AEM ELECTRODE COATING SYSTEMS FOR BATTERY APPLICATIONS
Model 2147

INTRODUCTION:
PURPOSE OF THE 2147 BATTERY ELECTRODE COATING MACHINE

This machine is designed to be simple, compact and efficient. It is easy to install and easy to use. For production operations multiple machines can be used to increase production at a lower cost and with better process flexibility than with a single larger coater. AEM, Inc. can provide all the support equipment need to use the machine. Installation can be completed in one day.

Outline of Coater Design Employing Continious Coating:

Machine Characteristics -

1. Substrate to be Coated	Cu and Al Foils PET and O-PP Films Release Paper
2. Substrate Thickness:	Aluminum 18 – 24 Microns Copper 8 – 12 Microns PET film 25 – 75 Microns O – PP film 25 – 75 Microns Release paper 125 Microns
3. Coating Binder	PVDF
4. Coating Solvent	NMP or Acetone
5. Coating Viscosity	1,000 to 30,000 cps
6. Deposition Characteristics	Continuous
7. Coating Method	Doctor Blade
8. Coating Head Clean-up	Simple and Fast (15 min.)
9. Drum Width	355 mm (14 in.) max.
10. Substrate Width	330 mm (13 in.) max.
11. Casting Width	317 mm (12.5 in.) max.
12. Drying speed	0.1 – 3 m/min.
13. Machine speed	0.1 – 5 m/min.
14. Drying Process Type	Bottom heat, air sweep
15. Drying Temperature (Max.)	150 deg., C. (300 deg. F.)
16. Web Tension Control (2 – 10 Kg.)	Automatic (Electronic)
17. Web Tracking (EPC)	Automatic (Pneumatic)
18. Operator Interface	Single Station
19. Safety	Designed for use with a flammable binder.

DESIGN APPROACH - ELECTRODE COATER

The AEM Battery Electrode Coaters are integrated machines capable of coating electrode material (both cathode and anode) on copper or aluminum foil, polymer carrier film or release paper.

The 2147 Electrode Coater is a precision device used to deposit the electrode slurry onto a moving substrate, and then dry it thoroughly. The slurry is deposited using a doctor-blade coating head that has very accurate control of the cast thickness.

COATING METHODS

AEM's battery electrode coaters are delivered with 1 modular coating head for coating up to a 317 mm (12.5 in.) maximum width. Thickness of the cast material is controlled using 2-micrometer adjustable stops built into the modular coating head. The width of the coating heads are to be specified by the customer.

Coating Reference Surface -

A hard chromed and ground steel roller is used. The grinding is precision to provide a high degree of uniformity in the coating. The drum rotates so that the surface speed of the roller will be the same as the speed of the carrier foil.

Slurry Application -

A doctor blade will be provided that adjusts for varying the coating thickness. The support structure for the doctor blade rests on the surface of the coating reference roll. This compensates for any run-out in the roll.

Slurry is fed to the coating head from a holding tank. One (1) 20 liter slurry tank equipped with a stirrer to prevent settling of the solids and air entrapment during the coating run is included. The slurry is feed to the coating head from the slurry tank by pressurizing the slurry tank with compressed air. Since it is important to avoid moisture, dry nitrogen should be used. The customer provides the nitrogen gas.

Control of the slurry level in the coating head is provided by a fiber optic sensor controlling a valve that stops the flow when the level rises to a desired level and turns it on when the slurry falls below a lower level limit. The operator can adjust the upper and lower slurry level limits.

Clean Up and Maintenance Provisions -

The coating head is a discrete module 420 mm long x 24 mm wide x 16 mm high and can be removed from the machine without tools. The disassembly of the head is simple and fast and allows rapid resumption of operation when development work is in progress. The head is manufactured from materials that resist deterioration from the effects of normal use. For example, heat treated stainless steel for precision parts and hard anodized aluminum for supporting structural parts.

Clean up of the slurry feed system is made easier by the use of specially designed components that disassemble easily. The slurry feed tube from the slurry tank to the coating head is disposable to save costly clean up time.

DRYING SYSTEM

The drying system uses a direct contact thermal transfer method. In this design the heat is passed into the wet coating by conduction from underneath. This drives the solvent upwards through the wet slurry. When the solvent leaves the surface of the coating, a heated air stream sweeps it away to the exhaust system. The heated surface consist of a two meter long arched path after the coating head and a one meter diameter wheel. The surface of both are coated with teflon similar to a frying pan coating. This prevents excessive friction and makes it easy to keep clean.

Heat Source -

Heat for drying is provided by recirculated hot oil and hot air generated by an oil-to-air heat exchanger. The oil is heated in an industrial oil heater with an internal recirculation pump. The heating unit is located a minimum of 2.4 m (8 feet) away from the coater which is outside the defined explosive hazard area. The operating temperature of the system can be up to 150 deg. C. When using NMP based binders, the ooperating temperature is typically 125 deg. C. With Acetone systems a much lower temperature is used. Digital temperature controllers are provided for each of the three heating circuits. The three heating circuits consist of two curved drying beds and a large circular, 1.1 m radius (3.4 ft.) drying drum. Additional control of the drying process is provided by heated air which is blown throughout the inside of the coater cabinet to remove moisture laden air and remove condensate that could build up on interior surfaces. Total length of the drying surfaces is 5.2 m (17 ft.).

Graded temperature zones and careful airflow management provide control of acetone evaporation rate.

The heater will be delivered with the necessary volume of oil, length of pipe and insulation to locate the heater 2.4 m away for operation. If the oil heater is located farther away, the customer needs to supply the additional pipe required.

For lower drying temperatures the oil heating system is replaced with a water heating system that operates in a similar manner.

Contamination Controlled Drying - Temperature and Airflow Controlled Drying Chamber

The entire casting operation is conducted in a filtered air environment within the coater's exterior walls. A class 100 HEPA filter is provided. A glass cover is provided which can be closed while the coating is proceeding. A duct connection is provided for exhaust air, which will be vented to an external site.

CARRIER FILM TRANSPORT

Automatic Tracking -

Film tracking adjustment is provided on the model 2147 coater to give precise uniform rewind of the coated foil. The automatic part of the system operates by sensing the edge of the substrate with a pneumatic sensor. A pneumatic rewind position actuator moves the rewind shaft in and out to position the roll correctly for accurate winding. The pneumatic system chosen is capable of operating in a solvent vapor environment and is capable of sensing all of the substrates specified. The accuracy of the rewind alignment is < 1mm.

Foil Transport and Tension Control: Unwind and Rewind -

The electronic tension control system is closed loop consisting of a tension sensor and magnetic particle clutches on the rewind shaft.

The substrate is supported on quick release, 76.2 mm (3 in.) inside diameter pneumatic core chucks for easy changing. A variable speed motor to provide coating rate control powers the drive capstan. The drive capstan is located adjacent to the rewind reel so that the web is pulled through the coater. Tension in the carrier web is controlled by use of an adjustable magnetic hysteresis clutch, which maintains consistent drag independent of speed. The hysteresis clutch is connected to a capstan over which the web must pass before passing through the coating head. The variable speed drive system pulls the web from the unwind reel around the clutch which then provides the required tension in the web. Adjustments are made easily by turning a knob and resetting the clutch adjustment. The unwind and rewind shafts can accommodate substrate rolls up to 400 mm (15.7 in.) in diameter and up to 100 Kg. (220 lbs.). The shafts accept a 76.2mm (3 in.) paper tube core up to 355 mm (14 in.) long.

Static Charge Removal System -

Explosion proof electronic air ionizers are located near the unwind and rewind core chucks to neutralize any static electric buildup. On the unwind side the web passes over the ionizer just prior to entering the coating head. This ensures the removal of any particles on the web and prevents any unwanted contamination.

FRAME AND CABINET

A heavy gage backing plate supports the various functional parts of the machine. In areas of heavy load reinforcing structures are provided to assure that there is no distortion of the frame or effect on the alignment of the components. For cleanliness and safety, the machine is enclosed in a sheet metal cabinet. The enclosure contains

and directs the filtered air. The machine will be painted according to the customer's preference with an industrial grade urethane coating. The top of the cabinet is stainless steel since it is often used as a work surface and will be exposed to various types of chemical spills.

Controls -

Speed, on/off, blower settings and temperature controls are placed in an easy to access location convenient to the operator. The controls are industrial quality intended for factory environment. Explosion proof components are used in all areas were vapors are present.

1.2.4.2 Connections

All connections to the machine including those for heating oil, compressed air, exhaust air, and electrical service, enter the machine at the top where they are conveniently grouped.

SAFETY

An explosion proof electrical system is provided to allow the use of solvent-based binders. The entire system is designed to use fresh air to purge the flammable solvent vapors out of the electrical system enclosure. This is done to prevent the possible danger of explosion due to electrical sparks from switches or motors if there is a spill of flammable binder near or on the machine.

Temperatures in this machine are very high (150 deg. C.). Where possible, heat shields and insulation will protect the operator. Warning labels will be included. Spills of hot oil are another hazard. The quality of customer supplied oil piping to the remote heater and the care taken with its installation must be assured. AEM will not be responsible for the consequences of oil spills from customer installed equipment.

SPECIFICATIONS

Finished product quality is effected strongly by factors solely under the customer’s control. This includes the quality and kind of foil used, binder formula and powder characteristics, dispersion, speed of casting, temperature settings and machine adjustments as well as other parameters. For this reason, AEM can only guarantee the quality of the machine and its compliance with the stated mechanical tolerances. These tolerances have been found to allow the production of high quality Lithium-ion battery electrodes. However, for the customer to achieve the optimum results he must supply the correct raw materials.

THICKNESS RANGE: -

The typical wet coating thickness range is 50 – 400 microns and the dry coating thickness range is 25 – 210 microns. These numbers depend on the slurry characteristics and the wet / dry ratio. They may vary accordingly.

PRODUCTIVITY: -

According to prior experience, a coating rate of about 3 meters per minute can be achieved using Acetone / PVDF binder depending on thickness. This is an estimate only. Results may differ depending on material characteristics.

SPECIFICATIONS

Foil Transport Speed Range:	0 to 5 m/min. max. (0 to 16 ft/min. max.)
Width:	
Casting Wheel Width	355 mm (14 in.)
Carrier Foil Width	330 mm (13 in.)
Cast Film Width	317 mm (12.5 in.)
Dimensions:	1371 mm x 609 mm x 2438 mm (4.5’ High x 2' Width x 8' Long)
Shipping Weight:	1224 Kg. (2700 lb.)

REQUIREMENTS:

Coater Power:	220 VAC 50 Hz @ 3 Amp
Oil Heater Power	230 VAC, 50 Hz @ 51 Amps
Ventilation:	External vent of 236 Liters/sec.
Heated Oil:	19 liter. /min. @ 160 deg. C. Required

Dry Nitrogen	2.5 bar. Static pressure
Compressed Air	6 bar at .25 cubic meters / min.

1.1 Dimensional Tolerance -

Run-out of coating reference roll	+/- 10 um.
Straightness of doctor blade	+/- 4 um.

1.2 General Criteria -

Max. Temperature on horizontal beds	140 C.
Max. Temperature on drying drum	140 C.

1.3 Documentation –

Electrical Diagrams	2 Copies
Spare Parts List with specifications	2 Copies
Operation & Maintenance Manual with Component Catalog	2 copies

1.4 Schedule –

Fabrication time from receipt of L/C (USA)	4-6 Months
Training Period for customer (USA)	1 Week
Crate Coater for shipment (USA)	1 Week
Ship to Customer (Customer)	TBD
Install, Setup and Train Operator (At customer facility)	1 Week