ABSTRACT

Electrostatic Coatings

Electrostatic Spraying with two blades on the top (Temper Mill Oiler)

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SPRAYING WITH TWO BLADES ON THE TOP (TEMPER MILL APPLICATION)

Temper Mill Electrostatics Explained

A basic characteristic of electrostatic blade spraying is the formation of oil "cusps" (or points) on the blade spray tip. It is these cusps that form the origination points of the atomized oil spray pattern. When the oil leaves each cusp as a very small stream, it carries with it the charge applied to it by the spray blade. It is this charge that causes the oil stream to begin to break up (atomize) into small droplets. Each small droplet generated will thus carry a charge of the similar value and polarity and will therefore repel its neighbor. In consequence, this controlled dispersion within the electrostatic field ensures excellent oil deposition uniformity over the surface being coated.

The electrostatic forces also ensure that each charged particle of liquid is attracted strongly to the target, whisch is grounded, and hence seen by the particle as being opposite polarity. The oil particles then loose their charge and return to a stable state. (Voltages as high as 105,000 volts may be used, but only at 200 micro amps).

If the oil to being sprayed is well suited to electrostatic spraying, the charge carried by the droplets will cause them to break up into a finely atomized cloud that is evenly attracted to the grounded substrate (strip). However, if a very large volume of oil is to be applied or the electrostatic properties of the oil are poor, the oil streams will not fully atomize in the conventional way & the oil will be applied to the strip in the form of coarsely atomized stripes. An example of this can be in a Temper Mill Oiler application where a large amount of oil must be applied to the topside of the strip at high speeds. Approximately half of this oil will then transfer to the underside of the sheet once the coil is wrapped. In an application of this type we may need to have two or four blades applying oil to the top of the strip in order to apply the large volume of oil that is needed to adequately cover both the top and bottom faces of the strip.

Observation of two or more spray blades arranged in parallel has shown that the spacing of the cusps on all of the blade tips remains the same when a given voltage is equally applied to all blades. This arrangement has been found to exhibit a lining type pattern when the applied oil is viewed on the strip surface. By exploiting this voltage/cusp spacing ratio, we have found by experimentation that applying a slightly lower voltage on one of the blades will result in a cusp spacing pattern that will be different from blade to blade. The effect of these differences in cusp spacing is to have effectively more cusp streams per inch applying oil onto the strip as illustrated in the following drawing. The result of this arrangement is to provide better initial coverage of oil on the strip surface, instead of relying on the oil spreading out in the coil ("plating out").

The high voltage that is applied to the spray blades to create this effect may be varied by either using two separately adjustable high voltage power supplies or by isolating the two blades electrically and connecting them via a 25 megohm high voltage resistor.

THE PRINCIPLES OF ELECTROSTATICS

Electrostatics Explained

The electrostatic principle is based on the law of physics which simply states; 'like charges repel, unlike charges attract'. Thus, when a suitable liquid (oil) is formed into a thin film exposed to an intense electrostatic energy field, it will separate almost immediately into a collection of very uniform and equally charged particles.

The reason for this is that the electrostatic charge in a sprayed particle tends to be forced to the outer surface, as all of the like-charged ions repel each other. Because of factors like surface tension, resistively, etc. only so much charge (energy) can exist in a droplet before it spontaneously breaks up into smaller droplets in order to increase its surface area, as the so-called "Rayleigh Limit" of the liquid is exceeded.

Each smaller droplet generated will thus carry a charge of the same value and polarity (normally negative) and will therefore repel its neighbor. In consequence, this controlled dispersion within the electrostatic field ensures excellent uniformity over the surface being coated; more drops for less coating material.

Electrostatics ensure that each charged particle of liquid is attracted strongly to the target, which is earthen and hence seen by the particle as being opposite polarity. It then loses its charge and returns to its stable state. (Voltages as high as 120,000 volts are used, but at only some 200 micro amps).

Such intense electrostatic energy fields overcome gravity, enabling the system to work equally well "upside down" to ensure uniform application on both sides of the target when presented horizontally. (For vertical presentation of strip, the sprayers are positioned to discharge horizontally).

The electrostatic effect is seen in its purest form in the Linear Accelerator (L.A.) Blade. However, for special applications, electrostatic systems from can also use air-assisted nozzles or high speed rotating cup (bowl) atomizers, thus extending the range of liquids can be sprayed electro statically.

THE PRINCIPLES OF ELECTROSTATICS
Features And Benefits Of Electrostatics

Uniform Coating

Electrostatic ensures that a uniform coating of oil is applied to a substrate at a precisely controlled coating weight, thus, reducing reject rates and hence cost as well as being better able to satisfy customers demands.

Significant Oil (Capital) Saving

Due to the high transfer efficiencies occurring, electrostatics reduce significantly the amount of oil/coating fluid needed for complete protection in comparison with non-electrostatic methods, therefore reducing coating costs. The saving is considerable and can result in the machine paying for itself in under a year.

Coating Weight Flexibility

Electrostatic applicator systems are capable of applying coating weights form as low as 3 mg/m2, if required. Hence a wide variety of different coating programs and oil (coating) types can be handled by a single machine.

If coating requirements change, the machine can normally accommodate them.

No Mechanical Contact

There is no mechanical contact with the target surface. Thus, the risk of surface damage is negligible and wear on the machine is minimal. Also, intermittent or patchy covering of the strip. as can occur with other systems using contract rollers, is eliminated. Further, roller bounce from uneven strip surface is avoided, as is costly maintenance of rollers and their bearings.

Coating Material Transfer Efficiency Near 100%

Any unused coating / oil is confined within the machine and is recycled, giving an overall transfer efficiency approaching 100%. Thus, coating costs are further reduced.

THE PRINCIPLES OF ELECTROSTATICS
Features And Benefits Of Electrostatics

Improved Environment - Improved Coil Shape

Because excessive coating is eliminated, seepage from coils does not occur. Thus, there is no opportunity for coils to lose shape and hence the tension in the coils remains stable. Further, capillary evacuation form high pressure points (which can cause circular dry patches) cannot occur.

Oil spillage to floors and nearby machinery and oil mist emissions are effectively eliminated, thereby improving the working environment and often allowing for reduced insurance costs.

Few Moving Parts - Low Maintenance Costs

The Electrostatic Coating System achieves its objective using very few moving parts. Hence, maintenance is minimized so downtime of the line is reduced to the lowest possible level, giving further cost savings.

OILS FOR ELECTROSTATIC DEPOSITION

As specialist suppliers of electrostatic oiling machines it has been necessary for us to test many different types of coating oils for their suitability to the process. Although we have yet to find an oil which is totally unsuitable, it is clear from our tests that some oils perform better than others.

The test method is to duplicate, as closely as possible in the laboratory, the conditions in which the medium is to be run in production. Oil flow and high voltage control settings are adjusted to give the optimum atomization and spread patterns, and the oils classified between excellent and poor according to the recognized pattern achieved. Assessments are made by experience observed in controlled conditions, ensuring good correlation between tests.

There are three main factors which contribute to the compatibility of an oil with electrostatics application. These are:-

1. Conductivity.

2. Viscosity.

3. Surface tension.

All three factors are inter-related and all are affected by environmental conditions.

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Conductivity

The conductivity of an oil will determine the degree of charge which it will accept and therefore, the strength of electrostatic field generated. For convenience the property measured is in fact the reciprocal of a material's conductivity, i.e. its resistively and this is accomplished by rating with a test meter and probe.

In relation to suitability for electrostatic application the following tabulation broadly applies:-

Resistance	Characteristics
0 - 90K Ohm	Almost totally conductive. Erratic uncontrollable atomization. Special needs for insulation.
90 - 750K Ohm	Excellent atomization, particularly suitable for low film weights. Some insulation precautions may be necessary.
750 K Ohm - 15M Ohm	Good atomization. Ideal for finishing mill application.
15M Ohm - 50m Ohm	Medium atomization. General purpose and pickle line applications.
50M Ohm +	Coarse atomization. Complete coverage of coated surface may rely on after flow. Heating is normally required.

Resistance of an oil may be changed in two ways (i) by adjusting the extender present in the oil, e.g. by altering its polar properties, and (ii) by altering its temperature; although not linear in value the resistance is inversely proportional to temperature increase.

OILS FOR ELECTROSTATIC DEPOSITION

Viscosity

Viscosity is a liquid's resistance to flow at a given temperature so the manner in which an oil can flow from a blade, and its mobility upon reaching the target surface, may be given a numerical value.

Oil viscosity's may conveniently be typified as follows:-

Viscosity (Centipoises at ambient temperature)	Characteristics
100 +	Heavy and immobile. Heating required to allow to flow.
70 - 100	Medium/heavy coarse atomization.
20 - 70	Good atomization - preferred range.
Less than 20	Very thin consistency. Very narrow slot gap required, for uniform output from blade.

The viscosity of an oil is also inversely proportional to temperature change. Normally, higher viscosity oils will be heated to a reduced viscosity suitable for atomization.

Surface Tension

The surface tension of an oil is the measure of internal force holding the mass together and resisting its atomization into small particles. High surface tension equates with difficulty in atomizing.

Commonly encountered oils are from the following range:-

Surface Tension (Dynes/cm)	Characteristics
34 +	Requires heating for good atomization and should be in preferred resistively range.
26 - 34	Good atomization properties. Preferred range.
Less than 26	Erratic uncontrollable atomization. Unsuitable for blade coaters.

Surface tension is also inversely proportional to temperature change.

The foregoing are generalities aimed at indicating the more desirable features of oils intended for electrostatics application. All are inter-related and GFG Peabody's experience can maximize an oil's performance through experience related engineering.

OILS FOR ELECTROSTATIC DEPOSITION

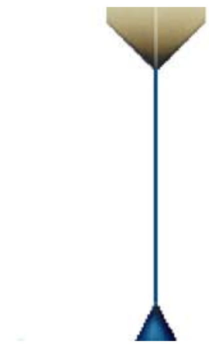
Figure A
Excellent atomization and coverage at all coating weights.

0.015-2M. Ohm

Figure B
Good atomization with slight deterioration of coverage at some levels.

2M.Ohm-15M. Ohm

Figure C
Coarse atomization. To achieve full coverage some after flo may be required



15M. Ohm-50M. Ohm +

These spray patterns can be expected using oils having resistance readings as shown. The figures given are approximate guidelines. Also, spray patterns can vary with oil output. For example; oil emission of 2cc/cm of blade length may result in spray pattern (Fig A) whereas, an output of 10cc.cm ma Dy result in (Fig B) using the same oil. The patented GFG Peabody D.V.C (Dynamic Voltage Controller) unit which delivers the optimum charging strength for any given oil output, has been developed to minimize these differences and maintain stable spray patterns over a wide range.

Typical spray pattern as seen from side of blade.

Figure A

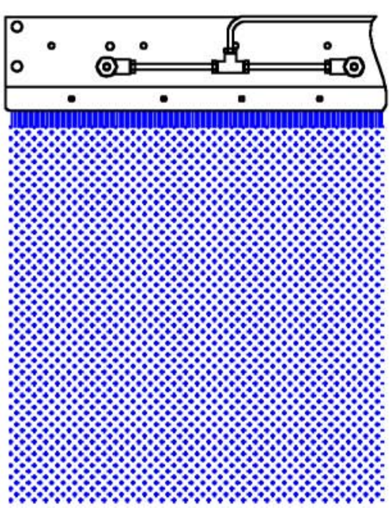


Figure B

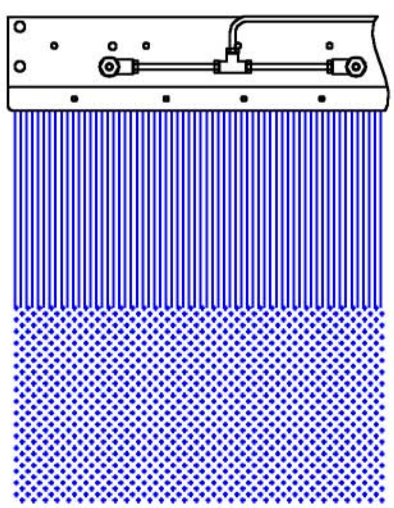
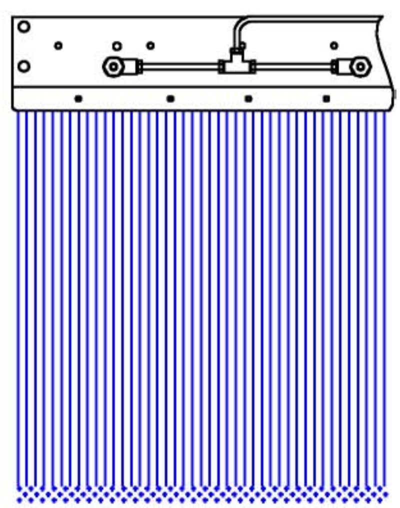


Figure C



OILS FOR ELECTROSTATIC DEPOSITION

Types of Electrostatic Applicators

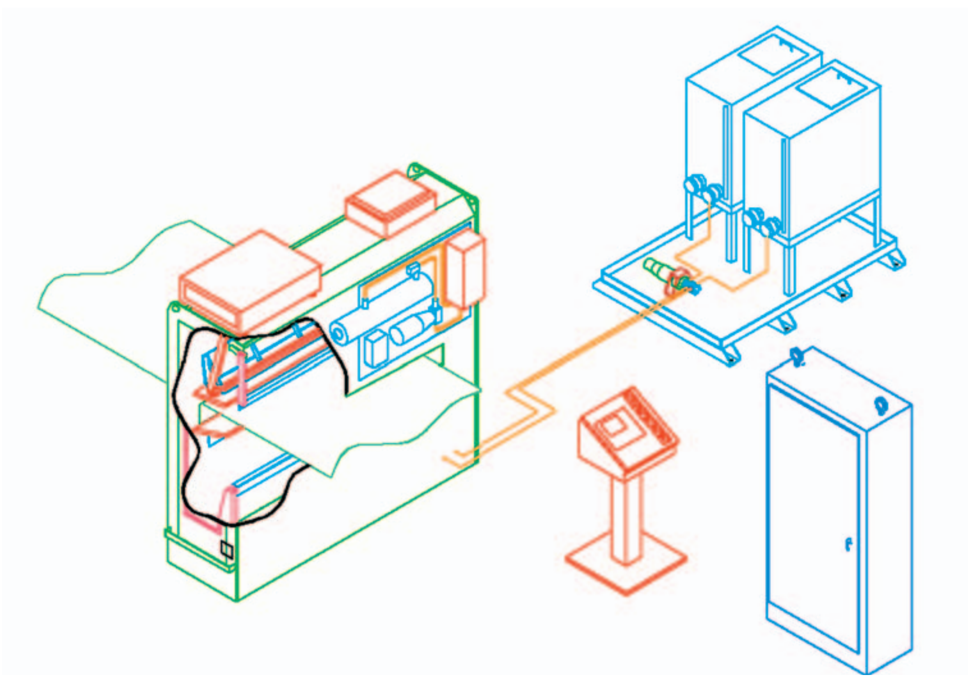
We can offer several methods of spraying the various types of coating oils, waxes or other materials, to give a fineness and uniformity of particle size suitable for electrostatics. These are described below:-

The Blade Coater

We originally developed the concept of the Electrostatic Blade Coaters some 30 years ago. The latest form is the so-called L.A. (Linear Accelerator) Blade and it offers a wide range of coating weights and product speeds.

Blade coaters utilizes a narrow slot to distribute the coating fluid. A natural interaction between the electrostatically-charged particles after atomization ensures complete uniformity of coating fluid over the entire target surface. The blade converts the fluid into a dense, well-defined pattern of electrostatically charged particles, which are strongly attracted to the target surfaces with a transfer efficiency approaching 100%.

The latest L.A. Blade embodies design features which increase the density of the atomized particles within the charged pattern almost six-fold over earlier blade types. Therefore linear accelerator blade uses less coating fluid and is able to operate over a much wider range of coating weights than earlier blade design, generally from 15 mg/m2 upwards.



TYPES OF ELECTROSTATIC APPLICATORS

The Rotary Atomizer

Rotary Atomizers have been used for many years in industrial applications. In electrostatics, the coating fluid applied to the bell of an atomizer is spun out to its edge and subjected to an intense electrostatic energy field.

The cup-shaped atomizer is rotated at high speeds (up to 40,000 rpm) using a friction-free air turbine and utilizes a combination of centrifugal and electrostatic energy to atomize and distribute uniformly coating fluids down to low mg/m2 levels.

The resultant dense, uniformly-distributed pattern of charged fluid particles is strongly attracted to the earthen target, providing almost 100% transfer efficiency.

The particular advantage of the rotary atomizer is its ability to maintain uniform distribution down to extremely low coating weights (as low as 3mg/m2) and generally up to 200mg/m2 with excellent control characteristics.

Further, many types of coating can be used, including waxes and water-based fluids. Another advantage is that the rotary atomizer has excellent response time to accelerations/decelerations are required.

The Electro-Air Atomizer

The electrostatic spray nozzle uses air-assisted atomization and is especially designed to handle a wide range of coating weights from low mg/m2 levels. It is thus ideally suited to sheet coating processes particularly where mineral or water-soluble coating fluids are used. Each spray nozzle is supplied with its own fluid control valve, offering unique air flow adjustment for both atomizing and pattern shape control.

A needle electrode at the nose of the gun creates a high energy electrostatic fluid which induces an electrostatic charge on each atomized fluid particle. The resulting electrostatic attraction ensures efficient transfer of the coating material to the target.

Air-assisted spray nozzles are normally incorporated in completely integrated systems designed to cat and handle varying widths or lengths of, say, cut steel sheet. Of special note is the facility to spray on to selected areas of, for example, blanks for press feeding in the Automotive Industry using PLC (Programmable Logic Controller) Control. Coating weights handled are typically in the range of 100-4,500mg/m2.

ABSTRACT

NEW DEVELOPMENTS
The Following New Developments Can All Be Retro-Fitted To Existing Electrostatic Oilers

Air gap temper mill hood with direct feed fluid valves

We have noticed that the old plastic lined temper mill spray hoods are damaged by the tail of the strip at the end of a coil, or if the strip breaks while under tension. The strip then bangs into the spray hood which can crack the plastic liner. The plastic liner is used to insulate the high voltage from ground, so if it has a crack the high voltage seeks the ground through the crack instead of the oil. Also the plastic is hard to keep clean.

We have developed a new Air gap temper mill hood with direct feed fluid valves. This does not use the plastic liner. We have also remover the air operated valves on the spray blade. We have found that the compressed air to the valves is not always dry air and can become conductive. We replaced the air operated valves with direct operating solenoid valves placed out side the spray hood.

Adjustable Spray Width (ASW) Extruded Aluminum

ASW blade so that a spray width control system can be included in their range of coating equipment and offered where appropriate.

The spray band width is adjusted in 50mm steps from either side of center line up to maximum strip width. Each step is fed from a specially designed segmented high precision pump ensuring that an accurate metered amount of oil is fed to each blade step or zone.

ADVANTAGES OF THE ASW STEEL BLADES Extruded Aluminum

1. Gives complete oiling across strip width.
2. Greater accuracy across the strip uniformity in oil coating. Typically +/- 6%.
3. Scalloped tip edge with 0.002 inch (0.05 mm) gap giving the best atomization quality and directional control of the spray.
4. Ability to emit oil spray through a narrow gap (150 mm) allowing plastic wing protectors to be shaped and positioned so as to give adequate protection plus facilitating front edge strip feeding through the oiling enclosure which therefore need only be 850 mm in width if there are on line space restrictions.
5. No delay in oiling at start of line running. With the blade coater using the catchment trough facility the strip is completely oiled from the moment the strip begins to move.
6. Capable of withstanding temperatures in excess of 80oC.

In order to achieve the best oiling results from the system we have improved blade manufacture where the slot gap is now controlled to within extremely tight tolerances (ie. better than 5% deviation over 2 meter length). Greater emphasis has also been put on improved filtration which has virtually eliminated blade clogging.