

Sept. 16, 1958

W. D. MacDONALD

2,852,418

METHOD FOR TREATING METAL BORINGS

Filed Feb. 20, 1956

2 Sheets-Sheet 1

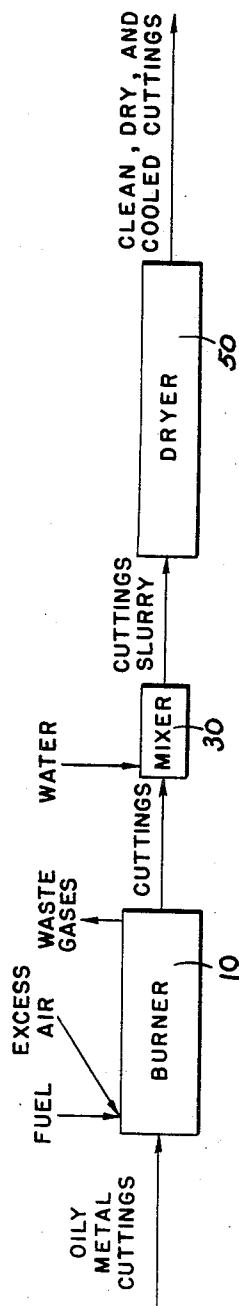


Fig. 1

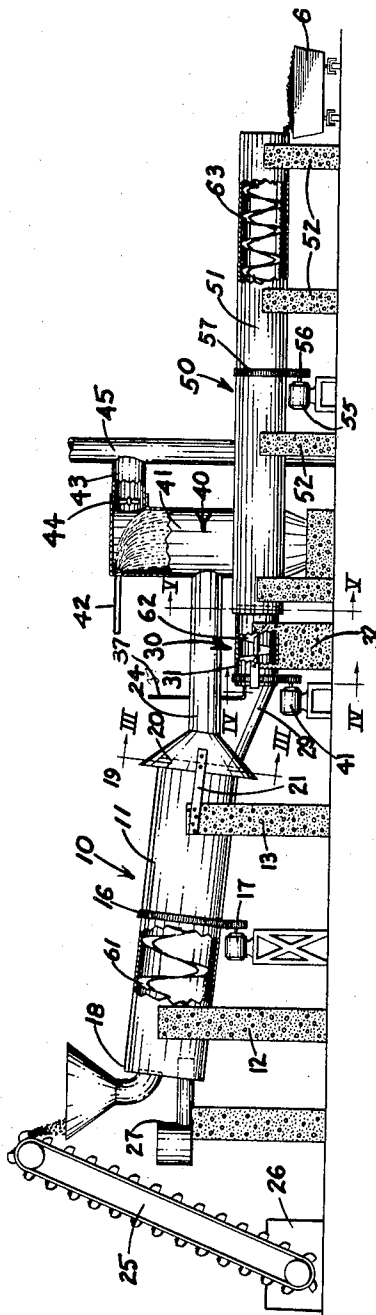


Fig. 2

INVENTOR.

Ward D. MacDonald
BY

BY

Lloyd A. Senevald

ATTORNEY

Sept. 16, 1958

W. D. MacDONALD

2,852,418

METHOD FOR TREATING METAL BORINGS

Filed Feb. 20, 1956

2 Sheets-Sheet 2

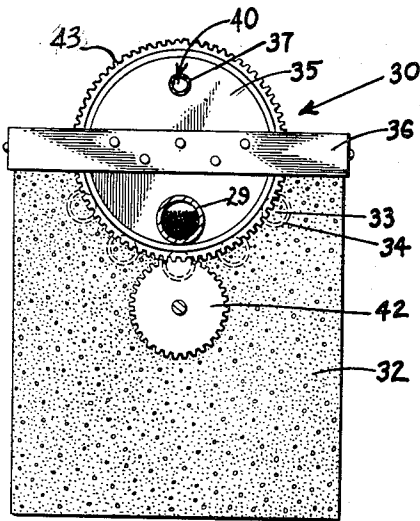


Fig. 4

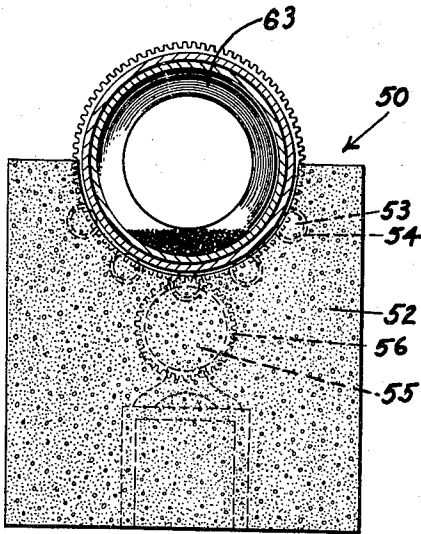


Fig. 5

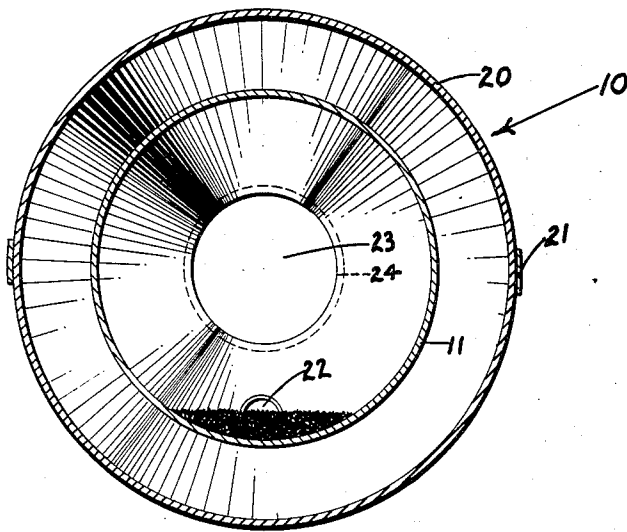


Fig. 3

INVENTOR.

Ward D. MacDonald

BY

Lloyd G. Zeneveld

ATTORNEY

1

2,852,418

METHOD FOR TREATING METAL BORINGS

Ward D. MacDonald, North Muskegon, Mich., assignor to Michigan Foundry Supply Company, Muskegon, Mich., a corporation of Michigan

Application February 20, 1956, Serial No. 566,458

11 Claims. (Cl. 134—2)

This invention relates to a method and means for treating metal borings. More particularly, this invention relates to a method and means for cleaning oily, metallic cuttings for use in making aniline or any other compound requiring clean iron particles.

Aniline ($C_6H_5NH_2$) is a parent substance for making dyes and other chemicals. It is made by the reduction of nitrobenzene with iron filings or borings, generically referred to herein as cuttings, with hydrochloric acid as a catalizer. This reduction process requires exceedingly clean iron cuttings. The source of such cuttings are foundries or other machine shops of which cuttings are a by-product from their boring, milling and other operations. In these operations, cooling and lubricating oils are used. This oil adheres to the cuttings, requiring the removal of same before the cuttings can be used in the aniline reduction process. This invention relates to the method and apparatus for cleaning this oil from the cuttings.

The only known method for cleaning such cuttings is to burn the oil therefrom and then cool the cuttings by passing them through a zone surrounded by a cooling jacket through which water or other coolant is circulated. This previous type method has been unsatisfactory for several reasons. First, the oil content of the cuttings produced by this method has been comparatively high, thus adversely influencing the effectiveness of the iron in the reduction process. These prior methods also have a relatively low production rate of three to five tons per hour. In passing through the cooling zone at the extreme temperatures of the cuttings, oxidation occurs, which also influences the effectiveness of the iron in the reduction process. Such oxidation also results in great losses of iron particles. Losses of iron particles, particularly the fines, is an unsatisfactory result from the high air currents passing through the cooling chambers.

Another disadvantage of previous methods is the required low oil content of the cuttings which can be handled by such methods. To my knowledge, other methods require less than 1% oil content. Apparently, this is due to the extreme temperatures required to burn off greater quantities, such temperature elevation requiring more fuel and more elaborate cooling equipment.

This invention is designed to avoid and eliminate these disadvantages of prior methods. Therefore, an object of this invention is to provide a faster method of cleaning oily cuttings.

Another object of this invention is to provide a method of cleaning oily cuttings in which the resultant product has a low oil content and very little oxide or corrosion.

Still another object of this invention is to provide a method of cleaning oily cuttings in which the loss due to oxidation and loss of fines is appreciably reduced.

A further object of this invention is to provide a method for cleaning oily cuttings which, under certain conditions, does not require any fuel except to start the method, thus making the process exothermic.

Other objects of this invention will become obvious

2

upon reading the following specification in conjunction with the accompanying drawings wherein:

Fig. 1 is a block diagram of my method schematically representing the various steps.

Fig. 2 is a side elevational view of my apparatus for carrying out the method.

Fig. 3 is an end view of the burner taken along the plane III—III of Fig. 2.

Fig. 4 is an end view of the mixer taken along the plane IV—IV of Fig. 2.

Fig. 5 is an end view of the dryer taken along the plane V—V of Fig. 2.

Briefly, this invention is concerned with a method and apparatus for cleaning oily, metallic cuttings. The method consists of the steps of burning the oil from the cuttings and mixing water with the cuttings after the oil has been burned therefrom. This mixture of water and cuttings is then passed through a dry zone, the cuttings being almost entirely cooled by the evaporation of the water. Thus, the heat removed from the cuttings is substantially equal to the heat of vaporization required by the water. The apparatus for performing this method comprises a burner having means for burning the oil from the cuttings as they pass therethrough. A mixer is provided for mixing water with the cuttings. The mixer passes the mixture of water and cuttings to a dryer where the cuttings are dried by evaporation of the water from the cuttings.

The method of this invention as schematically illustrated by Fig. 1 comprises three main steps—burning of oil from the cuttings; mixing the hot cuttings with a predetermined amount of water; and then cooling and drying the cuttings by the evaporation of the water therefrom.

In accordance with a broader aspect of this invention, the oil is burned from the cuttings by any conventional method. It is important that substantially all of the oil be evaporated from the cuttings and burned. To accomplish this purpose, I have found that the operating temperature of the burner should indicate from 700 to 1200 degrees F. In the conventional method, the burner is fired by fuel such as gas, oil, or other hydrocarbon fuels. In passing the oily cuttings through the burner, the cuttings themselves should normally reach a temperature of 800 to 1100 degrees F., at which temperature substantially all of the oil is evaporated from the cuttings and burned into waste gases.

Although conventional methods of burning the oil from the cuttings are used in a broader aspect of this invention, I have found that for certain oil-water ratio conditions a much improved result is obtained by my preferred and novel method of initial auxiliary firing of the furnace by the addition of hydrocarbon fuel but eventually causing self-firing by the oil on the cuttings by passing excess oxygen and sufficient cuttings through the burner to provide enough fuel for firing the process. In order to accomplish this, I draw excess air through the burner supplying it with additional oxygen for completing the combustion of the oil.

In conventional burners of the size comparable to that of this invention, passing more than five tons of oily cuttings through the burner is extremely hazardous due to the large quantities of stored combustible material accumulating in the burner. These excess quantities of combustible materials, in the form of smoke, gases and suspended liquid hydrocarbons, frequently cause explosions. I have found that when excess oxygen is supplied to the burner this hazard is eliminated. In certain conditions of low water content and high oil content such excess oxygen provides a self-firing, exothermic process requiring no additional fuel except that necessary for initially

starting the process. The excess oxygen permits passing cuttings of high oil content, and greater quantities of such cuttings through the burner with resultant greater quantities of oil being burned from the cuttings. My apparatus will process cuttings of any oil content, whereas the older apparatus require cuttings having 1% or less oil. The oil content range of the cuttings resulting from my invention is from 0 to 0.005%. My method can handle fifteen tons per hour of cuttings as compared to three to five tons per hour in old methods.

By supplying excess oxygen as used herein, is meant the supplying of oxygen in quantities greater than that normally occurring in the burner. Therefore, forcing or drawing excess air through the burner supplies excess oxygen. Pure oxygen or oxygen in various degrees of concentration in a particular gas is satisfactory but cost prohibitive. This additional air can be injected or drawn into the burner at the front of the burner, at several points or any suitable location which proves to be successful in causing more complete combustion of the oil on the cuttings. In my preferred form, the excess air is injected or withdrawn at the inlet end of the burner.

The next step after the oil has been burned from the cuttings is to mix the cuttings with water. The amount of water mixed with the cuttings is extremely important. The optimum quantity is that which when evaporated by the heat in the cuttings will cool the cuttings to the desired temperature.

It is well-known that the B. t. u.'s of heat required to evaporate water is equal to the heat required to raise the water to 212 degrees F. plus that required to evaporate the water. This can be expressed as follows:

$$Q = m_w c_w t_w + m_w L_w$$

where Q = total quantity of heat; m_w = mass of water; L_w = the heat of vaporization of water; c_w = thermal capacity of water; and t_w = temperature change of the water in rising to 212 degrees F. L_w = 970 B. t. u.'s per pound and c_w = 1 B. t. u. per pound.

This formula, disregarding the effect of the ambient air, gives the quantity of heat required to evaporate a certain mass of water. Accordingly, if the quantity of heat present in the cuttings is known, the amount of water which the cuttings are capable of evaporating can be resolved.

The quantity of heat present in the cuttings is expressed by the following formula:

$$Q_c = m_c c_c t_c$$

In this formula Q_c = the quantity of heat present in the iron cuttings; m_c = mass of cuttings; c_c = the thermal capacity of the iron cuttings; and t_c = the drop in temperature of the cuttings.

Disregarding the very small effect which the ambient air has on the cooling of the cuttings, in the preferred form of the method of this invention the heat required to evaporate the water is equal to the heat lost by the cuttings. Thus, $Q_w = Q_c$ and $m_w L_w + m_w c_w t_w = m_c c_c t_c$. Accordingly,

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

Utilizing this formula and knowing the value of the factors therein, the mass of the water can be determined. It is this mass of water upon which the optimum amount to be mixed with the cuttings is determined in accordance with the preferred form of this invention. A hypothetical problem will illustrate the procedure for determining this amount of water.

Suppose 100 lbs. of cuttings leave the burner and enter the mixer at 1000 degrees F. and the water mixed with the cuttings is at 60 degrees F. Also suppose the desired resultant temperature of the cuttings is 100 degrees F. The thermal capacities of water (c_w) and iron (c_c) are 1 and .15, respectively. The heat of vaporization L_w for

water is 970 B. t. u. per pound. Neglecting the effect of the ambient air, the formula would read as follows:

$$m_w = \frac{100 \times 9.15 \times (1000 - 100)}{970 + (212 - 60)}$$

$$m_w = 12 + \text{lbs.}$$

In accordance with this calculation, 12 pounds of water is added to each 100 pounds of cuttings as they enter the mixer at 1000 degrees F.

Obviously, the ambient air has some effect upon cooling the cuttings. The extent of such effect is very difficult to determine or predict. This cooling effect of the ambient air will decrease the amount of water required to cool the cuttings by the evaporation thereof and accordingly the quantity of water to be mixed with the cuttings may fall somewhat below the quantity as determined by the above procedure. On the other hand, other ambient conditions such as the humidity, temperature, etc. may have the opposite effect of requiring more water than that determined by the above formula. Therefore, it should be understood that in accordance with the preferred form of this invention, the percentage of water to the weight of cuttings may vary at least 25% more or less than the amount determined by the above formula. The quantity of water added to the cuttings in the above hypothetical case would then lie within the limits of 9 to 15 pounds of water per 100 pounds of cuttings.

This mixture of water and cuttings has the consistency of mortar. It will stand alone but is still wet. Thus, the entire cuttings are surrounded by particles of water and in the drying step the water withdraws the heat from the cuttings as it evaporates.

Although in the preferred form of this invention the amount of water to be added to the cuttings is 25% more or less than the greatest amount of water that the cuttings will evaporate as determined by the above formula, I have found that less satisfactory results, but better results than that obtained by previous types methods, is obtained by mixing with the cuttings water in quantities outside this preferred range. It should be understood, however, that in all aspects of this invention the cuttings are cooled by some heat of vaporization. Water added to the cuttings in quantities greater than the preferred range must be less than the amount which by thermal capacity alone will cool the cuttings to a temperature of 100 degrees F. This upper limit is easily determined by the following formula:

$$Q_w = m_w c_w t_w \quad Q_c = m_c c_c t_c$$

or

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

Substituting the above hypothetical values for the factor in this formula, m_w becomes equal to:

$$m_w = \frac{100 \times .15 \times (1000 - 100)}{1 \times 40} = 338 \text{ lbs.}$$

In this hypothetical case, 338 pounds of water will absorb the heat in the cuttings solely by its thermal capacity. Thus, it should be evident that a quantity less than 338 pounds requires some cooling of the cuttings by heat of evaporation.

The advantage of adding less than this amount of water is that less additional heat is required to dry the cuttings. The extreme case is the preferred or optimum quantity of water wherein the raising the water to 212 degrees F. and evaporating it utilizes all of the excess heat content of the cuttings, thus requiring no additional heat to dry the cuttings. The exact amount of water within the broad range depends upon the additional heat available at the operation site. For example, excess heat may be available for drying the cuttings, in which case it may be advantageous to cool the cuttings more quickly by adding more water and then drying the cuttings of that water which is not evaporated by the heat of the cuttings. The flue gases from the burner could probably be used for this

purpose. In any event it should be realized that sufficient additional excess heat is practically never available for evaporating all the water mixed with the cuttings. The heat in the cuttings usually evaporates most of the water. As a result, rarely, if ever, is it feasible to mix with the cuttings a quantity of water which will almost entirely absorb the heat in the cuttings by its thermal capacity alone. In most cases, it is advisable to use water in quantities falling within the optimum range of limits as previously described.

The cuttings ultimately produced by the method of this invention are cooled to a temperature of 100 degrees F. At temperatures exceeding 100 degrees F., the cuttings are subjected to oxidation which adversely influences the effectiveness of the cuttings for use in the aniline reduction process. In some cases, the temperatures of the cuttings can be 200 degrees F. But preferably should not exceed that temperature.

The temperature of the water, of course, has a great effect upon the amount of water added to the cuttings. This temperature is taken into account in the above formulas and thus the amount of water will change accordingly. The higher the temperature, the more water required and the lower the temperature the less water required.

The temperature of the cuttings also has an effect upon the amount of water required. This effect is reflected in the above formulas and should be evident therefrom. Considering the hypothetical case set up above, in accordance with the broadest aspect of this invention, water should be added to 100 lbs. of cuttings in quantities less than 338 pounds. In the preferred and narrow aspect of this invention, the amount of water added would lie in the range of 9 to 15 pounds per 100 pounds of cuttings. In such hypothetical case, this invention also covers all quantities of water from 9.0 to 338 pounds per 100 pounds of cuttings.

The cooling and drying step is very simple and can be accomplished by several means. The purpose of this step is to expose the cuttings to the ambient air so that the water is permitted to evaporate therefrom. This is preferably accomplished without supplying any additional heat or high air currents. The cuttings are merely agitated to expose them to the air. My preferred amount of water added to the cuttings makes this possible.

On the other hand, it is conceivable that if an additional supply of heat is available the water content can be increased and the additional heat supply utilized for helping to evaporate the water from the cuttings. It is preferred, however, that the evaporation be accomplished entirely by the cuttings rather than by any additional heat. It is believed that applying additional heat will result in greater oxidation of the cuttings thus adversely influencing the effectiveness of the cuttings for use in the aniline reduction process. Using high air currents results in loss of fines which become entrained in such currents.

Apparatus

Apparatus for performing the above operations is shown in Figs. 2, 3, 4 and 5. The burner 10, in this preferred apparatus, is a cylindrical drum. This drum 11, is inclined at an angle. It is supported by two cradles 12 and 13. The drum 11 has helical fins 61 extending throughout the entire length thereof for transferring cuttings inserted at one end to the other end. The drum is rotatably mounted on the cradles or pillars 12 and 13 by roller bearings mounted in bronze liners. The cradles as shown are constructed of concrete but any type of cradle can be substituted therefore without departing from the scope of this invention.

The mechanism for rotating the cradle includes a gear ring 16 secured to the outer circumference of the drum 11. The gear ring is fixed to the drum and driven by a gear motor arrangement 17.

The top end 18 of drum 11 is open. The bottom end 19 is closed by a funnel 20 (Fig. 3) secured to the cradle

13 by the straps 21. The funnel 20 has an opening 22 at its bottom through which the cuttings pass, by means of chute 29, from the burner to the mixer. It also has an opening 23 communicating with the waste fume stack 24. The funnel 20, waste fume stack 24, and chute 29 are held stationary by straps 21 while the drum 11 rotates.

At the open end 18, a conveyor 25 is provided for carrying the cuttings from a container 26 into the drum 11. A burner unit 27 extends into the end 18 to facilitate the burning or flashing of the oil as the cuttings pass through the burner.

The fume stack 24 leads to a separator or purifier 40, such as a multi-wash unit which is adapted to wash the waste gases removing any harmful or odorous gases. The unit 40 is conventional, consisting of a cylinder or stack 41, having a water inlet 42 and a waste outlet 43 at its top. The outlet 43 has a fan 44 therein which is sufficiently large to draw air through burner 10, stack 24, and cylinder 41. The fan in this apparatus creates the draft through the burner 10, such draft providing the excess air which is so essential in a preferred form of this invention as previously described. The fan 44 also disperses the water throughout the cylinder 41 so that the water can work effectively in removing the undesirable gases.

Fan 44 can be replaced by an air injector at the end 18 of drum 10, such injector would provide the necessary excess air. In such case, a spray nozzle would be located at the water inlet 42 for spraying and dispersing the water throughout cylinder 41. An exhaust stack 45 communicates with the outlet 43 for carrying the fumes into the air streams normally occurring in the atmosphere.

The mixer 30 is constructed of a cylinder drum 31 freely rotatable on the cradle 32 in substantially the same manner as the burner 10. The drum 31 extends into the dryer 50 and is concentric therewith. Mixer 30 rotates on the roller bearings 33 which are in turn rotatably mounted in the bronze liners 34 (Fig. 4). The cylinder 31 has helical fins 62 at its inner surface for transferring the mixture of cuttings and the water from one end to the other. The receiving end of the cylinder 31 is closed by the plate 35 which is held stationary in respect to the cylinder 31 by the straps 36 secured to the cradle 32. Plate 35 has an opening 40 for the water supply pipe 37 and an opening communicating with the chute 29 extending to the burner 10. The plate 35, supply pipe 37, and chute 39 are all held stationary by straps 36 as the drum 31 rotates. The drum 31 is driven by motor 41, gear 42, and gear ring 43 (Figs. 2 and 4).

The dryer 50 is of substantially the same design as the mixer 30 and burner 10. It is a long, cylindrical, hollow member having helical fins 63 on its inner surface for transferring the cuttings from one end to the other. The cylinder 51 is supported by several cradle-like supports 52 having the roller bearings 53 and bronze liners 54 (Fig. 5). The cylinder 51 is driven by a motor 55 through the driving gear 56 and a ring gear 57 secured rigidly and fixedly to the outer circumference of the cylinder 51. The cylinder 51 is open at both ends. The mixer 30 extends into its receiving end so that the cuttings pass directly into dryer 50. The dispensing end is adapted to dispense the cuttings into a cart 60 or any other type conveying means.

In the preferred form of this invention, no exterior heat is applied to the dryer 50 and no high air currents are blown through the dryer. The drying is accomplished entirely by exposing the wet cuttings to the ambient air, thus causing the water on the cuttings to evaporate and withdraw heat from the cuttings.

In its broadest aspect, it may be desirable when more water is used than that contemplated by my preferred form of this invention to pass the hot waste gases from the burner around the dryer, either in the form of a coil or a jacket surrounding the dryer. This additional heat would facilitate the drying of the chips if the contents

of the cuttings were not sufficient to evaporate all the water. It should be understood that such practice is only contemplated within the broadest aspect of this invention and that within the preferred aspects the evaporation of the water on the cuttings is accomplished substantially entirely by the heat of vaporization.

The burner 10, mixer 30, and dryer 50, as illustrated, are different sizes. Burner 10 has a 42 inch diameter and 14 foot length. Good results are obtained by running it at 15 R. P. M.'s which carries the cuttings through the burner in 1 minute and 15 seconds. The mixer 30 is 3 feet long and 24 inches in diameter. It rotates at 60 R. P. M.'s, thus carrying the cuttings through it in 5 seconds. The dryer 50 is 30 feet long and 36 inches in diameter. The cuttings are carried through it in 1 minute and 17 seconds as it rotates at 26 R. P. M.'s.

It should be understood, that although specific sizes and speeds of all these units have been given, that such sizes are not necessarily critical. Various different sizes and speeds can be used depending upon various conditions, including the amount of water and oil in cuttings and the desired capacity. For example, the burner may be made longer if requiring a longer time to burn the oil from the cuttings. This, of course depends upon the oil content of the cuttings and the temperature of the burner. Increase or decrease in the size of the burner may necessitate changing the size of the mixer and the dryer. The dryer's size may be changed in accordance with the time required to dry the cuttings, which depends entirely upon the water content of the cuttings and water mixture.

Operation

The operation of this apparatus is simple. First, the motors for driving the burner, the mixer and the dryer are set into operation, thus rotating the various units. Then the flame from burner nozzle, the excess air, and the cuttings are all simultaneously fed into the burner at the receiving open end 18. As the cuttings are introduced into the receiving end 18 of the burner 10, the heating flame from the heater unit 27 is applied to raise the temperature of the chips. At the same time, excess air is drawn into the burner. This forms a strong draft through the drum and also provides excess oxygen for facilitating a more complete combustion of the oil. I have found that with this apparatus, if more than 5 tons per hour of chips are passed through the drum and the oil content is high and the water content low, the heating flame is only necessary during the initial burning process. Thereafter, the oil on the chips furnishes enough fuel to sustain the temperature for flashing or burning of the oil from the cuttings. This is especially made possible by the excess air.

As the chips pass through the drum 11, the heat in the drum causes all the oil to vaporize and to ignite in the presence of the excess air. Thus, the oil burns to clear waste products such as carbon dioxide, carbon monoxide and water vapor. These fumes are drawn through the fume stack 24 and then passed through the unit 40. The water injected at inlet 42 is dispersed throughout cylinder 41 cleaning the fumes as they pass upwardly and the water spray falls downwardly. The gas is drawn into and blown out of the exhaust stack 45 by fan 44.

As stated previously, it is conceivable that these gases which are at rather high temperatures can be used for supplying excess heat to the dryer 50. In the preferred form of this invention, however, these waste gases are merely discarded.

The cuttings, as they pass through the burner, are transferred to the dispensing end 19 by the rotation of the drum 11 and the helical fins 61. The fins 61, also agitate the chips thus exposing the oil for evaporation and burning. The inclination of the burner 10 also helps to transfer the cuttings from the receiving end to the dispensing end.

The cuttings 19, after all the oil has been burned off,

pass through the chute 29 into the mixer 30. The cuttings at that time are at a temperature of approximately 800 to 1200 degrees F. At this temperature, the cuttings are subject to oxidation, which is commonly referred to as rusting or corrosion. Thus cooling such cuttings in the ambient air would have a deleterious effect upon the cuttings for use in the aniline reduction process. In accordance with this invention, the cuttings and the water are introduced simultaneously into the receiving end of the mixer 30. Water can be sprayed either at such entrance or at the intermediate part, depending upon the various circumstances. The percentage by weight of water to cuttings is that previously discussed. In the preferred form of this invention, such ratio is calculated in accordance with the formula

$$m_w = \frac{m_c c \Delta t_c}{L_w + c_w t_w}$$

Twenty-five percent more or less of this quantity is the preferred amount of water to be mixed with the cuttings. In the broadest aspect of this invention, the water should not exceed the amount required to cool the cuttings by thermal capacity of the water alone. Thus, the amount of water should not exceed a quantity determined by the formula

$$m_w = \frac{m_c c \Delta t_c}{c_w t_w}$$

The water mixed with the cuttings results in a mixture which has the consistency of mortar. During the mixing step, inherently some of the water is evaporated, resulting in the lowering of the temperature of the cuttings. Also the cutting's temperature is lowered due to the thermal capacity of the water which rises to 212 degrees F. before evaporating. This entire mixing process takes about 5 seconds.

The mixture of slurry of cuttings and water passes into the dryer 50. The dryer 50 transfers the cuttings from the receiving end to the dispensing end. During such transfer the drum 51 constantly rotates and agitates the cuttings, exposing them to the ambient air. The chips or cuttings dry by evaporating the water thereon. The entire drying process takes about 1 minute, 17 seconds.

At the exit or dispensing end of the drum 51, a cart 60 or other conveyance means is located for catching the cuttings which are then transferred to loading spot for packing into boxes or other containers ready for shipment.

In operating the above described apparatus, the water required to cool a definite amount of cuttings to 100 degrees F. was measured. It was determined that 172 pounds of water was required to cool 2000 pounds of cuttings whose temperature at the exit of burner 10 varied from 880-1020 degrees F. (930.45 degrees F. average). The temperature of the water mixed with the cuttings was 40 degrees F. and the ambient temperature 22 degrees F.

In accordance with the above formula the following quantity of water is required:

$$\begin{aligned} m_w &= \frac{m_c c \Delta t_c}{L_w + c_w t_w} \\ &= \frac{200 \times .15 \times (930 - 100)}{970 + (212 - 40)} \\ &= \frac{249000}{1142} \\ &= 218 \text{ lbs. of water} \end{aligned}$$

It should be evident that the exact amount of water required in practice is 21% less than that theoretically required. This difference is explainable because of the cooling effected by the 22 degrees F. ambient air and other conditions. The practical amount required does, however, fall within the broad and narrow limits of this invention.

With this method and apparatus, I have found that I

can more than triple the output of conventional methods for cleaning cuttings. My process and apparatus is also much less expensive and complicated than other type apparatuses in which the cuttings are cooled by a cooler jacket.

With my method and apparatus, the loss due to oxidation and loss of fines is also greatly reduced. In older methods, 12% and above losses are very common while in my method and apparatus loss is reduced to below 8%. This is due probably to the reduction in oxidation and also due to the reduction in loss of fines resulting from high velocity air currents being injected through the cooling chambers. Usually the velocity of such air currents exceeds the entraining velocity of the bulk of the fines, thus the currents carry the fines out of the cooling chamber, resulting in the loss of such fines. In my method, and apparatus, I do not pass a high velocity air current through the drying chamber. The entire drying process is accomplished with the normal air running through such chamber. This is made possible by cooling the cuttings by the heat of vaporization of the water rather than having the air itself dry and cool the cuttings.

My invention also is more economical when the original oil content is high and water content low because after it is started, it does not require any additional fuel or flame for sustaining the process. In such cases, above 5 tons per hour, the oil content of the normal cuttings passing through the burner is sufficient to fire the process, thus eliminating the need for any additional fuel such as oil or gas.

My invention under the right conditions is thus a self-firing exothermal process rather than an endothermic process. This is made possible due to the capacity of the unit which can handle 5 tons per hour of high oil content cuttings and also due to the forcing of excess air through the burner, resulting in more complete combustion. In conventional burners, passing more than 5 tons per hour through them would be very hazardous because of the explosion possibilities.

It should be evident that my invention, both as to the method and apparatus, is entirely new and has many advantages over other methods and apparatuses for cleaning cuttings. It should be understood that although I have described preferred method and apparatus for obtaining these new results, other equivalent structures and methods can be used without departing from the scope of this invention. Therefore, all such equivalent forms will be considered within the scope of this invention unless expressly excluded by the appended claims.

I claim:

1. A method for cleaning oily metallic cuttings comprising the steps of burning said oil from said cuttings; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings being sufficient to prevent instantaneous evaporation of all of said water and less than that required to cool said cuttings to a temperature of 100° F. solely by the thermal capacity of said water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, c_w =thermal capacity of water, and t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

2. A method for cleaning oily metallic cuttings comprising the steps of burning said oil from said cuttings; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings lying within certain limits, the upper limit being that amount required to cool said cuttings to a temperature of

100° F. solely by the thermal capacity of said water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

and the lower limit being 25% less than that amount required to cool said cuttings to a temperature of 100° F. by the thermal capacity and heat of vaporization of the water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

3. A method for cleaning oily metallic cuttings comprising the steps of burning said oil from said cuttings; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings lying within certain limits, the lower limit being a sufficient amount to prevent instantaneous evaporation of all of said water, the upper limit being 25% more than the amount required to cool said cuttings to a temperature of 100° F. by the thermal capacity and heat of vaporization of the water as determined by the formula:

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

4. A method for cleaning oily metallic cuttings comprising the steps of burning said oil from said cuttings; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings lying within the range extending from 25% more than to 25% less than the greatest amount of water that the quantity of heat in said cuttings will raise to 212° F. and then evaporate as determined by the formula:

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture through a drying zone having no heat other than the ambient air thereby causing said water to evaporate and withdraw heat from said cuttings.

5. A method for cleaning oily metallic cuttings comprising the steps of igniting and burning said oil from said cuttings; simultaneously causing excess air to pass into the vicinity of said ignited oil on said cuttings thereby supplying oxygen in greater concentration than that normally occurring in the ambient air; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings being sufficient to prevent instantaneous evaporation of all of said water and less than that required to cool said cuttings to a temperature of 100° F. solely by the thermal capacity of said water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature

of cuttings, c_w =thermal capacity of water, and t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

6. A method for cleaning oily metallic cuttings comprising the steps of igniting and burning said oil from said cuttings; simultaneously causing excess air to pass into the vicinity of said ignited oil on said cuttings thereby supplying oxygen in greater concentration than that normally occurring in the ambient air; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings lying within a certain limit, the lower limit being an amount sufficient to prevent instantaneous evaporation of all of said water the upper limit being 25% more than the amount required to cool said cuttings to a temperature of 100° F. by the thermal capacity and heat of vaporization of the water as determined by the formula:

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

7. A method for cleaning oily metallic cuttings comprising the steps of igniting and burning said oil from said cuttings; simultaneously causing excess air to pass into the vicinity of said ignited oil on said cuttings thereby supplying oxygen in greater concentration than that normally occurring in the ambient air; mixing water with said cuttings after said oil has been burned off; the amount of said water mixed with said cuttings lying within the range extending from 25% more than to 25% less than the greatest amount of water that the quantity of heat in said cuttings will raise to 212° F. and then evaporate as determined by the formula:

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture through a drying zone having no heat other than the ambient air thereby causing said water to evaporate and withdraw heat from said cuttings.

8. In a method of cleaning metallic cuttings in which the cuttings are raised to a high temperature, and then cooled, the improvement in cooling said cuttings comprising the steps of: mixing water with said cuttings after they are cleaned; the amount of said water mixed with said cuttings being sufficient to prevent instantaneous evaporation of all of said water and less than that required to cool said cuttings to a temperature of 100° F. solely by the thermal capacity of said water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, c_w =thermal capacity of water, and t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

9. In a method of cleaning metallic cuttings in which the cuttings are raised to a high temperature and then

cooled, the improvement in cooling said cuttings comprising the steps of: mixing water with said cuttings after they are cleaned; the amount of said water mixed with said cuttings lying within certain limits, the upper limit being that amount required to cool said cuttings to a temperature of 100° F. solely by the thermal capacity of said water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{c_w t_w}$$

and the lower limit being 25% less than that amount required to cool said cuttings to a temperature of 100° F. by the thermal capacity and heat of vaporization of the water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

10. In a method of cleaning metallic cuttings in which the cuttings are raised to a high temperature and then cooled, the improvement in cooling said cuttings comprising the steps of: mixing water with said cuttings after they are cleaned; the amount of said water mixed with said cuttings lying within certain limits, the lower limit being an amount sufficient to prevent instantaneous evaporation of all of said water, the upper limit being 25% more than the amount required to cool said cuttings to a temperature of 100° F. by the thermal capacity and heat of vaporization of the water as determined by the formula

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture of water and cuttings through a drying zone thereby causing said water to evaporate and withdraw heat from said cuttings.

11. In a method of cleaning metallic cuttings in which the cuttings are raised to a high temperature and then cooled, the improvement in cooling said cuttings comprising the steps of: mixing water with said cuttings after they are cleaned; the amount of said water mixed with said cuttings lying within the range extending from 25% more than to 25% less than the greatest amount of water that the quantity of heat in said cuttings will raise to 212° F. and then evaporate as determined by the formula

$$m_w = \frac{m_c c_c t_c}{L_w + c_w t_w}$$

wherein m_w =mass of water, m_c =mass of cuttings, c_c =thermal capacity of cuttings, t_c =drop in temperature of cuttings, L_w =heat of vaporization of water, c_w =thermal capacity of water, t_w =temperature change of water in rising to 212° F.; passing said mixture through a drying zone having no heat other than the ambient air thereby causing said water to evaporate and withdraw heat from said cuttings.

References Cited in the file of this patent

UNITED STATES PATENTS

1,383,418	Needham	July 5, 1921
1,580,723	Hapgood	Apr. 13, 1926
2,357,695	Skowron	Sept. 5, 1944
2,538,057	Steele	Jan. 16, 1951

UNITED STATES PATENT OFFICE
Certificate of Correction

Patent No. 2,852,418

September 16, 1958

Ward D. MacDonald

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, lines 33 and 34, for "Q=" read $Q_w =$; column 8, line 62, for "200×" read 2000×.

Signed and sealed this 10th day of March 1959.

[SEAL]

Attest:

KARL H. AXLINE,
Attesting Officer.

ROBERT C. WATSON,
Commissioner of Patents.