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CATALOG FOR AEM 2163
ELECTRODE CONTINUOUS COATING MACHINE
FOR LITHIUM ION BATTERY

INTRODUCTION

PURPOSE OF THE 2163 ELECTRODE CONTINUOUS COATING MACHINE

This machine is designed for use in process development and production. It is a very compact and easy to use machine .

Outline of Machine Design For Battery Coating Employing Continuous, Double Sided & Incremental Coating

Machine Characteristics

1) Substrate to be Coated	Cu Foil, Al Foil , Polymer film or paper
2) Substrate Thickness:	Aluminum 10 to 25 Microns Copper 10 to 25 Microns PET 50 to 75 Microns
3) Coating Binder	PVDF or other
4) Coating Solvent	NMP or other
5) Coating Viscosity	1,000 to 30,000 cps
6) Coating Capability	Both sides, with registration
7) Deposition Characteristics	Incremental or continuous
8) Coating Method	Doctor Blade
9) Coating Head Clean-up	Easy and Fast
10) Coating registration (Front / Back)	Automatic
11) Drying Process Type	Bottom heat, air sweep
12) Web Tension Control	Automatic
13) Web Tracking	Automatic
14) Control Computer Type	Programmable Logic Controller
15) Operator Interface	Single Station
16) Safety	Designed for use with flammable binder

DESIGN APPROACH - ELECTRODE COATER

The AEM Electrode Coater Model 2163 is an integrated machine for coating electrodes (both cathode and anode) on copper and aluminum foil,paper or PET.

This is a precision machine used to deposit the electrode slurry onto a carrier film, and then dry it thoroughly. The slurry is deposited on the carrier foil with high level of controllability over the finished thickness. During the coating process, the slurry can be gated so that it is coated on the carrier foil in a segmented pattern. The coating can be applied to both sides of the carrier foil in a coordinated way so the coated areas are aligned front to back.

COATING METHODS

AEM's Electrode Coater Model 2163 is delivered with 1 modular doctor blade coating head for coating up to 318.5 mm (12.5 in) wide.

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 is provided that is adjustable for varying the coating thickness. The support structure for the doctor blade rests on the surface of the coating reference roller. This compensates for any run-out in the roller. A gating system is provided that allows the flow of slurry to be stopped and restarted repeatedly, exposing a section of carrier foil and producing an incremental coating pattern. The length of the coated and uncoated segments are variable and set by the operator at the control console.

Control of the coating head motions for starting and stopping the flow of slurry is tied to the movement of the foil. As the speed of the machine is changed the coating head changes its gating action automatically to match.

Slurry is fed to the coating head from a pressurized slurry tank. A 20 liter tank is supplied that is equipped with an air driven stirrer to prevent settling of the solids during the coating run. The slurry is feed to the coating head by pressure applied to the slurry tank. Dry nitrogen or argon can be used to prevent moisture from contaminating the slurry. The gas pressure system is provided by the customer.

Control of the slurry level in the coating head is provided by a fiber optic sensor controlling a valve that stops the flow as the slurry level rises to a pre-set level and then restarts the flow when the slurry level drops to a minimum operating level.

Clean Up and Maintenance Provisions -

The coating head is designed and manufactured so it can be removed from the electrode coating machine without tools Disassembly of the coating head is straight forward and allows rapid resumption of the coating operation when development work is in progress. The coating head is manufactured from corrosion resistant (stainless steel) or hard anodized (aluminum) materials that resists deterioration from chemical effects during normal use.

The pressurized slurry feed system is designed for ease of disassembly so it can be quickly cleaned, adjusted and replaced in the coating machine. The polymer tubing used to feed the slurry from the pressure tank, through the shut-off valve and into the coating head is inexpensive enough to be discarded after each coating run. This eliminates the need to clean it and risk contamination from dissimilar coating materials.

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 the slurry is provided by recirculating hot oil and hot air generated by a oil-to-air heat exchanger. The oil is heated by an industrial oil heater with a recirculation pump and is located outside the explosion hazard area, approximately 2.5 m (8 feet) away. The operating temperature of the system when NMP is the binder solvent is approximately 150 deg. C (302 deg F). The inside of the coating machine has three independently controlled drying zones and oil flow controls and temperature indicators are provided for each of the three heating zones. Temperature controllers for each zone are provided at the operator control panel and are individually set by the operator. The oil heater is delivered with the necessary volume of oil required for operation. The total length of the drying surfaces is 6 m (19 feet).

Contamination Controlled Drying - Temperature and Airflow Controlled Drying Chamber

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

FOIL TRANSPORT

Automatic Tracking -

Carrier foil tracking adjustment is provided to give precise rewind of the coated foil. The tracking system is automatic and operates by sensing the edge of the foil with a pneumatic sensor. A pneumatic servo-valve powers an air cylinder that moves the rewind shaft and roller in and out to position the roll correctly for accurate winding. The pneumatic system was chosen because of its ability to operate in a solvent vapor environment and is part of the explosion proof design requirements.

Foil Transport and Tension Control -

The carrier foil is supported on quick release core chucks for easy changing. The drive capstan is powered by a variable speed motor to provide coating speed control. The drive capstan is located adjacent to the take-up reel so that the carrier foil is pulled through the caster. Tension in the carrier foil is controlled in three separate systems; unwind, transport and rewind. The rewind is the most critical. Rewind tension is controlled by use of a magnetic particle drag clutch. Tension sensors are attached to a roller in the rewind system which generate a signal for that allows the electronics to adjust the tension to the desired level. The unwind system maintains a consistent drag force independent of the carrier foil speed. This keeps the foil from slipping over the encoder capstan. In the transport tension system another magnetic hysterisis drag clutch is connected to a capstan over which the carrier foil must pass before passing through the coating head. The variable speed drive system pulls the carrier foil from the supply reel around the drag capstan which then provides the required tension in the carrier foil. Adjustments are easily made by turning a knob and resetting the clutch adjustment. Rewind tension is set digitally at the remote operator’s console. An easily visible meter indicates the rewind tension so the operator can monitor the correct performance.

Speed Controlled Drive -

The drive for the carrier foil transport is provided by an explosion proof AC motor. Speed variation is accomplished with an inverter type electronic speed controller. The speed is set by a digital control on the operator’s panel. The motor and gearbox are

located on the base of the machine and are supported by rubber vibration isolators. Drive between the gearbox and the drive spindle is provided by a roller chain.

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. All the controls that require electrical power are sealed and explosion proof.
The operation of the coating machine is controlled by a programmable logic controller (PLC). All input parameters are loaded into the PLC through an operator interface panel (OTI) located at the operator station. Inputs are drum run, coating run, continuos coating option, coat/uncoat length, coating head drop and lift delay, distance setting, back (second side) selector, slurry sensor on/off and drum stop. Each of these settings is operator entered to produce the coated segment pattern that is required.

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 center 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 up to 150 deg. C. (302 deg F.). Where possible, heat shields and insulation protect the operator and internal components of the machine. Warning labels are placed near all exposed hot surfaces. 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 productions of high quality Lithium-ion battery electrodes, however the correct raw materials must be supplied by the customer to achieve optimum results.

COATING THICKNESS RANGE: -

This is very dependent on the formulation and viscosity of the coated material and the required drying rate the process requires. Some customers have achieved thickness of 200 microns on each side.

ACCURACY: -

The tolerance of the doctor blade is specified +/- 12 microns across its width.
The tolerance of the coating roller is specified +/- 10 microns across its width.

PRODUCTIVITY: -

According to prior experience, a coating rate of 2.5 meters per minute can be achieved using NMP/PVDF binder depending on thickness & material. Fast drying requires additives that prevent cracking of the coating during high temperature drying. This is an estimate only. Results may differ depending on material characteristics.

Machine speed:	0.1 to 5 m/min	(0.3 to 16.4 ft/min)
Coating Speed:	0.1 to 3 m/min	(0.3 to 9.8 ft/min)

Drying drum width:	355.6 mm	(14.0 in)
Coating roller Width:	381 mm	(15.0 in)
Carrier foil width:	330 mm	(13.0 in)
Coating width:	317.5 mm	(12.5 in)
Coating thickness:	80-300 mircrons Wet - coated both sides	
Drying Path Length	6 meters	(19 ft.)
Thickness uniformity:	+/- 5 microns	
Front/Back alignment:	+/- 1 mm	
Rewind alignment:	+/- 1 mm	
Core chuck diameter:	76 mm	(3.0 in)
Wind / Unwind diameter:	305 mm	(12.0 in)
Tension control	1-25 kg	(2.2 - 55 lbs)

Electrical power Requirements:	
Coater Power:	380 V ±10% 50 Hz , 3 Phase
Oil Heater Power	380 VAC, 50/60 Hz @ 51 Amps
Ventilation:	External vent of 118 Liters/sec.
Heated Oil:	19 liter./min. @ 150 deg. C. Required
Compressed Air	100Nl/min
Dimensions:	1371 mm x 609 mm x 2438 mm (4.5’ High x 2' Width x 8' Long)
Shipping Weight :	2800kg (6173 lb) Machine & Equipment

Acceptance Criteria

1.1 Dimensional Tolerance -

Run-out of coating reference roll	+/-10 um.
Straightness of doctor blade	+/- 12 um.

1.2 Uniformity of start and stop of coated segment +/- 1 mm

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1.3 Dimensions of coated segment length

Length +/- of setting	+/- 1mm
Width +/- of target	+/- 1mm

1.4 Registration

Front to Back longitudinal alignment	+/- 1mm
Front to Back lateral alignment	+/- 1mm

1.5 General Criteria

Max. Temperature on horizontal bed	150 C.
Max. Temperature on drying drum	150 C.
Speed Range	0 to 5 m/min.
Slurry Feed Control Functioning	Yes/No
Oil Heating System Functioning	Yes/No

3. INSTALLATION REQUIREMENTS

Air: Dust free

Humidity: As required by electrode materials

Ambient Room Temperature: 20 Deg C +/- 5 Deg