons of post-consumer shingle waste are sent to landfills every year in the United States. The Asphalt Roofing Manufacturer's Association (ARMA) has pledged to reduce landfill disposal of shingle waste to 50% by 2035 and 0% by 2050.[1] Numerous technologies have been explored within academia and industry to address this opportunity for shingle circularity, but none have proven to replace virgin raw materials. Owens Corning, in conjunction with Redivius, has developed an approach that deconstructs waste shingles into three components: extracted asphalt from recycled shingles (EA-RAS), granules, and mixed solids. The process is designed to reclaim the entire shingle to prevent any components from going to waste. The proprietary, patent-pending process allows the deconstruction of shingle waste through mechanical and chemical treatment to produce EA-RAS, which Owens Corning will reuse in making new products. This creates a circular model by recovering asphalt and reducing the use of virgin raw materials.

Owens Corning aims to build a sustainable future through material innovation. This Shingle Circularity initiative supports the enterprise sustainability goals to achieve zero waste to landfill, reduce GHG emissions by 2030, and explore circular economy models.[2] This paper will describe the process developed to convert shingle waste into reusable materials and the reuse of EA-RAS in shingle production.

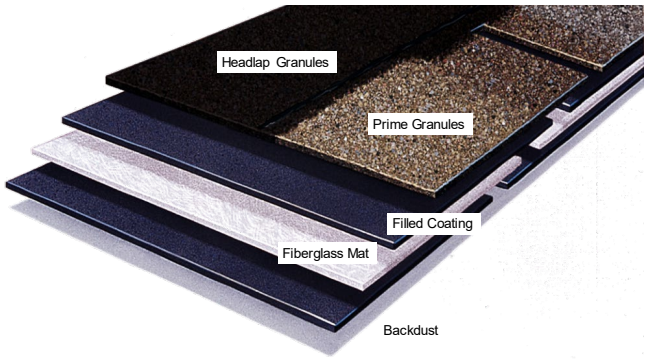
Introduction and Motivation

Asphalt shingles represent over 80% of the residential roofing market in the United States.[3] Figure 1 illustrates the various components of a shingle, each serving distinct functions such as weather resistance, fire resistance, ease of application, aesthetics, and minimal maintenance. The weather resistance comes from the granule's surface over filled asphalt coating. The asphalt coating is filled with approximately 65% calcium carbonate as a mineral stabilizer, which provides fire resistance and improves the weatherability. Prime and headlap granules cover the top surface of the shingle. The exposed prime region is covered with ceramic-pigmented granules in a controlled color, applied in a discrete pattern during production to enhance the shingle's aesthetic appeal. The headlap granules, which are not exposed, consist of various dissimilar materials.[4] Sand, dolomite, limestone, or other materials are applied as backdust to prevent shingles from sticking together in bundles.

In recent years, there has been greater visibility to shingle recycling due to the amount of shingle waste going to landfill. With approximately thirteen MM tons going to landfills annually, there is increasing urgency to find methods to divert shingles from landfills. In 2022, the Asphalt Roofing Manufacturer's Association (ARMA) published an industry aspiration to reduce landfilling of shingle waste by 50% by 2035 and divert 100% by 2050.[1] This has sparked

a renewed effort among shingle manufacturers, recyclers, and other stakeholders to develop circular economies aimed at diverting waste shingles from landfills.

Figure 1. Components of a Shingle Construction



Recycling end-of-life shingles present multiple challenges. When shingles are removed from roofs, they must be separated from wood, nails, flashing and gutters, vents, underlayment, plastic wrappers, and general trash. Once at a recycler or processor, the waste shingles need to be tested for asbestos, which can be costly, and then processed for end-use applications. Mechanical size reduction is typically required, with three-eighths inch (3/8”) and smaller being commonly used in the hot mix paving industry. The asphalt component is critical for recycling, as it has at least ten times the value of the other materials, providing a financial incentive to recycle. However, the aged nature of the asphalt and its mixed composition presents unique challenges. Recovering asphalt from waste shingles is key to successfully developing a viable circular economy.

While all asphalt is the result of a refinery atmospheric distillation and vacuum tower processing of crude oil, not all asphalt is suitable for use in the production of shingles. The primary raw material used for making asphalt coating for shingles is called roofing flux, which is a select material produced by only a few refineries in North America. Asphalt coating is produced when the asphalt flux goes through an air-blowing process. The decreased availability of this stream necessitated the production of asphalt coating by alternative means. The use of EA-RAS in asphalt coating offers a unique method for recycling shingles while ensuring supply security for one of the most critical components in a shingle.

Review of Related Work or Current State of the Technology Industry Uses

Shingle recycling started in the late 1970’s when the oil embargo drove up the price of petroleum derived products. There has been significant work in the use of Recycled Asphalt Shingles (RAS) in Hot Mix Asphalt (HMA) paving. RAS usage in asphalt paving peaked in the 2014-2015 period when high asphalt cost pushed contractors to use higher recycled contents to replace virgin binder.[5] During this period, there were no specification requirements measuring the cracking resistance of an asphalt mixture. The most common testing performed was the Hamburg Wheel Tracking Test, which measured the resistance of the asphalt mixture to permanent deformation at elevated temperatures. Higher RAS usage increased the resistance to permanent deformation but also caused greater cracking potential. This led the Federal Highway Administration to issue a memorandum limiting the use of RAS in pavements due to premature cracking failures.[6] Since that time RAS usage has declined from a peak of almost two million tons recycled annually to just over 670,000 tons in 2022.[7]

The two primary routes to shingle recycling are mechanical reduction and deconstruction. The mechanical reduction process typically is done by means of a Rotochopper®, which reduces the size to 3/8”. Several established technologies exist that further process shingles into powder. ASR Systems developed a process to produce an asphaltic limestone powder, allowing for further processing or use in other applications.[7] Asphaltica developed a novel approach where the ground shingle is pelletized with a rejuvenator and anti-stripping agent, with the benefit of

providing a recycled shingle form that has multiple functions.[9] These processes are primarily mechanical and utilize the recycled shingle in a form where all components remain mixed.

The deconstruction process is more challenging and requires chemical reagents to separate the asphalt coating from the solids. Crown Iron Works developed the first patented process.[10] Crown Technologies, in partnership with Recovery Technology Solutions (RTS), developed a solvent-based extraction system for recycling asphalt shingles. This approach leveraged an immersion bath, large solids separation, centrifuge, and subsequent solvent removal. Their facility in Shakopee, Minnesota was the first to implement this technology on a commercial scale, but was never commercially successful. This facility was sold to Flint Hills Resources™.[11] Other companies attempting to employ solvent recovery of asphalt include Sky Quarry and Northstar,[12-13] with Northstar currently building their first full-scale facility in Canada.

Redivius has developed a novel shingle extraction facility that leverages multiple material processing technologies. They have partnered with Owens Corning® to advance this technology and build a viable circular economy for shingle recycling. This initiative is part of Owens Corning's commitment to creating a circular shingle economy model. Owens Corning aspires to recycle two million tons of shingles per year in the United States, primarily through their collaboration with Redivius and the use of recycled materials in asphalt pavements. The pilot facility has successfully deconstructed asphalt shingles into their component parts, such as EA-RAS, granules, and mixed solids. These materials are then used to develop new prototype shingles and for use in asphalt pavements.[5]

Industrial Uses for Waste Shingles

The use of RAS has been explored in a wide range of applications with limited success. Two prominent areas are asphalt paving applications and asphaltic roofing materials. The most successful approach with RAS in paving is Stone Matrix Asphalt (SMA) applications where a stiff binder and polymer modification is required. However, SMA represents a small proportion of asphalt paving type mixtures, limiting the impact on shingle recycling. There is limited use of RAS in public paving projects and it varies by state. Some HMA contractors will supplement the asphalt mixtures on non-DOT jobs with RAS for economic and environmental reasons.[14] Manufacturing waste shingles are used in pavement applications because the shingles have not aged. Other road applications include the use of RAS in full depth reclamation and as a dust suppressant of unpaved roads.

The use of recycled shingles is likely to increase as paving mix designs evolve. One recent advancement in asphalt mix design is the use of Balanced Mix Design.[15] Although still in the implementation phase, this method provides the ability to test for both permanent deformation and cracking, enabling more innovative use of recycled materials, including RAS.

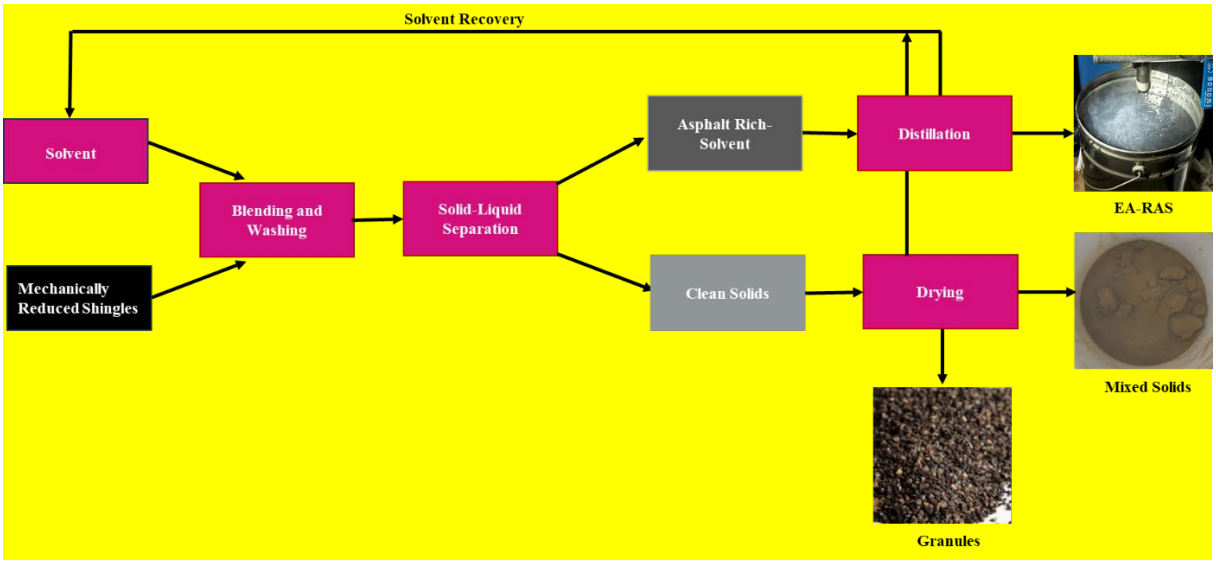
Technology Approach

Redivius and Owens Corning have built on previous efforts to develop a novel chemical recycling approach to deconstruct shingles into their component parts. The key to success lies in creating a recycling process that can recover high-quality materials for economic reuse. While asphalt recovery and reuse are the technological and economic drivers for shingle recycling, asphalt constitutes only 20% mass of the shingle. Therefore, the process also focuses on recovering and reusing other components to contribute to a circular economy.

Recycling Process Overview

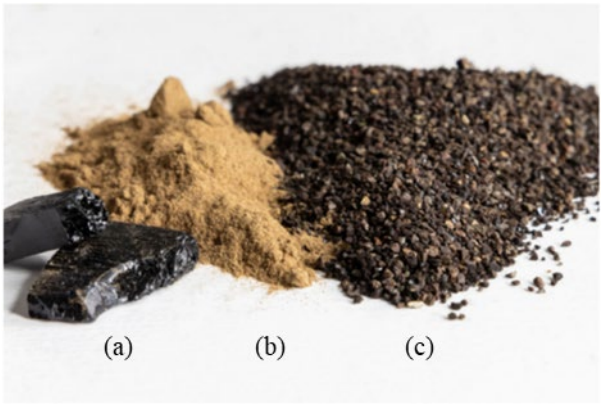
1. **Material Collection and Preparation**: The process begins with the collection of end-of-life shingles, primarily from roofing contractors, followed by the separation of non-shingle materials (e.g., wood, nails, flashing, plastic wrappers). The shingles are then shredded using a horizontal grinder and screened to achieve the desired size.
2. **Mechanical Processing**: The shredded shingles (Recycled Asphalt Shingles, or RAS) undergo further mechanical refinement to reduce size and contamination, often achieving a 3/8" particle size for use in paving mixes or further processing.
3. **Chemical Extraction**: Redivius has developed a proprietary, patent pending extraction process (Figure 2). It takes the RAS feedstock and mixes it with a proprietary solvent, which dissolves the asphalt component of the shingles. After agitation, the asphalt-rich solvent is separated from the solid mineral components through centrifuge. The asphalt-rich solvent is then distilled at temperature exceeding 400˚F to recover and reuse it in subsequent extractions. The EA-RAS is separated and stored for reuse.

Figure 2. Chemical Extraction Process



4. **Separation of Solid Materials**: The remaining solid components, including granules and mixed solids (e.g., limestone filler, sand, glass), undergo drying and additional processing including separation and classification to prepare them for reuse.
    - Recovered Materials (see Figure 3): The recycling process yields three primary materials:
        - EA-RAS (20%)
        - Mixed solids (limestone filler, sand, etc.) (50%)
        - Granules (30%)

Figure 3. Recovered materials from shingle recycling – EA-RAS (a), mixed solids (b), and granules (c)



Recovered Material Reuse

EA-RAS differs from virgin asphalt due to aging and weathering on the roof. The recovered asphalt is significantly harder than virgin asphalt used to make asphalt coating. Reuse requires proprietary formulation and modification to reintegrate it into new asphalt coating, ensuring the resulting coating meets ASTM D3462 requirements.[16] The key is to determine the optimal level of EA-RAS that can be effectively utilized without adversely affecting processing, quality, or durability of the finished product.

Recovered granules are reduced in size due to handling and mechanical processing, resulting in a non-homogenous mixture of diverse colors. This contrasts with virgin granules, which are processed to a specific size range and coated with ceramic pigment in a controlled manner. Successful reuse also requires the absence of residual asphalt, as it can impact flowability through the manufacturing process.

Mixed solids consist of the remaining materials present in shingles, such as limestone filler, sand, dolomite, ground-up glass mat, fractured granules and other contaminants. These mixed solids must undergo additional processing and purification before being reused in shingles or other applications that utilize mineral fillers.

Discussion

The shingle recycling process, and the associated treatment of the recovered materials for recycling, has been developed from benchtop experiments to pilot scale over the past several years. In 2024, a significant milestone was achieved when the first truckload of EA-RAS was produced at the pilot facility and shipped to the Owens Corning's Trumbull® Asphalt plant for modifications. The subsequent coating containing EA-RAS was used in a shingle production trial, marking the first full-scale use of extracted asphalt in shingle production.

In the future, both Redivius and Owens Corning will scale up material production and conduct trials to further refine the process. The next phase of pilot operations will incorporate previous learnings to improve process efficiencies and optimize the materials. Additional trials with increased amounts of EA-RAS in the coating will be conducted. The use of recovered granules in headlap during shingle production will also be expanded, transitioning from previously conducted short plant trials to a full-scale production trial.

Successfully scaling up the recycling process will enable the diversion of waste shingles from landfills and reduce our reliance on virgin materials, such as asphalt flux and other mined components. The commercialization of this process offers considerable environmental benefits, including reduced reliance on virgin materials and lower emissions.

Conclusions & Recommendations

The purpose of this work was to demonstrate a viable method for creating a circular economy for shingle recycling through the recovery and reuse of extracted asphalt and other materials. Emphasis was placed on developing a process that chemically extracts asphalt suitable for transformation and treatment into asphalt coating, along with the recovery of other solid materials. Although the asphalt coating constitutes about 20% of the recovered materials, its higher value can financially justify scaling up the process. The granules can be a viable replacement for use in the headlap of the shingle, while the mixed solids have multiple end use outlets to explore. Owens Corning, in partnership with Redivius, has successfully demonstrated asphalt recovery and the first full-scale use of EA-RAS in shingle production, with ongoing efforts to refine the process and use of additional recycled materials.

Acknowledgements

This work has been supported by the corporate sustainability goals of Owens Corning and the collaboration of Redivius and their sister company CRS Reprocessing Services. Correspondence on this work should be directed to Laurand Lewandowski, Owens Corning.

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