An Overview of Sweeping Equipment Technology

The intent of this paper is to assist sweeping industry professionals in reaching a better understanding of the differences between the major types of sweeping equipment being used in the American road sweeping marketplace. First, a brief overview is provided of some of the emerging concerns in the sweeping industry.

Since its inception, sweeping has been used to remove what might be termed 'cosmetic' or 'political' debris from roadways and other paved surfaces. It has been so-called because of consensus that if a street *looked* clean, it *was* clean. Today, however, this reason for sweeping is undergoing significant re-appraisal by the U.S. Environmental Protection Agency (EPA), as well as by public works professionals and others throughout the country.

That's because recent studies have shown that more than 50% of heavy metals and other serious pollutants are attached to particles that are 60 microns in size and smaller (as a comparison, a human hair is about 70 microns in width), *even though particles of this size compose a relatively insignificant amount of the total weight and volume of a typical sweeper's hopper load*. It has been confirmed that even though a street may *look* clean (before or after being swept), there still may be a significant loading of small-micron, pollution-laden debris on it. From an environmental standpoint, it is exactly this material that it is most important to remove. A high level of increased emphasis, by the EPA and others, is now being placed upon the removal of small-micron debris as a Best Management Practice (BMP) for reducing stormwater runoff pollution.

These small-micron particles are now seen to pose a significant environmental concern. That's because with rainfall they tend to run off into stormwater systems as total suspended solids (TSS), or to get pounded into the air by passing cars (or blown into the air by wind) as fugitive dust (PM-10s). Either way, these particles pose an environmental challenge. According to EPA estimates, 30,000 people in the U.S. are killed each year by pollutants attached to small-micron dust particles, and 1,000,000 more sustain serious lung impairment. And for pollutants such as zinc, which tend to become dissolved in water, there is not even any effective way to filter them out through sophisticated catch-basin or other stormwater filtration technology.

Following are brief overviews of the major types of sweeping equipment available, as well as examples of usage and applicability:

Mechanical Broom Sweepers

Mechanical broom sweeping technology may be likened to cleaning with a broom and a dustpan. For years, mechanical broom sweepers were the only machines that were used for road sweeping by municipalities and departments of transportation. Mechanical broom sweepers are still the primary machines in use by municipalities around the US.

Typically, these machines have a 'main broom' that runs transversely — from one side of the sweeper to the other — such that the broom bristles contact the paved surface the full width of the sweeper unit. The broom rotates in a clockwise fashion when viewed from the left side of the vehicle, and collected debris is swept onto some type of a conveyor belt for transfer to a containment hopper.

Mechanical broom machines may or may not be outfitted with a 'gutter broom' on one or both sides of the sweeper. Gutter brooms are relatively small (typically 36 to 50 inches in width), are located to the left, right, or both sides of the sweeper, and are primarily used to transfer debris from the gutterline into the path of the main broom. Even though mechanical sweepers are usually outfitted with a series of water spray nozzles, because they have no vacuum component, they still tend to create a substantial amount of dust in dry weather.

In recent times, it has been recognized that modern air sweepers have many advantages over mechanical broom sweepers for general road sweeping usage. One reason is that mechanical sweepers only give the i*llusion* of leaving a clean pavement surface. Although large debris is removed by mechanical broom sweepers, they are virtually ineffective at removing particles 60 microns and smaller. Studies have even shown that from an environmental standpoint mechanical broom sweepers may actually have a negative effect on the amount of stormwater runoff pollution. This is because the action of the broom tends to break larger particles down into smaller ones, creating more small-micron particles than there were to start with. And, because debris pickup is via an elevator, rather than involving any type of air/suction action, a large amount of these small particles are left on the pavement's surface.

Any municipality with a fleet of mechanical broom sweepers should re-evaluate its street sweeping needs, given today's EPA requirements for reducing stormwater runoff as part of its stormwater management plan. Because modern regenerative air sweepers can remove a much higher percentage of the more highly polluted small-micron debris, material removal may be significantly improved by replacing current mechanical broom sweepers with regenerative air sweepers. The latter are also much less expensive to operate. However, especially for snowbelt areas of the US, initial spring sweeps may still have to be done by mechanical broom sweepers. Municipalities located in areas with significant stormwater or air pollution concerns should also consider the benefits of the new small-micron dry filtration sweepers.

Advantages: Mechanical broom sweepers remain the standard for sweeping extremely heavy or packed-down material such as road millings. This type of sweeper is also still required for 'spring cleanup' in snowbelt areas of the U.S. where a large amount of sand and other abrasives are put down in the winter as traction aids.

Disadvantages: A mechanical sweeper is a poor choice where environmental concerns exist about stormwater pollution or air quality. Also, mechanical sweepers are significantly more expensive to maintain than comparable air sweepers, due to having so many moving parts (including continuous ground contact by main broom and mechanical movement by the elevator system). Because of the vast improvement in air-based sweepers in the last few years, they are now better suited for many types of general road sweeping.

Vacuum Sweepers

Vacuum sweepers may be compared to a household vacuum system. An engine powers a fan, which creates vacuum/suction. Typically, there is a suction inlet on one side of the sweeping head, and then the 'used' air is constantly exhausted during the sweeping process. Most vacuum

sweepers do not have an air blast that transfers to the vacuum opening. Instead, they employ some type of broom system to brush debris toward the vacuum opening in the head.

Part of the impetus for the advent of vacuum sweepers was the recognition that the majority of debris, especially the heavy debris, collected within 36 inches of the curb line. Vacuum sweepers are designed to do an effective job of cleaning within that area.

Today, as the importance of cleaning the entire lane width is becoming widely recognized, vacuum sweepers are being supplanted by the 'blast and suction effect' of regenerative air sweeping technology. The blast force employed by regenerative air sweepers (see next section) cleans more thoroughly across the entire path of the sweeper. A disadvantage of vacuum sweepers is that their windrow broom tends to fill pavement irregularities with debris that the suction effect isn't strong enough to remove. Vacuum machines also have more moving parts than comparable regenerative air sweepers, as well as smaller diameter curb brooms. As is illustrated in the next section, the regenerative air technology has become widely seen as having a number of advantages: cleaning a wider path, removing small particles better, and limiting the amount of dust-laden air that is exhausted back into the atmosphere.

Even though they typically use water-based dust suppression systems, all but the latest technology (see information on the new, small-particle filtration sweepers, further down) vacuum sweepers exhaust a high level of particulates into the atmosphere on a continual basis. As a result of the studies by the EPA and others, it is now known that these are pollutant-laden particles that pose a quantifiable hazard to human health and safety.

Another disadvantage to vacuum sweepers is their relatively small intake tubes. These are often as small as 8 inches in diameter, so they are more likely to become plugged with larger debris. Also, the sweeping width of vacuum sweepers is generally less (62 to 68 inches wide) than that of regenerative air sweepers (up to 90 inches wide).

Advantages: Thorough cleaning near the curb line. Less dust created than with mechanical broom sweepers. Fewer moving and wear parts than mechanical sweepers.

Disadvantages: Because suction nozzle must be located on one side or the other of the sweeping head, vacuum sweepers cannot operate with both gutter brooms working. Suction tubes must be smaller than on regenerative air sweepers (generally 8 inches wide vs. as much as 14 inches on regeneratives), so vacuum sweepers can't handle as large of debris.

Regenerative Air Sweepers

Generally speaking, regenerative air systems are more environmentally friendly than are vacuum or mechanical broom sweepers. There are several factors that contribute to this.

Regenerative air sweepers employ a closed loop, 'cyclonic effect', to clean. They are similar to vacuum sweepers, in that there is a similar vacuum inlet located on one side of the sweeping head. Unlike vacuum machines, however, regenerative air sweepers constantly re-circulate (regenerate) their air supply internally. To accomplish this, the re-circulating air is blasted into the sweeping head on the side opposite the pickup, or inlet, tube. Essentially, the air 'blasts' down onto the pavement on one side of the head, travels across the width of the head (gathering debris with it as it goes), and then travels up the pickup hose on the other side with the debris. Manufacturers design their sweeping heads so as to swirl the air, so it will retain the collected debris within the airstream as it moves from the blast to the intake side of the head.

Because of the way they operate, regenerative air sweepers are recognized as providing a more thorough cleaning action — even though a vacuum system may be able to boast a greater airflow per horsepower. Because they 'air-blast' the pavement across the entire width of the sweeping head, regenerative air sweepers tend to do a better job of cleaning over the entire pavement surface covered.

Although some air is lost by the regeneration process (due to unevenness of the pavement, which allows air to escape from under the sweeping head's rubber flaps, etc.), the amount of exhausted, pollutant-laden air is typically much less than with a vacuum sweeper. Because of this, and the fact that regenerative-based machines also tend to pick up the small micron particles across the entire sweeping head, regenerative air sweepers are usually a better choice where either air quality or stormwater runoff pollution are concerns.

The blast-and-pickup cycle also makes these machines more capable at picking up heavy debris, since the blast is more able to dislodge heavier materials and get them into the airflow. Regenerative air sweepers are also able to support larger intake tubes, so larger debris may be removed without clogging. This is especially important when sweeping material such as leaves. As a result, today's regenerative air sweepers are able to supplant mechanical broom sweepers for all but the most challenging applications. In most applications, they also are a better choice than are vacuum sweepers.

Regenerative air sweepers are more suitable for most everyday road sweeping needs, and also cost significantly less to maintain. For these reasons, regenerative air sweeping equipment is now often being specified by U.S. governmental agencies that are involved in paying a portion of sweeping equipment being purchased.

Some manufacturers now offer waterless sweeping regenerative air models. This means they may be used year 'round, even in freezing weather, and this also increases sweeping time and reduces dumping costs, since water doesn't have to be loaded or picked back up by the sweeper. This waterless technology is in its relative infancy, and probably is best used for specific situations rather than full-time sweeping.

Advantages: Best all around, multi-purpose sweeper. Can clean a wide range of debris in a large variety of situations. Work very well under routine street maintenance-type operations, for cities or contractors in their routine cleaning programs. Air system makes them better for leaves than mechanical broom sweepers, and larger intake hoses makes them better than vacuum sweepers for leaves. Fewer moving and wear parts than mechanical sweepers. Can be used to clean catch basins by adding hand hose. The sweeping industry's most multi-purpose machine.

Disadvantages: Can't handle millings, spring cleanup and other extremely heavy-duty applications as well as can mechanical sweepers. They use water for dust suppression, which leaves some dissolved small-micron debris in pavement cracks and on the surface. They exhaust some amount of particulates into the atmosphere.

New Technology High Efficiency Dry Vacuum Sweepers

A new technology that sweeps without using water, and that employs a sophisticated filtration system for dust containment. This new technology of dry sweepers is typified by Schwarze Industries' much heralded EV-series machines that studies have heralded as the first-ever *pavement cleaners*. One departure from regenerative air systems is that the EV-series machines

employ a self-cleaning filtration system that can filter 'dust' output down to 2.5 microns (PM-2.5). This level of small particle filtration cannot currently be approached by any other sweeping system.

Tests have shown that the pickup ability of the new EV-series' sweeping technology surpasses even that of regenerative air sweepers in terms of total, and environmental, cleaning ability. Models are even available which filter the in-cab air supply for operator safety in cleaning toxic, pavement-based wastes. Because it uses no water for dust suppression, and because it cleans to a small-micron level, these machines are ideal for any application where dangerous or toxic materials are present. This includes usage in industrial and manufacturing settings where material needs to be recycled, reused or securely contained and disposed of after pickup.

Unfortunately, the EV machines have not posed much of a challenge to regenerative air sweepers. They are about twice as expensive to purchase and complex to repair and keep running. However, more importantly, they have not proven themselves on uneven street pavement and, because they are mounted onto purpose-built chassis, their top speed of about 25 mph is also seen as a large disadvantage. Schwarze sells them as industrial sweepers, best used for in-house accounts where toxic and/or hazardous materials need to be cleaned up and/or recycled.

Advantages: Most thorough cleaning of all sweeper types, below PM-10. Collected debris is not mixed with water. Can be operated in freezing weather, since there is no need for water-based dust suppression. The sweeper also cleans air to PM-2.5. By not using water, there is a cost-savings from not having to fill the water tanks. This also means the sweeper will hold more material prior to having to dump, since no part of it is water. Probable best choice for industrial cleanup situations.

Disadvantages: Current disadvantages are a slow transport speed of around 25-mph between jobs. Although the machines carry a higher initial purchase price than traditional sweepers, the manufacturer claims this is largely offset by cost savings due to not using water: less rust, no need to fill sweeper with water, less frequent dumping, no pumps or other components for water usage, etc. Also, the current machines are not suitable for most municipal curb-and-gutter configurations and are complex and expensive to repair and keep operating.

This information is also available in Adobe's Acrobat Reader PDF format.

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