DIAMOND BLADE GRINDING AS A MEANS FOR REMOVING SURFACE CONTAMINATION FROM CONCRETE

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The use of a highway grinding unit for the decontamination of a 5,000 square foot surface is described. The type of equipment presently in use is described. Performance characteristics, waste collection and water usage are commented on. Variables in blade design are discussed. Feasibility of the grinding technique for water soluble contaminants and vertical surfaces is referred to.

INTRODUCTION

In the process of decontaminating a depleted uranium manufacturing facility, a considerable area of blacktop was found to have a contaminated surface layer. The blacktop, approximately 5,000 square feet, adjoined a building in which depleted uranium was the stock used in a manufacturing process. As a result of a decision to relocate and expand the manufacturing operation, the facility had to be inspected for agency compliance. The inspection revealed widespread contamination throughout the main manufacturing building as well as the surrounding blacktop area. With respect to the blacktop area, the problem was viewed as finding a suitable method for the removal of a surface layer of approximately 1/8" thickness in order to render the area suitable for unconditional release. The level of contamination was low (approximately 10,000 - 20,000 DPM per 100 square centimeters) but above acceptable levels.

A description of the project emphasizing the blacktop problem was presented to the Penhall Company. Penhall, with over 20 years experience in the sawing, breaking, and grinding of concrete, was requested, to study the problem and recommend a solution. The recommendation was to apply a diamond blade grinding procedure to the blacktop. This process was identical to the grinding process which Penhall had perfected in the removal of approximately 9,000,000 square feet of highway and freeway surfaces.

In the subject case the surface was successfully removed by the grinding operation. The generated swarf was picked up by a vacuum system attached to the unit and pumped to a water tank truck. The moist swarf was removed from the tank truck, allowed to dry and transferred to 55 gallon drums for shipment to a burial site.

Subsequent radioactivity surveys demonstrated that the remaining blacktop was within acceptable levels for unconditional release.

BACKGROUND

The removal of vast amounts of concrete pavement using diamond saw blades dates back to the early 1960's when the process of highway grooving proved to be highly effective in reducing the number of wet pavement accidents on California freeways. In the years since, hundreds of miles of freeway pavement have been grooved in the Los Angeles area alone. Although the initial costs for blades are high, grooving with diamond saw blades is the only known method by which this process can be done economically.

By the mid 1970's, the process known as highway "grinding" became an economically feasible method for rehabilitating old, bumpy sections of highway, which process might be described as grooving with diamond blades spaced very closely together.

The working "head" of a grinding machine is a spindle on which as many as 250 diamond blades are mounted, and the blade assembly may be up to 4 feet wide. The amount of concrete removed from the surface of a highway, of course, depends on the degree of roughness. Often it is necessary to grind away the surface to depths of over one inch, and this normally requires two or more passes with the diamond head. A single head of blades will remove from 30,000 to 100,000 square yards of highway surface, depending on the hardness and abrasiveness of the concrete mixture and one machine will typically resurface about 3,000 square yards per 8-hour shift (about 1/2 mile of a 12-foot wide lane).

The grinding unit used on the subject project weighed 16,000 lbs. and was powered by a 225 h.p. turbo-charged diesel engine. It was hauled on a three axle truck equipped with a tilting and rollback bed for ease in loading and unloading. A 38" wide cutting head was used.

Technical Discussion

Highway grinding machines are built for rigidity - the ability to deliver maximum horsepower and torque to the heavy blade spindle so as to produce an even profile on the highway surface. The tractor engines used (usually diesel) will generate up to 300 horsepower at about 2,000 rpm. The blade spindle rpm is varied with interchangeable pulleys, and is most often rotated in the direction counter to direction of forward motion to produce a condition known as "up-cutting". The thrust of up-cutting tends to drive the blades down into the pavement thus making it easier to maintain level cutting.

The critical elements in a grinding process includes diamond blade selection, collection system and water control.

The diamond blades (12 to 14 inch diameter) are essentially alloy steel disks on which are mounted diamond-bearing composite "segments" carefully formulated from mixtures of industrial diamond particles and metal powders. The diamond/metal powder mixtures are molded under heat and pressure to produce dense composite "segments" subsequently silver brazed onto the steel disks. Each blade will contain from 16 to 20 segments. The diamond particles may be either natural "mined" diamond or they may be synthesized, the latter of which are generally stronger due to the lesser amounts of defects in the crystals. In both cases, the particle sizes used range from 20 down to 60 U.S. Mesh.

The proprietary metal alloys used to hold the diamonds in place are known as "bonds" and these can be tailored to the properties of the concrete being ground - a bond suitable for grinding high strength concrete containing very hard aggregates would not necessarily be suitable for low strength concrete containing soft aggregate and vice versa. For this reason, it is highly desirable to know as much as possible about the properties of the concrete in advance of the job. Some of the more important properties to be sought out in advance are:

1. Hardness, size, and soundness of the aggregate.
2. Composition, size, and shape of the sand particles used in the mix.

3. Compressive strength of the concrete mix in the present state of cure. (Compressive strength tests can be performed non-destructively on the job site.)

From these data, the blades can be formulated so as to optimize the grinding process in terms of blade wear and cutting rates and, hence, give the lowest overall costs.

The cooling and waste collection systems are of particular concern for contemplated uses in decontamination. The entire grinding head is enclosed in a vacuum hood which fits closely over the blades. Rubber seals fitted around the hood are in contact with the pavement surface at all times.

An 8,000 gallon capacity water tanker truck supplies cooling water for the blades. The water is pumped from the tanker by means of a centrifugal pump and the blades are wetted through a spray bar at a rate of approximately 50 gpm.

During the grinding operation, an impeller vacuum pump which is mounted on the grinding unit pulls the swarf and returning cooling water into a collection box which is also mounted on the unit. Within this collection tank, the difference in density between the air and water is utilized to separate the two. The air is exhausted to ambient while the water and solids are drawn out of the bottom of the collection tank. A centrifugal pump then transfers the swarf and water back to the tanker truck which is equipped with baffled and filtered compartments. The solids settle out in the forward tanks and the clean water is recirculated back to the grinding unit. The efficiency of the entire vacuum system is such that the pavement surface after grinding has the appearance of being damp-mopped. Within a few minutes, the pavement surface is completely dry.

In routine highway grinding operations approximately 4,000 gallons of water is utilized in the recirculation process. By the end of an 8-hour work shift, there are typically 11 tons of swarf in the tanker. The amount of swarf generated is, of course, variable due to the composition of the material removed. The swarf is dumped through six inch lines located under the water tank and is cleaned with high pressure water jet.

Concrete Decontamination

The highway grinding equipment in its present form may be used for the removal of low-level insoluble contaminants. In this case, the water usage would be minimized. The use of flocculents settles the swarf quickly and facilitates drying. The damp swarf can be removed from the holding tanks without the use of a flushing stream. The greatest part of the swarf empties itself through the six inch lines and the little remaining may be cleaned out with some sort of squeegee. Holding tanks or plastic lined pits may be used for drying. The disposition of higher level insoluble wastes would necessitate considerable technical innovation based on the same general principles.

In cases where the use of cooling water is prohibited, dry grinding may be feasible. For example, diamond drills were developed for dry use in sodium-cooled reactors. It is conceivable that the principles applied there could be utilized in the development of a diamond grinding process without water cooling. The design of blades for maximum heat transfer using high conductivity metal bonds, high conductivity disks, and high speed rotating seals would have application in this area. It is, of course, to be expected that surface removal rates would have to be considerably slower so as to minimize the rates of heat build-up in the diamond tools.

Excessive heat generated in a diamond tool affects the integrity of the diamond particles through thermal shock and through graphitization. Excessive heat also affects the rotational stability of the blade itself due to uneven thermal expansion, and this effect shows up quickly via sudden heavy vibrations in the rotating system. However, there are cases where diamond sawing without the use of liquid coolants have been successful, such as the sawing of porous, abrasive brakelining materials. In these cases, the adverse effects of thermal expansion were avoided by simply splitting the blades into two semicircular sections and reassembling the sections on a specially designed spindle. When this was done, thermal expansion became uniform and did not distort the blades.

To date, we have not developed equipment that will perform the diamond blade grinding operation on vertical surfaces. However, the problem has been conceptually examined by our equipment division.

It is considered that a reasonable approach would be based on technology already developed for concrete wall sawing. In this technique, small diameter holes are drilled on the wall surfaces and concrete anchors set in place. Metal track is bolted to the anchors, and the saw traverses the track either man-operated or automatically by servo motors. Waste collection and water control would present a more severe problem here than on horizontal surfaces.

Another approach to vertical surfaces which would have the advantage of increased working distances from higher level radiation fields would involve the use of a backhoe or similar device. In this case, the articulated arms would press the track against the wall and the rest of the grinding operation would be controlled by the backhoe operator.

In cases where access or working space is limited, there are lawn mower size grinding units available. So far, we have not equipped these units with vacuum waste collection systems. However, this would not appear to present any fundamental problems.

In summary, diamond blade grinding has present application in contaminated concrete removal under certain circumstances. The scope of its application could be extended considerably with further development.