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(54) **MOBILE MICROWAVE PROCESSING UNIT FOR PAVEMENT RECYCLING AND ASPHALT PAVEMENT PRODUCTION**

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(63) Continuation-in-part of application No. 13/887,828, filed on May 6, 2013.

(60) Provisional application No. 61/643,010, filed on May 4, 2012, provisional application No. 61/643,046, filed on May 4, 2012.

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USPC **404/113**

(57) **ABSTRACT**

A mobile asphalt plant for producing a high performance hot mix asphalt product, comprising: RAP material, emulsion added to the RAP, and low energy microwave heating system for processing the RAP emulsion mix.

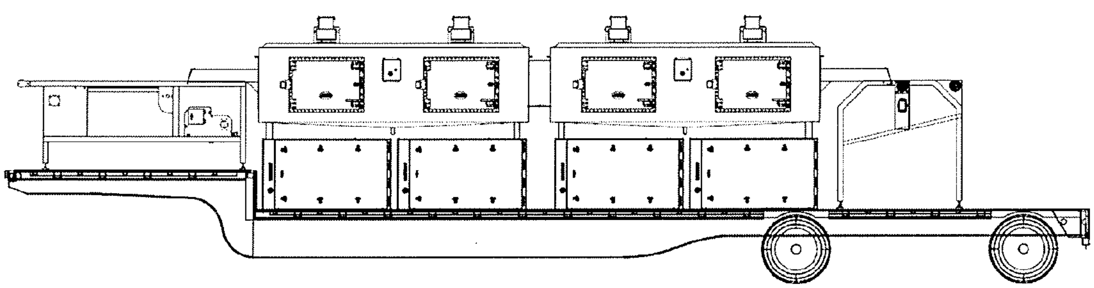


Figure 1 (Prior Art)

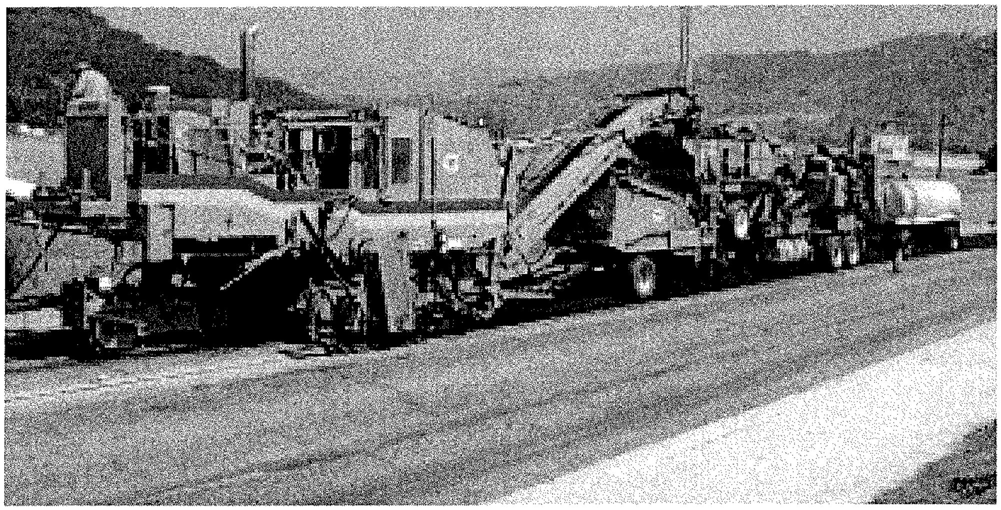


Figure 2 (Prior Art)

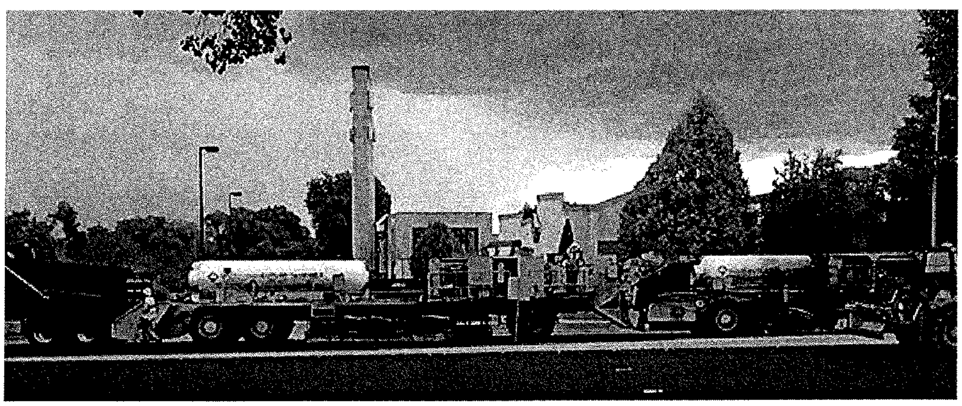


Figure 3 (Prior Art)

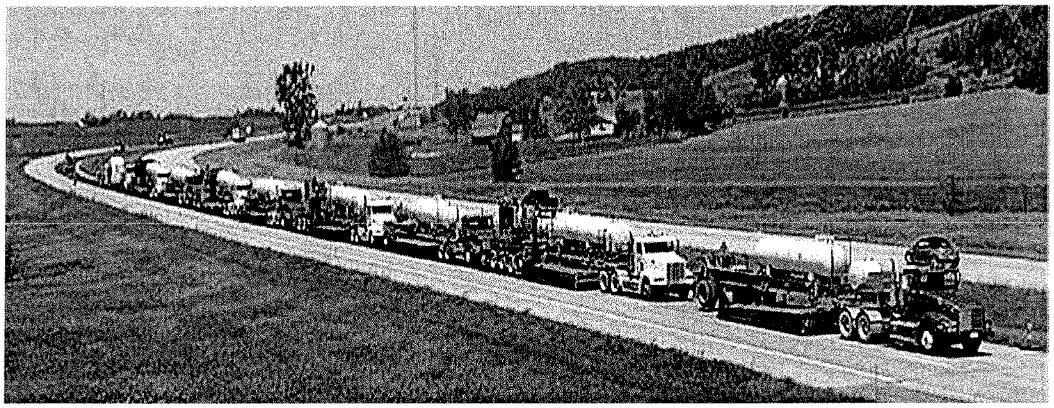


Figure 4 (Prior Art)

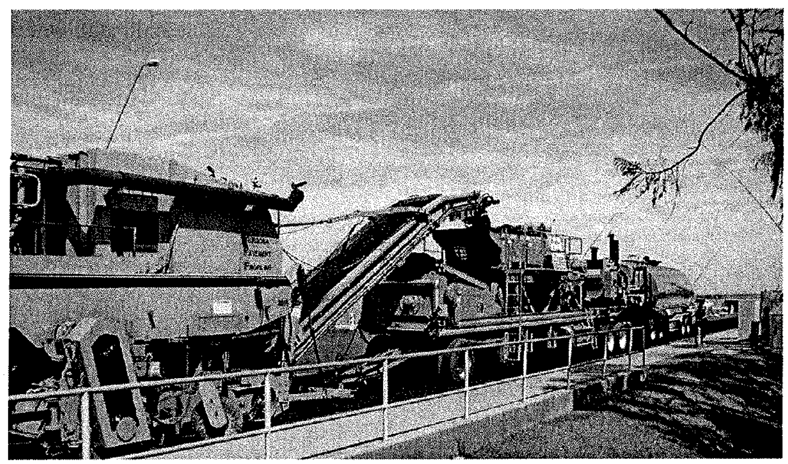


Figure 5 (Prior Art)

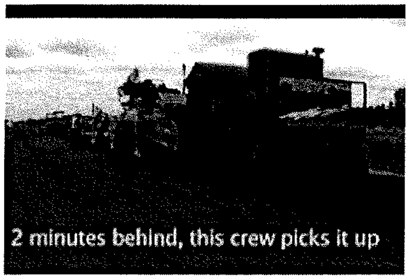


Figure 6

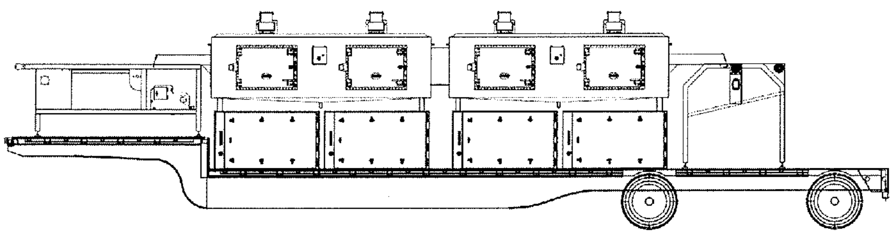


Figure 7

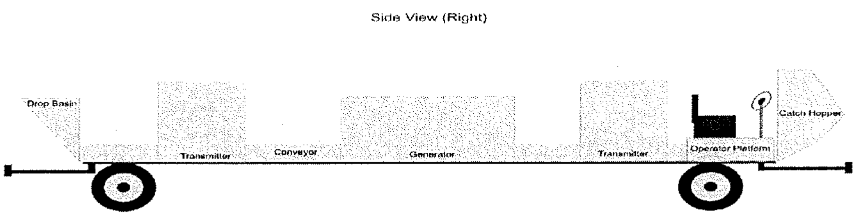


Figure 8

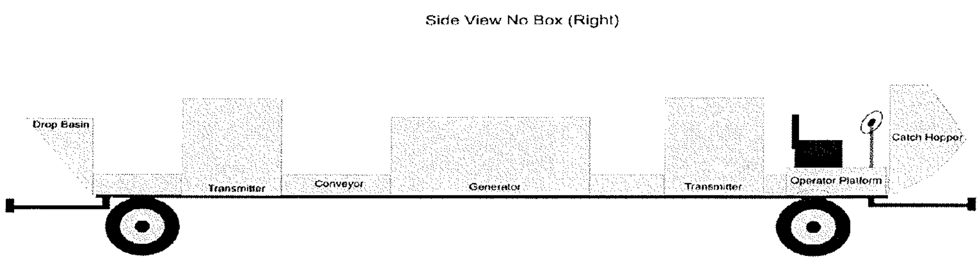

Side View No Box (Right)
Drop Basin
Transmitter
Conveyor
Generator
Transmitter
Operator Platform
Catch Hopper

Figure 9 (bottom view)

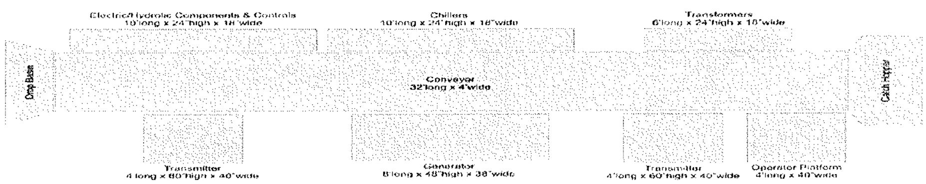
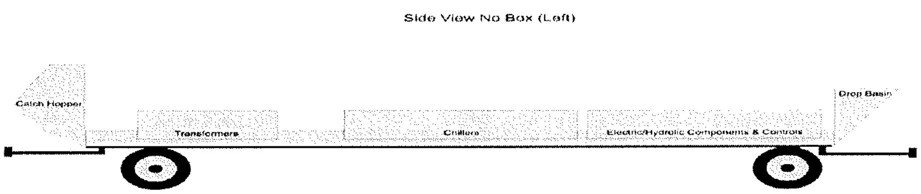


Figure 10



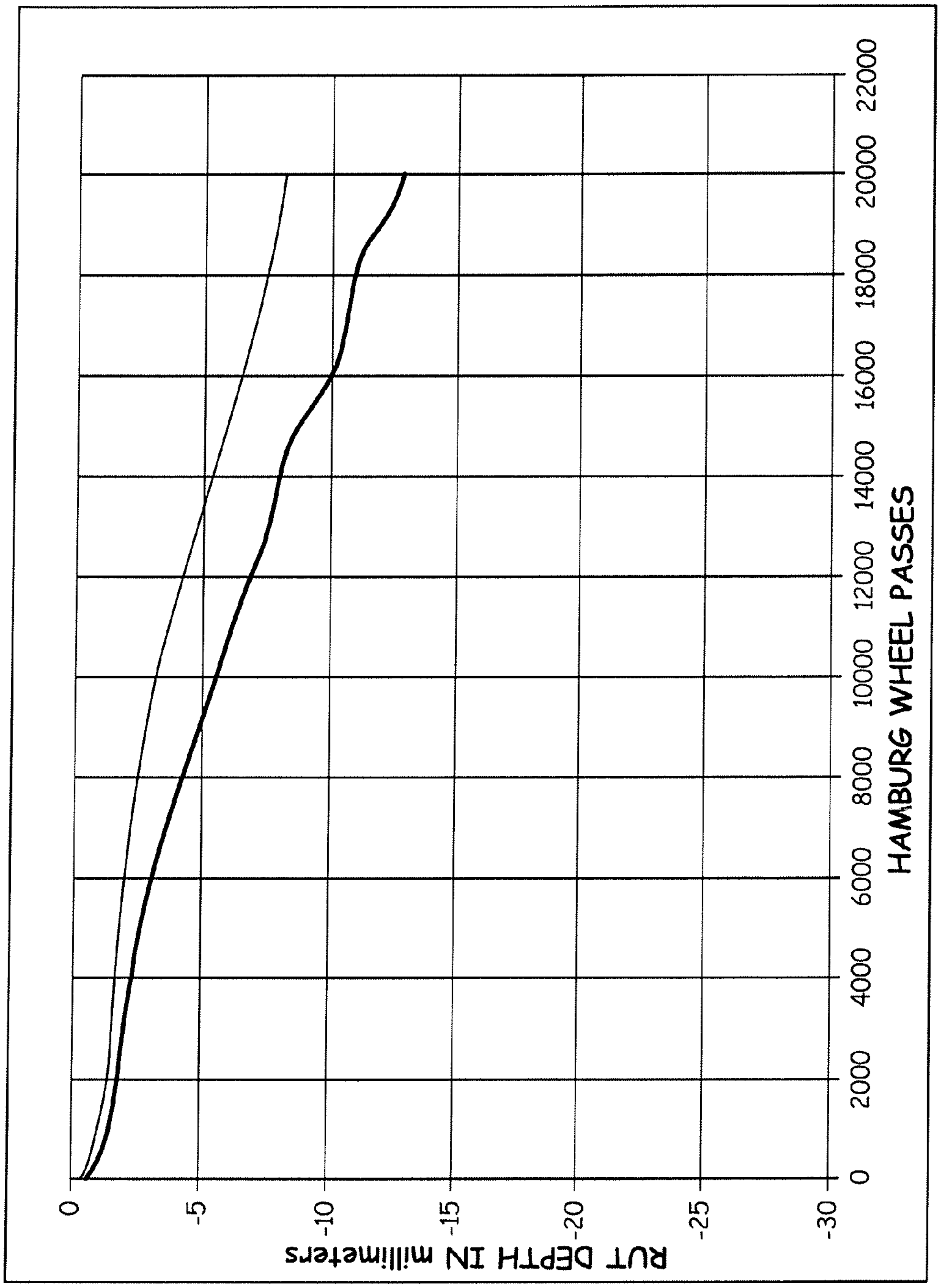

RUT DEPTH IN millimeters
0
-5
-10
-15
-20
-25
-30
HAMBURG WHEEL PASSES
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000

FIG.11

MOBILE MICROWAVE PROCESSING UNIT FOR PAVEMENT RECYCLING AND ASPHALT PAVEMENT PRODUCTION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to and incorporates by reference the following U.S. Provisional Patent Application Nos. 61/643,010 and 61/643,046 filed on May 4, 2012, and is a continuation in part of and incorporates by reference U.S. patent application Ser. No. 13/887,828 filed on May 6, 2013.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention is in the technical field of asphalt production. More particularly, the present invention relates to the use of microwave energy in a mobile asphalt production plant.

[0004] 2. Background

[0005] Asphalt recycling and reclamation is a process of removing the aged asphalt pavement. The process can removed from about f few inches to several inches of asphalt pavement, and can include removing a portion of the base aggregate below the asphalt and crushing it to a particular size. After removal and crushing the material, the product is blended with an asphalt emulsion (in most cases emulation is added at the ratio of about 1.5%-6% by weight), which has performance characteristics that are refined for the particular region and weather conditions.

[0006] Reporting from DOT agencies has shown a disconnected rate of success and failures between methods and there is no current national specification to follow for asphalt recycling. DOT agencies, townships, and counties are looking for better more economical ways to prolong pavement life. In recent years hot in place recycling ("HIR") processes have been on the rise in popularity, but these processes suffer from a number of drawbacks. Drawbacks include that fact that the processes are environmental unfriendly, cause pollution, and require large amount of energy to produce the heat necessary for HIR process.

[0007] Other processes for pavement recycling exist including: CIR—Cold In-Place Recycling, FDR—Full Depth Recycling, and HIR—Hot In-Place Recycling.

[0008] CIR is an eco-friendly pavement rehabilitation process performed without the use of heat and has been a common pavement rehabilitation technique since the early 2000's. The two most common methods of CIR use either an asphalt emulsion or foamed asphalt as a stabilizing agent. Anywhere from 2 to 5 inches of the current road surface are pulverized down to a specific aggregate size, mixed with the emulsion or foamed asphalt, and are then reused to pave that same road. The equipment used (FIG. **1**) mills a section of pavement, up to 14 feet wide, in a single pass, passes it through a mobile crushing and sizing plant, then through a pug mill where the asphalt stabilizer is added, and the final material is windrowed out the back where it is picked up by standard asphalt paving equipment and laid back down over the same road surface. The paving train is approximately 150' in length.

[0009] CIR produces a final product that has approximately 10% air voids (compared to 3-7% for hot-mix asphalt) and has approximately 60-80% of the structural value of new hot-mix asphalt (AASHTO layer coefficient of 0.25-0.28 vs. 0.35-0.44 for hot-mix). Thus, the final product has substantially less integrity of the original, and is inferior in quality to new asphalt pavement in terms of strength and longevity.

[0010] FDR is similar in nature to CIR, although typically the process recycles more base material, where normally 2 plus inches of base is pulled up and included in the recycling process.

[0011] HIR is also a similar process, consisting of four steps: (1) softening of the pavement surface with heat; (2) mechanical removal of the surface material; (3) mixing of the material with recycling agent and/or virgin aggregate and asphalt binder; and (4) laydown and paving of the recycled mix on the pavement surface. The equipment used to perform HIR is approximately 200 feet or more in length, including the preheaters, scarifier, and mixing equipment. HIR is typically limited to recycling only the upper 1 to 2 inches of a pavement. There is no published research available regarding the structural value of HIR pavement, however because of the process used, it is likely equivalent or slightly better than CIR, but still not the equivalent of new asphalt pavement. The equipment required to produce HIR utilizes a significant amount of heat to soften the pavement. The pavement is typically scarified after heating rather than being milled, which results in a less defined pavement edge compared to CIR—leaving a less finished final product. The heat is typically generated by an infrared heater that uses propane as a fuel source (Heat Master 16 is most commonly used). According to the manufacturer's specifications, the HM-16 has a total BTU/hr. output per main panel of 8,222,000 BTU/hr.×two=16,444,000 BTU/hr. Because of the direct application of high heat to the pavement, it is possible that the asphalt binder is aged and thereby hardened, reducing the ability of the final product to resist thermal cracking.

[0012] These pavement rehabilitation approaches are best suited to long sections of pavement, because of the size of the reclaiming equipment trains, as shown in FIG. **2**. HIR equipment trains can be quite large (FIG. **3**).

[0013] The growing traffic demands on our nation's roadways over that past couple of decades, decreasing budgetary funds, and the need to provide a safe, efficient, and cost effective roadway system has led to a dramatic increase in the need to rehabilitate our existing pavements. The last 25 years has also seen a dramatic growth in asphalt recycling and reclaiming as a technically and environmentally preferred way of rehabilitating the existing pavements. Asphalt recycling and reclaiming need to be improved to meet all of our societal goals of providing safe, efficient roadways, at the same time there need to be drastic reductions in both the environmental impact and energy (oil) consumption compared to conventional pavement reconstruction. The period of rapid expansion of roadway networks through new construction has peaked, the existing roadway infrastructure has aged, and a significant number of roadways are nearing the end of their useful service life. Limited funding and demands on existing resources have shifted the emphasis from new construction to preservation and/or extending the service life of the existing roadways. The implementation of more timely or proactive preventative maintenance and rehabilitation treatments is being used as a means of preserving the existing roadway infrastructure.

[0014] Although, these prior art technologies are more environmentally sound and cost effective, their implementation has not been accepted widely due to lack of knowledge and awareness of their benefits as well as hesitation on the part of some agencies to try new strategies. In some cases, improper design and construction techniques that resulted in premature failures impeded the progress of these technologies. Such barriers hamper the efforts of marketing and promotion of innovative and improved recycling strategies. The following is a list of some barriers that have impeded the implementation of in-place recycling: lack of experience and technical expertise; non-availability of local contractors; lack of local support from the asphalt industry; difficulties in leaving the comfort zone; biases and misconceptions; past premature failures; lack of clear guidance on proper usage and process control; inconsistent specifications; lack of awareness to cost-effectiveness; air quality concerns regarding HIR; large expense of recycling equipment; concerns regarding the adequacy of the structural capacity; many emulsions used need to "cure" up to a week before the final hot-mix asphalt ("HMA") or alternate wear coarse is installed, which causes a substantial delay in construction and in some cases a double mobilization of the construction equipment increasing costs and duration of construction; the engineered emulsions and foamed emulsions have inconsistent success rates throughout the country which has caused a lack of willingness of some agencies to participate in this cost savings process; a significant amount of lab testing is required for new emulsion mix designs prior to project specification and bidding. Based on the current success rate this is a deterrent; the HIR process consumes a tremendous amount of energy to be effective; and although existing recycling methods add life to aged pavement they fall short of new HMA overall performance criteria.

[0015] Thus, a need exists for an improved asphalt recycling product and method that does not suffer from the drawbacks and disadvantages of the prior art.

SUMMARY OF THE INVENTION

[0016] An object of the present invention is to provide an improved apparatus and method for a mobile asphalt plant for producing a high performance hot mix asphalt product, comprising, RAP material, emulsion added to the RAP, and low energy microwave heating system for processing the RAP emulsion mix. These and other objects of the present invention will become apparent to those skilled in the art upon reference to the following specification, drawings, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** shows a CIR equipment train moving down a roadway.

[0018] FIG. **2** shows a portion of a HIR equipment train.

[0019] FIG. **3** shows a HIR equipment train equipment train moving down the roadway heating up the pavement with direct flame derived from the large fuel tanks located on top of the trailers being pulled.

[0020] FIG. **4** shows a CIR train injecting engineered emulsion ahead of the pick-up machine and the paver.

[0021] FIG. **5** shows a pick-up machine and the paver, where the present invention will be placed therebetween.

[0022] FIG. **6** shows the MLEHS.

[0023] FIG. **7** shows the MLEHS.

[0024] FIG. **8** shows the MLEHS.

[0025] FIG. **9** shows the MLEHS.

[0026] FIG. **10** shows the MLEHS.

[0027] FIG. **11** shows the results for testing of two variations of the LEAS HMA.

DETAILED DESCRIPTION OF THE INVENTION

[0028] The present invention is directed at overcoming the problems associated with the current recycling methods in an effort to provide a better pavement performance solution with an economic and energy savings. The invention processes the recycled asphalt during or after the emulsion blending stage is complete in a standard CIR or FDR recycling equipment train and rapidly heats the material using a microwave system that includes a minimum of four microwave transmitter units with a splitter/wave guides that direct microwave energy from each transmitter into two rotary head heating chambers using about 2.4 or 915 MHz. The microwave process is referred herein as low energy heating system ("LEHS") or mobile low energy heating system ("MLEHS"). Using the microwaves in a series gives the ability to cycle the power and intensity to achieve the best heating results over a controlled surface. Another possible configuration for conveyance of microwave energy is through a tube or stainless steel pipe using a stainless steel auger (or such other materials that are suitably resistant to damage from microwave energy) while using wave guides to split the microwave energy from each transmitter and direct the energy into the chamber from multiple sides.

[0029] The microwave unit has the proper shielding to protect the operators and provide the adequate amount of heat to the material to achieve temperatures of about 220 to 340 degrees Fahrenheit while traveling through the MLEHS processor. The correct heat is applied while the material is conveyed through the MLEHS heating chambers and is critical to soften the limited asphalt emulsion binder present in the aged asphalt so it blends with the new asphalt emulsion. The finished material is dropped in the paver at the required temperature to provide the best compaction and fusion between the remaining asphalt existing in the aged pavement and the new emulsion being introduced.

[0030] The process using an existing CIR equipment train is shown in FIG. **4**. This equipment removes old pavement, or pavement and base material, directly from the roadway. The pavement material is removed and conveyed to a blending station where up to two different new engineered asphalt emulsion binders are infused, the injected material is then dropped back to the ground. The process happens while the equipment train is moving down the road. After the large equipment train a smaller "pickup" unit follows removing the injected material from the roadway and dropping it into a paver to be reinstalled on the roadway (FIG. **5**).

[0031] The models shown in FIGS. **6-10** show configurations of the MLEHS microwave processor that can be plugged into the train of equipment after the pickup machine and just before the paver. As the pick-up machine shown in FIG. **5** removes the injected recycled asphalt pavement ("RAP") from the ground it is conveyed up and placed directly on the conveyor at the front of the MLEHS. The injected RAP is heated as it passes through the MLEHS to the designed performance HMA mix specification for the region. The high performance HMA exits the MLEHS and is dropped directly into a paver for even distribution on the roadway. A compaction roller follows the paver to compact the HMA to the correct compaction level. Other possible MLEHS configurations include mounting the Microwave unit on top of the paver or attached to the recycle pug mill where the new emulsion is introduced.

[0032] The MLEHS device shown in FIG. **6** includes four microwave transmitter units with internally located splitter/wave guides that direct microwave energy from each transmitter into two rotary head heating chambers per transmitter using about 2.4 or 915 MHz (low energy heating system). However, different numbers of microwave transmitters can be used based on the application. For example, up to ten or more microwave transmitters can be used, with internally located splitter/wave guides that direct microwave energy from each transmitter into two rotary head heating chambers

[0033] The MLEHS device will be pulled by a small semi-tractor with operator station to the left or right off center to accommodate the material conveyor. The injected RAP material is feed in one end onto a conveyor, processed, and then deposited directly into the paver from the other end. This unit uses its own on board generator for a power source. The combined generator and microwave power usage is approx. 800,000 BTU's per hour (only a fraction of the 16 Million BTU's/HR for the HIR equipment) while producing high performance HMA.

[0034] The mobile LEHS can have an operator station built in so it is totally maneuverable. Additional views are shown in FIGS. **7-10**; FIG. **10** shows the device without the microwave units.

[0035] The above MLEHS has the ability to be utilized in a train or as a mobile/temporary asphalt plant when used in conjunction with the crushing and injection system as pictured on the previous page in the equipment train. This high performance HMA plant would take up little space while producing little to no particulate or voc emissions as shown below. The plant could be set up on site for any large scale remove and replace of roadways or parking lots.

[0036] Using bid tabulations from 2012 taken from county projects in Minnesota, the typical bid price for 4-inch deep CIR is $1.90/square yard, with the emulsion costing an additional $4.20/square yard (3% addition rate) for a total price of $6.10/square yard. Using a $60/ton price for traditional HMA, and $2/square yard for 4-inch deep milling, the total price for a 4-inch mill and overlay would be $15.50/square yard.

[0037] From this cost comparison it can be seen why CIR is a desirable approach for pavement rehabilitation when the other factors influencing the decision (geometrics, pavement height, vertical clearances, etc.) allow it to be considered. Because CIR is typically only given about 70% of the structural value of HMA, and is not considered suitable for a final wearing surface, a 1.5 to 2.0 inch of traditional HMA overlay is typically placed over the CIR as the final surface, adding an additional $5.50-$6.75 to the price, resulting in a total price of $11.60-$12.85/square yard. The present invention yields costs similar to below traditional CIR, in part because the resulting product is superior to HMA it eliminates the need for the traditional HMA overlay.

[0038] LEAS HMA for has been tested in comparison to Superior Performing Asphalt Pavements ("Superpave") standard developed for the U.S. Department of Transposition, Federal Highway Commission and used for all paving projects that are funded in a whole or in part by federal funds. The principal measurement used for the evaluation of HMA is the tensile strength ratio ("TSR") which is used to predict the durability of the HMA. Some southern states, notably Texas and Louisiana, have replaced the TSR measurement with the Hamburg Rut Test measurement as HMA laid at elevated temperatures can become brittle. The following table shows the results of testing performed on LEAS HMA against the foregoing standards.

LEAP HMA Properly Testing Results per AET, Jan. 12, 2013[1]
(HMA Samples from Dec. 20, 2012 and Jan. 9, 2013)

Property	Superpave HMA SPWEB340B[2]	LEAP at 230° F. No Lime	LEAP at 220° F. With Lime	LEAP at 290° F. With Lime
Asphalt Cement or Emulsion Content - % by weight	5.5	5.0	5.0	5.0
TSR	80.9	73.8	75.5	83.4
Percent Air Voids	4.0	3.0	2.8	3.8
Hamburg Rut Test - 12.5 millimeter depths	8,500	N/a	19,200	20,000+[3]
Bulk Specific Gravity	2.438	2.356	2.358	2.356
Density, lb./ft^3[4]	152.1	147.0	147.1	147.0
Maximum Specific Gravity	2.540	2.396	2.422	2.396
Dry Tensile Strength, psi[5]	68.1	128.6	199.1	226.3
Soaked Tensile Strength, psi	55.1	94.9	150.3	188.8

[1]Engineering Testing Summary, Crius Corporation Asphalt Plant Air Emissions Engineering Test, Dec. 18, 2012. AET Project Number 14-01235

[2]SPWEB340B is a Minnescta Department of Transportation Superpave specification where "SP" indicates the gyratory (testing) design. "WE" indicates a wear mixture 'B' indicates <3/4" aggregate "3" indicates the traffic level. "40" indicates 4.0 percent design air void and the 'B' indicates the virgin asphalt cement binder grade.

[3]Test haited at 20,900 cycles, the upper limit of the testable range.

[4]Lb/ft^2 = pounds per cubic fool

[5]Psi = pounds per square inch.

[0039] The Superpave specification, and most derivative state specifications, do not permit the use of more than 25 to 50 percent RAP within the HMA mix design due to the inability of traditional batch and drum HMA plants to sufficiently heat the aggregate within the RAP to temperatures necessary to meet the minimum TSR specifications without forming excess smoke emissions and particulate matter which violates standard air permits. The HMA produced using LEAS production process meets or exceeds the min TSR specification for most states while using 100% RAP and produces virtually zero emissions or particulate matter.

Minimum TSR for Select State DOT Specifications	
TSR (Minimum)	States
85%	MS (with 1% lime)
80%	VA, OR, FL, AL, NM, OK, SD, IA, NY, GA, AR, MN
70%	CA, NV, MO, CO
60%	AZ
Hamburg Rut Test	TX, LA, UT

[0040] Several of the southern states have moved to the Hamburg Rut Test for a more robust measurement of durability of the HMA. Virgin asphalt cement had two primary chemical components, asphaltenes and maltenes. Asphaltenes are hard materials that provide the mechanical strength while maltenes are the oily fraction that functions as the sticky component in HMA. Maltenes oxidize with age or excess heat to form asphaltenes that causes the HMA to become hard and brittle. The aged or heat damaged HMA cracks under heavy loads causing failures of the road surface. The Hamburg Rut Test is performed using a wheel that passed over an HMA sample until the ensuing rut exceeds 12.5 millimeters in depth. Southern states, where summer paving temperatures can prematurely age the HMA, have been transitioning to the Hamburg Rut Test as a proxy measurement to ensure that the maltene fraction was not damaged during application. This test is an important benchmark for LEAS HMA as the asphalt cement within RAP has been aged, and traditional HMA using RAP is excess of 25 percent had a proclivity to fail early due to the relative lack of maltenes.

[0041] The graph in FIG. **11** shows the results for testing of two variations of the LEAS HMA.

[0042] LEAS Rut Test results far surpass Rut Test results for the best performing HMA product s, especially when you consider the RAP used was never designed for loading anywhere near this level (tensile<60).

[0043] The Green line represents material that was heated to 220 degrees; the purple line was heated to 290 degrees. Conventional Superpave HMA fails at 8500 passes, while the LEAS HMA exceeded 20,000 cycles in some cases without failure.

[0044] Opportunities for Hot in Place Recycling Using Microwave Technology Laboratory testing has shown that blending 100% recycled asphalt pavement (RAP) with 4-5% LEAS asphalt emulsion and heating it to 250-300 degrees Fahrenheit through the MLEHS can produce an asphalt product with equal or better materials properties than new hot-mix asphalt (HMA). The microwave MLEHS unit designed for use in the CIR paving train converts the process into an HMA processing train. The addition of heat will allow the CIR material to be placed at density similar to HMA and the performance results prove the finished surface will be comparable to or better than conventional HMA.

[0045] The MLEHS unit requires the addition of engineered emulsion rates from about 4-8% (5% in the CIR and up to 8% for the FDR) in the CIR or FDR injection process to produce high performance LEAS HMA. At 5% emulsion content, the cost would increase from $6.10/square yard (for CIR) to $9.00/square yard (HIR). It appears that the HIR using microwave technology for heating will be a cost effective alternative since the MLEHS heating can be applied for less than $6.50/square yard (equipment and energy costs).

[0046] Currently there are 8,616,200 lane miles of pavement in the United States, including 292,599 in the state of Minnesota. In Minnesota, 40% of those roadway miles are paved with asphalt, with 2% being concrete, and 58% having gravel or dirt surfacing. Statistics on the surfacing of all of the paved roadways in the US are not readily available, but if the percentage of surface types are similar to MN (a reasonable assumption) there are approximately 3,446,480 lane miles of asphalt surfaced roadways. The average life cycle for an asphalt pavement between rehabilitation is 20 years (5-12 years in high traffic volume urban environments and 15-30 years in residential and low traffic volume rural environments), meaning there is a potential market of approximately 175,000 lane miles per year (1,232,000,000 square yards) for pavement reclamation as a potential rehabilitation approach. The financial impact of pavement rehabilitation in-place providing performance of new HMA is staggering.

[0047] Emission testing shown below was performed for particulate and volatile organic carbon ("VOC") testing of the exhaust from an indoor LEHS system inside. The summary of which is included below.

Overview: Particulate and VOC air emission testing was conducted on a pilot scale asphalt plant on Dec. 18, 2012. Particulate emission testing was conducted according to EPA Method 5 and EPA Method 202. VOC emission testing was conducted in adherence with EPA Method 25A using a Total Hydrocarbon (THC) Analyzer. At the time of the emission test, the pilot scale asphalt plant was producing 10 Tons/Hour of asphalt.

A federal regulation (NSPS Subpart I) exists for particulate matter for all Hot Mix Asphalt Plants (MHA). Currently, there is not a federal regulatory limit for VOC; VOC emissions are compared to the EPA emission factors in the table below. Detailed test results can be found in Table 1 and Table 2 which are attached to this document.

Emission Unit Tested	Pollutant		Test Result
		Federal Standard	
Cirus Pilot Scale Asphalt Plant as Tested	Particulate Matters	≤0.04 Grains/DSCF	0.0006 Grains/DSCF
Cirus Asphalt Plant (Scaled up 8 times	Particulate Matters	≤0.04 Grains/DSCF	0.005 Grains/DSCF
		EPA Emission Factor	
Cirus Pilot Scale Asphalt Plant as Tested	VOC	0.440 Lbs/Hr[a,b]	0.026 Lbs/Hr[a]

[a]VOC is equivalent to the Total Eydrocarbon as Propane.

[b]This number represents the EPA emission factor for VOC emissions for a Drum Mix HMA running on natural gas.

TABLE 1

Summary of Asphalt Plant Particulate Test Results
Crius Corporation - Plymouth, Minnesota
AET #14-01235

Parameter	Run #1	Run #2	Run #3	Average
Particulate Matter (PM) Results				
Date	12/18/12	12/18/12	12/18/12	
Run Time	9.28-10.28	11.43-12.42	13.28-14.28	
Stack Temperature ° F.	62	71	70	68
Stack Oxygen, %	20.7	20.7	20.7	20.7
Stack Carbon Dioxide, %	0.2	0.2	0.2	0.2
Measure, %	2.3	3.0	2.1	1.5
Stack Flow Rate DSCFM	700	700	700	700
Isokinetic Variation, %	101.4	100.1	99.2	100.2
Filterable Particulate Emission Results				
Particulate Concentration grains/dscf.	0.0010	0.0064	0.0005	0.0006
Particulate Mass Rate Lbs/Hr.	0.0059	0.0025	0.0028	0.0037
Organic Condensible Emission Results				
Particulate Concentration grains/dscf.	0.0002	0.0003	0.0002	0.0002
Particulate Mass Rate Lbs/Hr.	0.0011	0.0016	0.0013	0.0013
Inorganic Condensible Emission Results				
Particulate Concentration grains/dscf.	0.0008	0.0008	0.0007	0.0008
Particulate Mass Rate Lbs/Hr.	0.0050	0.0046	0.0042	0.0046
Filterable + Organic Condensibles Emission Results				
Particulate Concentration grains/dscf.	0.0012	0.0007	0.0007	0.0008
Particulate Mass Rate Lbs/Hr.	0.0070	0.0041	0.0040	0.0050
Total Particulate Emission Results				
Particulate Concentration grains/dscf.	0.0020	0.0014	0.0014	0.0016
Particulate Mass Rate Lbs/Hr.	0.0119	0.0086	0.0082	0.0096

TABLE 2

Summary of Asphalt Plant VOC Emission Test Results
Crius Corporation - Plymouth, Minnesota
Dec. 18, 2012 - AET #14-01235

Run #1 9:29-10:28

Exhaust Location	Airflow rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
Asphalt Plant Oven Outlet	700	590	0.028	17.7	0.023

Run #2 11:42-12:41

Exhaust Location	Airflow rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
Asphalt Plant Oven Outlet	700	494	0.024	14.8	0.019

Run #3 13:28-14:27

Exhaust Location	Airflow rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
Asphalt Plant Oven Outlet	700	510	0.025	15.3	0.020

AVERAGE RUNS #1-3

Exhaust Location	Airflow rate SCFM	PPMv, Ave As Propane	Lbs/Hr As Propane	PPMv, Ave As Carbon	Lbs/Hr As Carbon
Asphalt Plant Oven Outlet	700	531	0.026	15.9	0.021

[0048] The pollution testing results indicate the LEAS plant will fall well below the required emission standards for HMA production. These results demonstrate that the LEAS plants are suitable for locations that are outside the reach of conventional HMA plants in most states due to pollution and air quality regulations.

[0049] While the foregoing written description of the invention enables one of ordinary skill to make and use what is considered presently to be the best mode thereof, those of ordinary skill will understand and appreciate the existence of variations, combinations, and equivalents of the specific embodiment, method, and examples herein. The invention should therefore not be limited by the above described embodiment, method, and examples, but by all embodiments and methods within the scope and spirit of the invention.

1. An mobile asphalt plant for producing a high performance hot mix asphalt product, comprising:

RAP material;

emulsion added to the RAP;

low energy microwave heating system for processing the RAP emulsion mix.

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