SLITTER FOR AN ELECTRODE RAW MATERIAL SHEET AND THE SLITTING PROCESS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to slitting an electrode raw material sheet for an electrical component.

Description of Prior Art

Fig. 16 shows a conventional slitter to slit an electrode raw material sheet. The slitter **a** comprises an unwinding section **c** in a frame **b**, a splice **f**, a feed/nip roller **g**, a slitting section **d**, an electrode cleaner **h**, an electrode holder **i**, and a winding section **e**. All the components of the slitter **a** are closely integrated, which damages the operability and accessibility making it difficult to connect an electrode when the electrode is inadvertently slit off. Further, the slitter **a** is designed so that the a wide electrode raw material sheet **j** wound on the unwinding section **c** is slit at the slitting section **d** to form plural slit narrower electrode bands to be wound on plural winding sections **e, e**. However, convex portions created on plural electrode bands when slit cause a bad influence, e.g., short-circuit, on an electrical component utilizing the electrode.

OBJECT AND SUMMARY OF THE INVENTION

An object of this invention is to provide an electrode with an excellent quality for an electrical component. Another object of this invention is to provide an electrical component with less possibility of defects and to provide a slitter with an excellent accessibility.

In order to achieve the above-objectives, this invention provides a slitter for an electrode raw material sheet comprising an unwinding section to supply an

electrode raw material sheet for an electrical component, a slitting section having a slitter for the electrode raw material sheet, and a winding section to wind the slit electrode, wherein the unwinding section, the slitting section, and the winding section are positioned apart from each other so as to increase the operability. This invention also discloses a slitter for an electrode raw material sheet comprising an unwinding section to supply an electrode raw material sheet for an electrical component, a slitting section having a slitter for the electrode raw material sheet, a forming section to form a convex portion of the slit electrode, an electrode cleaning section to clean fragments on the electrode, and a winding section to wind the slit electrode. This invention also discloses a method of slitting an electrode raw material sheet of an electrical component comprising steps of slitting the electrode raw material sheet of the electrical component by a blade section, forming convex portions on the slit electrode, removing fragments adhered on the slit electrode.

BRIEF DESCRIPTION OF THE DRAWING

The above and other objects and advantages of the present invention will become readily apparent by reference to the following detailed description when considered in conjunction with the accompanying drawings.

Fig. 1 represents a drawing of a plurality of types of electrode structures containing an electrode material;

Fig. 2 is a drawing of an electrode structure containing electrode active material;

Fig. 3 is a drawing to explain a fixing or adhesion device;

Fig. 4 represents a drawing each showing an ion conductive polymer layer;

Fig. 5 represents a drawing of a slitter structure;

Fig. 6 represents a drawing of slitting an electrode raw material sheet;

Fig. 7 represents a drawing of upper and lower blades in the slitting section;

Fig. 8 represents an enlarged drawing of the first electrode cleaning section and a forming section;

Fig. 9 represents an enlarged drawing of the forming section;

Fig. 10 represents a partially enlarged drawing of the blade and the blade cleaning section;

Fig. 11 represents a drawing of the first electrode cleaning section;

Fig. 12 represents a drawing of the second electrode cleaning section;

Fig. 13 represents a drawing of explaining a suction device in the second electrode cleaning section;

Fig. 14 represents a drawing of a drive part of the second electrode cleaning section;

Fig. 15 represents a drawing to explain a press-sliding and kneading device; and

Fig. 16 represents a drawing of a conventional slitter structure.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

The embodiments of the invention are next described while referring to the accompanying drawings.

Electrical component

In an electrical component, in which ions migrate between electrodes, ion conductive materials are arranged between electrode structures as electrodes, and ions migrate within the ion conductive materials and electric current flows between the electrodes. For instance, such an electrical component includes a battery, an electrical double layer capacitor, etc.

In a battery, ion conductive materials are arranged between two types of electrode structures, i.e. a positive electrode structure and a negative electrode structure, and ions (including protons, i.e. cations of hydrogen) migrate from one of the electrode structures to the other electrode structure and are accumulated there. In an electrical double layer capacitor, ion conductive materials are

arranged between a pair of electrode structures, and an electrical double layer is formed between a material with high surface area in the electrode structure and an electrolyte of the ion conductive material.

Electrode structure

An electrode structure is used as an electrode of an electrical component, and it can deliver and receive electricity to and from ions or it can attract ions. In this respect, an electrode structure 1 comprises a layer of electrode material 13 (an electrode material layer 12) on a current collective member 11 as a conductive material such as aluminum or copper, and the electrode material can deliver and receive electricity to and from ions and has electric attracting power.

As shown in Fig. 1 (A), the electrode material 13 is used as a positive electrode structure of a battery using particulate material comprising bonded particles of powdery electrode active material such as $LiCoO_2$. As shown in Fig. 1 (B), the electrode material 13 is used as a negative electrode structure of a battery and uses particulate material such as graphite, hard carbon, etc. of powdery electrode active material.

As shown in Fig. 1 (C), the electrode material 13 uses a particulate material such as activated carbon, i.e. a powdery high surface area material with larger surface area, and is used as an electrode structure 1 of an electrical double layer capacitor. In Fig. 1, the electrode material layer 12 is formed on one surface of a current collective member 11, while the electrode material layer 12 may be provided on both surfaces.

In Fig. 1 (D), the powdery electrode material 13 of Fig. 1 (A) is covered with ion conductive polymer, and it is used as a positive electrode structure of a battery. In Fig. 1 (E), the powdery electrode material 13 of Fig. 1 (B) is covered with an ion conductive polymer, and it is used as a negative electrode structure of a battery. In Fig. 1 (F), the powdery electrode material 13 of Fig. 1 (C) is covered with the ion conductive polymer, and it is used as an electrode structure

1 of an electrical double layer capacitor.

Fig. 2 shows a process to produce the electrode structure 1 of Fig. 1 (D). As shown in Fig. 2, the powdery electrode material 13 comprises bonding particles such as $LiCoO_2$, and it is covered with an ion conductive polymer 16 and is attached to a current collective member 11. The electrode structure 1 as shown in each of Fig. 1 (E) – Fig. 1 (F) can also be produced in a similar manner. The conductive material 14 arranged in the electrode structure enhances electrical or electronic conductivity between the electrode materials, and also enhances electrical conductivity between the electrode material 13 and the current collective member 11 to improve current collecting efficiency.

Here, "adhere" or "adhesion" means that ions are attached in such manner that the ions can migrate between the ion conductive polymer 16 and the entire surface of the powdery electrode material. It means that the ion conductive polymer 16 adheres to the surface of the powdery electrode material 13 and covers it with the ion conductive polymer 16. The finer the particles are, the more active the powdery electrode material 13 is. When it is adhered to and covered by the ion conductive polymer 16, the activity is suppressed and can be turned to a more stable state.

When the deposit of the ion-conducting polymer 16 is thick, the electrical conduction decreases, and the current (charge) collection is poor. Accordingly, forming a thin coating of ion-conducting polymer is preferable.

The word "powdery" in the powdery electrode material 13 and the powdery conductive material 14 means the condition of a material in a fine powder state. In certain cases, this fine particle substance refers to a state wherein a large number of substances in a fine particle state constitute an agglomeration.

Relation to terminologies used to explain the electrode structure 1 will be explained hereunder. In Fig. 1, the electrode structure 1 is obtained by forming

the electrode material layer 12 on the current collective member 11. The electrode material layer 12 has the electrode material 13 and also has an electrically-conductive material 14 and a binder 15 as required. The electrode material 13 is an electrode active material used as an electrode of a battery or a high surface area material used as an electrode such as electrical double layer capacitor.

The electrode active material means a powdery electrode active material for positive electrode such as $LiCoO_2$ to be used as a positive electrode, or a powdery electrode active material for negative electrode such as carbon material to be used as a negative electrode.

Formation of the ion conductive polymer layer to the electrode structure

The ion conductive polymer layer is formed on a surface of the electrode structure. Dissolving ions on the ion conductive polymer layer facilitates migration between the pair of electrode structures. Simultaneously, the electrodes facing each other do not contact, thereby functioning to eliminate the problem of causing any short-circuit of the electrode.

Electrode raw material sheet

The electrode raw material sheet is to be slit to be used as electrode bands and for example may be the electrode structure formed on a wide surface of the current collective member or the electrode structure forming the conductive polymer layer thereon.

Electrode active material

As the electrode active material, a material where ions can be placed into or removed from, or a π-conjugate conductive macromolecular material may be used. For instance, there is no specific restriction on the use of the electrode active material to be used as a positive electrode of a nonaqueous electrolyte

battery, but in case of a chargeable secondary battery, a chalcogen compound where lithium ions can be placed into or removed from, or a complex chalcogen compound containing lithium may be used.

FeS_2, TiS_2, MoS_2, V_2O_5, V_6O_{13}, and MnO_2 may be employed as the above-chalcogen compounds. The chalcogen compound having lithium as described above includes $LiCoO_2$, $Li_xNi_yM_{1-y}O_2$ (where M represents at least one type of metal element selected from a transition metal or aluminum, or more preferably, it represents at least one type of metal element selected from Co, Mn, Ti, Cr, V, or Al, and $0.05 \leqq x \leqq 1.10$ and $0.5 \leqq y \leqq 1.0$), e.g., $LiNiO_2$, $LiMnO_2$, $LiMn_2O_4$. Using oxide, salt or hydroxide of lithium, cobalt, nickel, or manganese as starting materials, these starting materials are mixed in adequate composition, and the mixture is fired in the temperature range of 600℃ - 1000℃ under an oxygen atmosphere.

There are no particular restrictions on the electrode active substance used as the negative electrode for non-aqueous electrolyte batteries. However, a material allowing lithium ion insertion/separation may be used, and lithium metal, lithium alloys (alloys such as lithium and aluminum, lead, indium) and carbon quality materials may be utilized.

Polyacetylene types, polyaniline types, polypyrrole types, polythiophene types, poly-ρ (para) –phenylene types, polycarbazole types, polyacene types and sulfur polymer types are among the useful π-conjugated conductive macromolecular materials.

In particular, in a nonaqueous electrolyte primary battery, a higher battery capacity can be obtained when lithium metal is used in the negative electrode. Lithium metal not in powdery state may be used.

Also, in the nonaqueous electrolyte secondary battery, an excellent cycle service life can be attained if a carbon material where lithium ions can be placed into and removed from is used as the negative electrode. There are no particular

restrictions on the carbon material used but materials such as pyrolytic carbon types, coke types (pitch coke, needle coke and petroleum coke, etc.) graphite types, glass carbon types, organic macromolecular compound fired products (carbonized pieces baked to a suitable temperature such as phenol resin, furan resin) carbon fibers and active carbon may be utilized.

Electrode material with larger surface area

The electrode material with larger surface area is a powdery high surface area material, which can attract many ions to the surface. It has preferably a specific surface area of 500 m^2/g or more, or more preferably 1000 m^2/g or more, or most preferably 1500 m^2/g – 3000 m^2/g. Also, it has preferably average particle size of 30 μm or less, or more preferably 5 – 30 μm. If the specific surface area and average particle size are out of the above range, capacitance is too high, and it may be difficult to obtain an electrical double layer capacitor with low resistance.

As the powdery high surface area material, it is preferable to use activated carbon, which can be obtained from carbon material by a steam activation method or by a melted KOH activation process. As the activated carbon, coconut shell activated carbon, phenol type activated carbon, petroleum cokes type activated carbon, polyacene, etc. may be used. These materials can be used alone or in a combination of two types or more. Among those, because of a large electrostatic capacity, phenol type carbon, petroleum cokes type activated carbon, and polyacene are preferable

Electrically-conductive material

The conductive material is used to increase electrical conductivity of the electrode structure, and there is no specific restriction. For instance, carbon black, ketchen black, acetylene black, carbon whisker, natural graphite, artificial graphite, metal fiber, and metal power such as titanium oxide, ruthenium oxide, etc. may be used. These materials may be used alone or in a combination of two

types or more. Above all, it is preferable to use one type of carbon black, i.e. ketchen black or acetylene black. Average particle size of the powdery conductive material is preferably 10 – 100 nm, or more preferably 20 – 40 nm.

Ion conductive salt

As the ion conductive salt, any material normally used for electrochemical product may be used, and there is no specific restriction. In particular, it is preferable to use a salt obtained by combination of quaternary onium cation expressed by general formula $R^1R^2R^3R^4N^+$ or $R^1R^2R^3R^4P^+$ (where R^1 – R^4 each represents an alkyl group having 1 – 10 carbon atoms and may be the same or different) with anion such as BF_4^-, $N(CF_3SO_2)_2^-$, PF_6^-, ClO_4^-, etc.

More concretely, as the ion conductive salt used for the double-layer capacitor, the following material may be used: $(C_2H_5)_4PBF_4$, $(C_3H_7)_4PBF_4$, $(C_4H_9)_4PBF_4$, $(C_6H_{13})_4PBF_4$, $(C_4H_9)_3CH_3PBF_4$, $(C_2H_5)_3(Ph\text{-}CH_2)PBF_4$ (where Ph represents a phenyl group), $(C_2H_5)_4PPF_4$, $(C_2H_6)PCF_3SO_2$, $(C_2H_5)_4NBF_4$, $(C_4H_9)_4NBF_4$, $(C_6H_{13})_4NBF_4$, $(C_2H_6)_6NPF_6$, $LiBF_4$, $LiCF_3SO_3$, etc. These materials may be used alone or in a combination of two types or more.

As the ion conductive salt used for nonaqueous electrolyte secondary battery such as lithium ion battery, any material normally used for electrochemical product may be used, and there is no specific restriction. For instance, $LiClO_4$, $LiBF_4$, $LiAsF_6$, $LiPF_4$, $LiSbF_6$, $LiCF_8SO_3$, $LiCF_3COO$, $NaClO_4$, $NaBF_4$, NaSCN, KBF_4, $Mg(ClO_4)_2$, $Mg(BF_4)_2$, $(C_4H_9)_4NBF_4$, $(C_2H_5)_4NBF_4$, $(C_4H_9)_4NClO_4$, $LiN(CF_3SO_2)_2$, Et_4NPF_3 (where Et represents an ethyl group), etc. may be used. These materials may be used alone or in a combination of two types or more.

Electrolyte

As organic electrolyte, for example toroidal or heterocyclic carbonate, heterocyclic carboxylic acid ester, toroidal or heterocyclic ester, phosphoric acid

ester, lactone compounds, compounds such as amide compounds, or a mixture of the above, may be employed. As the toroidal carbonate, for example alkylene carbonate such as butylenes carbonate, propylene carbonate (PC), and ethylene carbonate (EC), may be employed. As the heterocyclic carbonate, for example dialkene carbonate such as diethyl carbonate (DEC), dimethyl carbonate (DMC), and methyl carbonate (MEC), may be employed.

As the heterocyclic carboxylic acid ester, for example methyl acetate and propionic acid methyl may be employed. As the toroidal or heterocyclic ether, for example tetrahydrofurane, 1,3-dioxolan, and 1,2-dimethoxyethane may be employed. As the phosphoric ester, for example phosphoric acid trimethyl, phosphoric acid ethyldimethyl, phosphoric acid diethylmethyl, phosphoric acid tripropyl, phosphoric acid tributyl, phosphoric acid tri (trifluoromethyl), phosphoric acid tri (trichloromethyl), phosphoric acid tri (trifluoroethyl), phosphoric acid tri (perfluoroethyl), 2-ethoxy 1, 3, 2-dioxaphosphoran-2-on, 2-trifluoroeethoxy-1, 3, 2-dioxaphosphoran-2-on, 2-methoxyethoxy-1, 3, 2-dioxaphosphoran-2-on, may be employed.

As lactone compounds, for example γ - butyrolactone may be employed. As nitrile compounds, for example acetonitrile may be employed. As amide compounds, for example dimethylformamide may be employed. Among these, it is preferable if toroidal carbonate, heterocyclic carbonate, phosphoric acid ester, or a mixture of these are employed because of a battery action with a high charge-discharge capacity and a high power output.

Ion conductive polymer

The ion conductive polymer is a polymer, which can dissolve at least an ion conductive salt such as lithium salt as given below at a concentration of 0.1 M (mol/l) or more, and the polymer dissolving ion conductive salt such as lithium salt at a concentration of 0.1 M or more shows electrical conductivity or 10^{-8} S (siemens)/cm or more at room temperature. Preferably, it is an ion conductive polymer, which dissolves at least ion conductive salt such as lithium salt at

concentration of 0.8 – 1.5 M and exhibits electrical conductivity of 10^{-3} S/cm to 10^{-5} S/cm at room temperature.

The lithium salt is at least one type of lithium salt having ClO_4^-, $CF_3SO_3^-$, BF_4^-, PF_6^-, AsF_6^-, SbF_6^-, $CF_3CO_2^-$ or $(CF_3SO_2)_2N^-$ as anion.

Here, description will be given on the relationship of the terms relating to the ion conductive polymer. The material for forming the ion conductive polymer is a material for preparing an ion conductive polymer layer 2 to be formed on the electrode structure 1 or an ion conductive polymer, which is adhered to a powdery electrode material. It represents an ion conductive polymer itself, an ion conductive polymer raw material, or both. A coating material 22 for forming the ion conductive polymer is a material to be coated for forming the ion conductive polymer layer, and it is a mixture of the material for forming ion conductive polymer itself or ion conductive salt or solvent.

Ion conductive polymer raw material

The ion conductive polymer raw material is a material, which is turned to an ion conductive polymer by polymerization, crosslinking, etc. when energy is supplied from outside. The energy to be supplied is heat, ultraviolet ray, light, electronic beam, etc. The ion conductive polymer raw material is added to give physical strength such as form a retaining property.

Under the condition where the ion conductive polymer itself and the ion conductive polymer raw material coexist, energy is supplied from outside, and the ion conductive polymer raw material is allowed to react, and 3-dimensional network is formed. In this case, the ion conductive polymer itself is entangled with the 3-dimensional network (entanglement). This is called a "semi-interpenetrating network system" and shows excellent physical property. The ion conductive polymer having such a structure is described in the patent publication JP-A-8-225626 as filed by the present inventors.

The ion conductive polymer thus obtained has a high strength, absorbs the solvent well and has a high adhesive strength. The ion conductive polymer obtained from the ion conductive polymer itself and ion conductive polymer raw material is such that a polymer dissolving lithium salt at a concentration of 0.1 M or more shows electrical conductivity of 10^{-8} S (siemens)/cm or more, or more preferably 10^{-5} S/cm or more, or most preferably 10^{-3} S/cm or more at room temperature.

A cellulose type semi-interpenetrating network system (IPN) is described in JP-A-8-225626, PVA type semi-interpenetrating network system is disclosed in Japanese Patent Application 11-78087 (PCT/JP 00/01734), polyglycidol semi-interpenetrating network system is disclosed in Japanese Patent Application 10-358825 (PCT/JP 99/07039), and polyurethane type semi-interpenetrating network system is disclosed in Japanese Patent Application 11-78085 (PCT/JP 00/01731).

Current collective member

The current collective member 11 may be any material which allows electric current to pass. Its shape and material are selected depending upon each electrical component. As an example, a conductive material such as aluminum, copper, etc. is formed in planar shape, or in form of a foil or mesh. The surface is processed by a chemical, electrical or physical process or by a process combining these processes, and surface irregularities and coarse surface are formed to provide a current collective member with better adhesion property. In case of the current collective member 11 in form of planar shape or foil, one surface or both surfaces are used depending on the structure of the electrical component, and the electrode material is attached on one surface or both surfaces. A wider current corrective member may be used for an electrode raw material sheet.

In the following, description will be given on a method for manufacturing the

electrode raw material sheet:

Process of manufacturing electrode raw material sheet

In a process of manufacturing electrode raw material sheet 4, a solvent is added to the electrode material to turn it to a liquid and paste-like state to be thinly coated on the surface of the current collective member 11. After coating, the solvent is evaporated, the product is dried, and an electrode raw material sheet 4 with the electrode material layer 12 formed on the wide current collective member is obtained. As the device to coat on the current collective member 11, a doctor knife applicator is used. The electrode material 13 existing in the electrode material layer 12 may be coated with an ion-conducting polymer 16. In addition, a binder such as a nonion-conducting polymer such as PVDF may be used here.

The electrode material layer 12 thus coated and dried may be pressed against the current collective member 11 to tightly fix it. To fix this, a fixing or adhesion device 6 as shown in Fig. 3 is used. In the fixing or adhesion device 6, the electrode raw material sheet is produced by sandwiching an electrode structure 1 between pressure rollers 61, rotating the backup rollers 62, 62 under pressure between the pressure device 63 and a fixed member 64, and tightly fixing the electrode material layer 12 on the current collective member 11. As the electrode raw material sheet 4, the ion-conducting polymer layer 2 may be attached on the electrode material layer 12.

The electrode raw material sheet obtained accordingly may be 100 – 200 μ m in total thickness depending on the condition of fixing. However, the tensile strength is about 1kg/cm, which has a significantly lower edge strength comparing with a magnetic tape and a metallic foil.

Formation of the ion conductive polymer layer to the electrode structure

A coating material 22 for forming a paste-like ion conductive polymer layer to serve as the ion conductive polymer layer 2 is thinly coated on the surface of the electrode material layer 12 of the electrode structure 1 as shown in Fig. 4 using a doctor knife applicator 21 (Fig. 4 (A)), and an ion conductive polymer layer 2 is formed on the electrode structure 1 (Fig. 4 (B)). The coating material 22 for forming the ion conductive polymer layer is a material for forming the ion conductive polymer layer 2 by coating, and it is the ion conductive polymer forming material or a mixture of this with ion conductive salt such as lithium salt or a solvent.

In case of the coating material 22 for forming ion conductive polymer layer, which is a mixture of ion conductive polymer forming material with organic solvent, it is dried after coating, and the solvent is purged from the ion conductive polymer layer 2 (Fig. 4 (C)). When the coating material 22 for forming ion conductive polymer layer mixed with ion conductive salt such as lithium salt is coated on the ion conductive polymer forming material, ions such as lithium ions are dissolved in the ion conductive polymer layer 2.

In the following, description will be given on a slitter to slit the electrode raw material sheet:

Slitter

The slitter 3 is to slit the electrode raw material sheet 4 into predetermined size, and one example of this is shown in Fig. 5. The slitter 3 for the electrode raw material sheet 4 comprises an unwinding section 31 to supply the electrode raw material sheet 4, a slitting section 32 having a slitter for the electrode raw material sheet 4, a forming section 35 to form a convex portion of the slit electrode, cleaning sections, i.e., a first electrode cleaning section 33 and a second electrode cleaning section 34 to clean fragments on the electrode, and a winding section 36 to wind the cleaned electrode.

The unwinding section 31, the slitting section 32, and the winding section 36 are

positioned away from each other for example as shown in Fig. 5 to be positioned on a floor. The unwinding section 31, the slitting section 32, and the winding section 36 are independently positioned as required. A rotatable workbench 44 stands or lays between the slitting section 32 and the winding section 36 as shown in Fig. 5.

An operator may step on the workbench 44 to operate. Accordingly, positioning the unwinding section 31, the slitting section 32, and the winding section 36 away from each other and positioning the workbench 44, operability of the slitter increases, which facilitates the connection of an electrode when accidentally cut off.

As shown in Fig. 6(A), the wide electrode raw material sheet 4 is slit into electrode bands 41 by a blade section 320, and the slit adjacent electrode bands 41 are orthogonally separated up and down relative to a pre-slit electrode surface. As shown in Fig. 6(B), when the wide electrode raw material sheet 4 is slit by a blade section 320, tips of the blades bite in the electrode raw material sheet 4.

Accordingly, as in Fig. 6(C), the convex portion 17, i.e., a projection or high edge portion, is created around the slit portion. The convex portion 17 on the electrode causes a short-circuit between the electrodes and possibly gives a bad influence on the electrical component. Then, the forming section 35 presses the convex portion 17 as in Fig. 6(D) to conduct smoothing on the surface.

Unwinding section

The unwinding section 31 supplies the electrode raw material sheet 4 to the slitting section 32. In case of using a wide electrode raw material sheet, the unwinding section 31 is equipped with an unwinding core-like member 311 to wind to hold the electrode raw material sheet 4. The electrode raw material sheet 4 unwound from the unwinding core-like member 311 is pulled by an infield roller 314, guided by a guide rollers 46, 46, passes through a temporary fixing section 312 having a horizontally arranged splice mount, passes through a

vertically positioned observation section 313 and each tension detection section 45, and supplied to the slitting section 32.

The temporary fixing section 312 is a section to connect the end of the previous electrode raw material sheet 4 and the top of the current electrode raw material sheet 4. The observation section 31 is a section where the operator observes the movement of the electrode raw material sheet 4 to find out any defective portion in the electrode raw material sheet 4 and any failure in the movement. The infield roller 314 controls the infield movement of the electrode raw material sheet 4 and controls the tension accordingly. The tension of the electrode raw material sheet 4 is detected by each tension detecting section 45 before and after the infield roller 314.

Slitting section

The slitting section 32 has knives, i.e., blade section 320, to slit the electrode raw material sheet 4. For example as shown in Fig. 7, the blade sections 320, 320 are fixed on an upper and a lower rotational shaft 321, 321. Upper blades 322 of the upper blade section 320 are positioned around the rotational shaft at the predetermined locations with upper spacers 324 and an upper gap spacer 325. The upper blades 322 are fixed with the upper spacers by upper blade coned disc spring holders 326 with intervals. Therefore, a top of each upper blade 322 is deformable in the axial direction relative to the rotational shaft 321. The lower blades 323 are positioned around the rotational shaft at the predetermined locations with lower spacers 324 and an upper gap spacer 325. A top of each lower blade 323 is flat and is fixed on the side surface of the lower spacer. Each upper gap spacer 325 is to adjust a gap between the adjacent upper blades 322 while each lower gap spacer is to adjust a gap between the adjacent lower blades 323.

Accordingly, the width of the slit electrode is defined, which enables to provide the electrode 41 with the necessary width. The electrode raw material sheet 4 as shown in Fig. 8 initially contacts the rotational shaft of the lower blade section to

be inserted between the two blade sections, and the top of the upper blades 322 are deflected and deformed to be slit by upper and lower blades 322, 323 functioning like a scissor.

Fragments 42 such as from the electrode layer adhered on the upper and lower blades 322, 323 are removed by blade cleaners 327, 327. For example, the blade cleaners 327, 327 are positioned near outer circumferential surface of the upper and lower blade sections 320, 320, which suck to supply airflow around the blade sections 320, 320, thereby removing the fragments 42. Each blade cleaner 327 has a suction device and is designed to generate an airflow with appropriate controlled speed to separate the fragments 42 on the blade sections 320 and airflow with appropriate speed to carry the separated fragments 42 thereon. Accordingly, if an air duct 3272 has a wider portion, the airflow becomes slower and therefore the air duct 3272 is designed to provide constant airflow speed at any portion.

An arrangement of parallel blocks 3271 of the blade cleaner 327, for example, is mounted near the blade section 320, supplies airflow of controlled speed between the blade 320 and the parallel blocks 3271, and carries the fragments by the airflow via the air duct 3272 formed in the parallel blocks 3271. The controlled speed of the airflow passing through the clearance between the blade 320 and the parallel section 3271 at least needs to be uniform, for example in the range of 0.1mm to 2 mm, preferably 0.1mm to 0.5 mm. The controlled airflow speed should be in the range of 5 to 25m/s. and preferably 7.5to 20m/s. The parallel section 3271 needs to be designed in an appropriate length which enables to provide a uniformed airflow and a stable airflow direction.

Further, the fragments 42 means articles that are not preferable to electrode such as powder or flakes of 30 μ m – 50 μ m. In addition, the blade section 320 is located each at a upper side and a lower side for a convenience of the explanation. However, the three-dimensional location arrangement may be decided as necessary.

Forming section

The forming section 35 is to form a convex portion 17. The forming section 35 for example as shown in Fig. 8 has a pair of rollers sandwiching the slit electrode bands 41 therebetween, and the rollers rotate to press the convex portions 17 to conduct smoothing thereon. Each pair of rollers for example include a drive roller 351 and a nipple roller 352, wherein the drive roller 351 is to rotate while the nipple 352 is abuttable against the drive roller 351. The surface hardness of the drive roller 351 and the nipple roller 352 is decided according to the type of electrode to be formed.

For a thin hard electrode, for example a steel roller having a hard surface may be used for both drive and nipple rollers 351, 352. For a thick elastic easily deformable electrode, for example a steel roller having a hard surface may be used for the drive roller 351 while a resilient roller which is more resilient than the steel roller may be used for the nipple roller 352.

For example as shown in Fig. 9, the drive rollers 351, 351 and the nipple rollers 352, 352 in the forming section may be mounted on a foundation base 353. The driving shaft 355 rotates the drive roller 351. The nipple roller 352 is rotatably mounted on a nipple roller arm 356 and abuts against the drive roller 351 to rotate according to the rotational speed of the drive roller 351. A cylinder 354 is connected to the nipple roller arm 356, thereby rotating the nipple roller arm 356 with the rotational axle as the fulcrum due to the telescopic motion of the cylinder 354. Because of this telescopic motion of the cylinder 354, the nipple roller 352 may be abutted against or departed from the drive roller 351, thereby adjusting the pressure at the abutment between the two rollers.

The steel roller and the resilient roller need to have sufficient hardness to form the convex portions, and for example the steel roller may be obtained by using a tool steel as a base metal to be coated with hard chromium plating and

conducting smooth grinding on the same. In addition, as required, a hard metal and ceramic spraying may be used for finishing. The resilient roller may be polyimide or denatured urethane, and the hardness for example may be 95 to 97 at Rubber Code Shore D Scale of JIS.

The rollers in the forming section 35 function as out-feed rollers and restrict the feeding speed of the electrode 41 by the rotational speed. As such, the in-feed roller 314 and the out-feed rollers in the forming section 35 enable to feed an electrode therebetween with the predetermined tension and feeding speed. The blade section 320 is located therebetween and is designed to rotate in the same direction as the electrode but for example about 0 to 3% faster.

In the forming section 35, adjacent slit electrode bands 41 are separated to be fed in upper or lower direction. Distance between the upper and lower sections depends upon the distance relation among the slitting section 32, the first electrode cleaning section 33, and the forming section 35. Accordingly, the arrangement above improves operability of the adjacent slit electrode bands 41.

Electrode cleaning section

The electrode cleaning sections 33, 34 are designed to remove the fragments 42 such as powder and foreign object adhered on the slit electrode 41. For example, the first electrode cleaning section 33 is located after the slitting section 32 before the forming section 35, i.e., between the slitting section 32 and the forming section 35. The second electrode cleaning section 34 is appropriately positioned between the forming section 35 and the winding section 36. The fragments 42 are removed more accurately by including the first and second electrode cleaning sections 33, 34.

First electrode cleaning section

The first electrode cleaning section 33 mainly removes fragments created at slitting. If forming is conducted on an electrode while having fragments thereon, the fragments may be adhered and fixed on the electrode. The first

electrode cleaning section 33 for example as in Fig. 11 uses brushes 331 and a suction device so as to remove the fragments. The brush 331 may be a wire brush made from plural stainless wires, and plural brushes 331 are positioned in the width direction of the electrode or the crossing direction with the electrode feeding with the predetermined intervals sufficient for the fragments to pass through.

The brushes 331 are arranged not to make one straight line but to make a staggered line relative to the electrode feeding direction. The brush 331 abuts against the electrode 41 by a spring 332 so as to contact fragments on any portion of the electrode 41. The suction device makes an airflow 336 between wires and sucks to catch the fragments on the electrode at a filter together with the brushes. As required, the first electrode cleaning section 33 may be provided at both sides of the electrode. In this case, the brushes 331, 331 at both sides of the electrode are arranged to indirectly face each other around the contact point with the electrode and with the brushes 331at one side comes after the other side with the predetermined interval between the two in the feeding direction. Accordingly, the brush 331 contacts the surface of the electrode 41 well.

The first electrode cleaning section 33 is configured such that the brush 331 is installed on a holding member 333 via a spring 332. The electrode 41 is fed to contact with the brush 331 to be brushed removing the fragments and to carry the fragments into a transfer tube 334 by the airflow. Then, the fragments are collected by the filter and are gathered in a dust/fragment collection container.

The transfer tube 334 for example may be an angular tube which may be positioned in the crossing direction relative to the electrode feeding direction. An airflow adjuster 335 is positioned at the electrode side of the transfer tube 334 so as to adjust a clearance with the electrode 41 into which a high airflow is supplied to efficiently carry the fragments. The clearance for example may be in the range of 1.5 mm – 2 mm. A clearance between the pair of the first electrode cleaning section 33 at their airflow adjusters is in the range of 3 mm – 4 mm.

As shown in Fig. 11(B), the adjacent slit electrodes 41 are orthogonally separated up and down relative to a pre-slit electrode surface, and a portion near the tip of brush 331 contacts an end surface of the electrode 41 so that the fragments on the end surface of the electrode may be well removed. As such, in order to divide the electrode orthogonally up and down and to brush the end surface of the electrode, the distance between the upper electrode band and the lower electrode band is decided based on a various conditions such as an shape of electrode and location of the device. For example, the first electrode cleaning section 33 is positioned adjacent to the slitting section 32, and if the distance between the first electrode cleaning section 33 and the forming section 35 is 200mm – 250mm, the distance between upper and lower electrode bands at the forming section 35 is about 5mm.

Second electrode cleaning section

The second electrode cleaning section 34 is to remove fragments mainly created at forming, and for example as shown in Fig. 12 the feeding roller 342 and the storing roller 344, on which the sheet roll 341 is rolled, an abutment roller 343, and a winding guide 347 are installed in a securing body 348. The second electrode cleaning section 34 for example uses the sheet roll 341 abutting against the surface of the electrode 41. The sheet roll 341 for example may have plural holes through which articles such as nonwoven fabric and woven fabric passes.

The sheet roll 341 for example is formed by forming an electrode band to be rolled on the feeding roller 342 and feeding the electrode band from the feeding roller 342 to be rolled on the storing roller 344 via the abutment roller 343 abutting against the electrode 41. The slit electrode 41 is inserted between and abuts against the winding guide 347 and the abutment roller 343 to be fed. The sheet roll 341 contacts the electrode 41 at the abutment roller 343 to remove the fragments from the electrode 41. The electrode cleaning section 34 has a suction device to suck the inside of the abutment roller 343 as required.

Plural holes are formed on the circumferential surface of the abutment roller 343, and the fragments are effectively removed by sucking the outside air from the holes. A suction pipe may be used as the abutment roller 343 having holes on its circumferential surface. The holes on the abutment roller are arranged to comply with the width of the electrode. Rotation of the abutment roller, i.e., driving and braking, is controlled by a motor so as to determine the feeding speed of the sheet roll 341.

A front half on the circumferential surface of the abutment roller/pipe 343 contacts the sheet roll 341 and a back half of the abutment roller/pipe 343 is covered by a suction plate 346. Accordingly, suction is conducted only at a portion where the electrode 41 and the sheet roll 341 are pressed to contact each other. The suction plate 346 does not rotate and only the abutment roller/pipe 343 rotates. If the feeding direction of the sheet roll 341 is opposite to that of electrode 41, a relative speed of the electrode 41 and the sheet roll 341 becomes larger and more sheet roll surface contacts with the electrode.

As a result, the fragments on the electrode can easily be transferred to the sheet roll 341. When the suction device sucks inside of the abutment roller, the fragments on the electrode and the sheet roll may be sucked and removed together with the movement of the sheet roll 341 and filtered to be gathered in the duct/fragment collection container.

As required, the second electrode cleaning section 34 may be provided at both sides of the electrode. In this case, the abutment rollers 343 at both sides of the electrode 41 are arranged to be facing each other around the contact point with the electrode but are not directly facing each other with the predetermined interval between the two brush lines in the feeding direction.

Accordingly, a contact point between the sheet roll 341 and the electrode 41 becomes larger/longer, thereby improving the fragment removal effect. The contacting length for example may be about 10 mm. This contacting length may

be decided according to conditions such as the size of the device and thickness of the abutment roller. However, unnecessarily long contacting length prevents from uniformly maintaining the tension of every slit electrode, thereby providing a possibility of braking or slitting the electrode off.

As shown in Fig. 13, the abutment roller/pipe 343 is connected to the suction device 3420 via a piping. For example, the piping is connected to a valve 3415, a flowmeter 3416, a dust/fragment collection filter 3418, a suction device 3420, and a high performance filter 3419. The valve 3415 is to adjust the amount of suction of the pair of second electrode cleaning sections 34. The flowmeter 3426 is utilized to measure the amount of suction so as to adjust the amount of suction. The duct/fragment filter 3418 is designed to collect the sucked fragments and alarms when clogged up. The collected fragments are gathered in the dust/fragment collection container.

The suction device 3420 for example may be a multistage high static pressure blower. The high performance filter 3419 has an alarm unit, which alarms when the filter leaks. A gas suction system such as the piping, the valve 3415, the flowmeter 3416, the dust/fragment collection filter 3418, the suction device 3420, the high performane filter 3419, and the suction device 3420 may be used at the blade cleaning section 327 and the first electrode cleaning section 33.

The securing body 348 for example as shown in Fig. 14 may removably be assembled with the drive section 349 along the slide rail 3414. The feeding roller 342 mounted on the securing body 348 the storing roller 344, and the abutment roller 343 are connected to joints so as to rotate and slide in the predetermined direction by the motor/driving device of the drive section 349 and the brake/slide device.

For example, the feeding roller 342, the storing roller 344, and the abutment roller 44 are connected to the unwinding powder brake joint 3411, the winding torque motor joint 3410, and the motor/brake joint 341, thereby generating a rotational force and conducting slide control. An ascensor 3412 moves the

second electrode cleaning section 34 to abut against or away from the electrode 41. As such, the second electrode cleaning section 34 may be moved and the securing body 348 may be detached from the drive section 349, thereby facilitating the maintenance of the second electrode cleaning section 34 and exchange of the sheet roll 341.

Winding section

The winding section is to hold the slit electrode 41. The winding section for example is winding cores 361 including plural reels and cores, and the narrowly slit electrode bands 41 are to be wound thereon. A stopper pad 46 and a tension detector 45 are positioned in front of the winding core 361. The stopper pad 46 is to temporary hold and stop the slit electrode band 41. The tension detector 45 is to measure the electrode tension between the forming section 35 and the winding core 361.

Description will be given below on an example of slitter operation.

Initial setting

A predetermined setting is to be made prior to the slitter operation. As an example of negative electrode, the setting needs to be made as to a tailoring speed of e.g., 20/min.), a blade slip ratio of e.g., about 1% added to the electrode feeding speed, a provisional winding tension, a slit length of e.g., 500 m, a speed curve at rise time, an automatic stop curve, an automatic on/off function for the second electrode cleaning section, pressure at the forming section, a unwinding tension, slitting tension, a nonwoven fabric feeding speed at the second electrode cleaning section, and a timing of stall tension preventing the nonwoven fabric sagging prior to the operation.

The remaining electrode raw material sheet and the remaining nonwoven fabric as to the length are to be displayed on the operation control panel, so that the operation does not automatically stop for lack of electrode raw material sheet

and nonwoven fabric In addition, it is designed that the operation does not stop for the dust/fragment collection container full of fragments.

Feeding the electrode into the slitter

First, the electrode raw material sheet 4 is slowly fed from the unwinding core 311 of the unwinding section and is slit into the predetermined width at the slitting section 32. Then, the slit electrode bands 41 are taped and fixed on the winding core 361 of the winding section 36 to be stall-tensioned to hold the same prior to the operation.

Slitter operation

Automatic operation of the slitter 3 starts automatically applying the stall tension. On of the pair of second electrode cleaning sections 34, for example an lower second electrode cleaning section 34, is lifted, and the winding tension is applied to prevent the sagging of the nonwoven fabric. Then, the suction device 3420 is turned on. The feeding speed of the electrode band 41 gradually increases at the initial stage to be a constant speed, then is tailored and decelerates at the end. Specifically, the electrode raw material sheet 4 is unwound from the unwinding core 311 by the in-feed roller 314.

The unwound electrode raw material sheet 4 is guided to the respective guide roller 46 and is to transferred to the slitting section 32 via the temporary fixing section 312, the observation section 313, and the respective tension detection section 45. The observation section 313 observes the feeding condition of the electrode. An back end of electrode raw material sheet and a front end of the next electrode raw material sheet are connected to make a flat surface at the temporary fixing section 312.

The tension and feeding speed of the electrode is restricted by the in feed roller 314 and the roller of the forming section 35. Feeding of the electrode raw material sheet starts from 0 and increases by 20/min. to reach the maximum

speed. Then, the feeding speed is held as the constant speed and the electrode raw material sheet is constantly slit while feeding. The feeding is automatically slowed down to pause, and the electrode 41 while a stall tension being applied is held by the stopper pad 46.

Here, since the electrode raw material sheet 4 wound around the unwinding core 311 is rather heavy, it must be carefully controlled so as not to be sagged or slit off. Therefore, tension detector 45 positioned between the temporary fixing section 312 and the observation section 313 detects the tension of the electrode raw material sheet 4 and applies the feed back to adjust the tension so as to unwind.

The electrode raw material sheet 4 is slit at the slitting section 32, and the adjacent slit electrode bands 41 are divided into upper and lower electrode bands passing through the first electrode cleaning section 33, the forming section 35, the second electrode cleaning section 34, and the tension detector 45, the stopper pad 46 so as to be wound around the winding core 361. The fragments created at the slitting are sucked and removed by the blade cleaner 372, and the fragments 42 on the electrode is sucked and removed by the first electrode cleaning section 33.

The convex portion 17 created at slitting is formed by press at the forming section 35, and the fragments 42 adhered on the electrode are sucked and removed by the second cleaning section 34. If the feeding of the electrode 41 is paused, the electrode 41 is held by the stopper pad 46 to be fixed. While holding the electrode 41 by the stopper pad 46, winding operation may be freely conducted manually. The end of the electrode band may be taped, and the reel with the wound electrode band may be removed. Then, a new empty reel may be prepared.

When finishing the operation of the slitter 3, the suction device 3420 of the second electrode cleaning section is turned off. Feeding of the sheet roll 341 is paused, and the lower second electrode cleaning section may be lowered. Since

the electrode 41 as slit accordingly has the convex portion 17, the electrode band 41 is wound evenly around the winding core without irregular winding.

In the following, description will be given on a method for manufacturing electrode material, to which ion conductive polymer is adhered.

Method for manufacturing electrode structures

To manufacture the electrode structures, ion conductive polymer or ion conductive polymer raw material or a mixture of these, i.e. the material for forming ion conductive polymer, is attached in very low thickness on the surface of an electrode material. Then, a solvent is added to turn it to liquid and paste-like state. This is coated on a current collective member and is dried to evaporate the solvent. Alternatively, the solvent may be added from the beginning, and it may be turned to paste-like state at the same time as it is adhered to the ion conductive polymer forming material.

In this case, only a slight quantity of the ion conductive polymer forming material is used. The surfaces of particles of the powdery electrode material are adhered with ion conductive polymer so that there will be no void, and that gaps between powder particles will be minimized.

To adhere the ion conductive polymer forming material with powdery electrode material, the ion conductive polymer forming material and the powdery electrode material are pressurized and ground against each other, and a pressurized product is obtained.

Pressurizing and sliding

Pressurizing and grinding is defined as an operation to grind a mixture of the ion conductive polymer forming material and the powdery electrode material against each other while pressurizing. An external force is applied to the mixtures so that they adhere to each other and the particles rotate, and this

process is performed repeatedly to obtain a press-sliding product.

Pressurizing, grinding and kneading device

A pressurizing, grinding and kneading device 5 is as shown in Fig. 15, for instance. The mixture 50 of the ion conductive polymer forming material and the powdery electrode material 13, or a mixture 50 containing this mixture and solvent, is placed in a container 51, and a main blade 52 is rotated by the main motor 522. There is a gap between a bottom 511 of the container 51 and the main blade 52.

When the main blade 52 is rotated, a part of the mixture 10 is moved between the bottom 511 of the container and the main blade 52. It is subject to press-sliding and kneaded. This procedure is repeated, and the ion conductive polymer forming material is adhered to the powdery electrode material 13. The bottom 511 of the container 21 may be flat or inclined, and the facing surface area between the main blade 52 and the bottom 511 is preferably large to increase the effective press-sliding.

In the pressurizing, grinding and kneading device 5, a dispersing blade 531 is provided in the container 51. A sub-motor 531 rotates the dispersing blade 53 at high speed, and the mixture 50 pressurized and slided is dispersed.

Container

The container 51 is provided for holding the mixture 50 which is press-slide and stirred. At the bottom of the container 51, there is provided a lower portion 5111 with a part of it at lower position. The bottom surface is inclined upward as it goes toward peripheral portion.

For instance, it is lower at the center, and it gradually goes up toward the periphery. It is formed in a bottom 211 in shape of conical mortar. The inclination angle of the lower portion 5111 is set to 120℃, for example. The bottom 511 of

the container 51 has wear resistant property. It is made of SUS, for instance, and it is formed by spraying tungsten or carbide. Plural bottom parts of this type may also be formed on the bottom surface 211.

Main blade

The main blade 52 functions together with the bottom surface 211 of the container 51, serving to press-slide and stir the mixture 10. The main blade 52, is positioned via shaft 5111 to the desired location relative to the bottom 5111 of the container 51 as shown for example in Fig. 15(B). The main blade 52 curves upwards corresponding to the slant of bottom 211 of the container 21. The main blade 22 may comprise two blades attached from the center part as shown in Fig. 15(B), or it may comprise a larger number of blades, e.g. 10 or more, depending on the amount and type of mixture.

The number of rotations of a main motor 521 driving the main shaft 522 is set low for example to 120 rpm or less, when press-sliding is performed.

The gap between the bottom surface 211 of the container 51 and the base surface of the main blade 52 is set as narrow as is necessary for press-sliding the mixture, for example 15 mm or less. This distance depends on the capacity of the press-sliding mixer 5 and on the shape of the main blade, etc.

The surface in the motion direction (press-sliding direction) of the main blade 52 is formed so that a pressing angle θ relative to the bottom surface of the container 51 is an acute angle. For example, if the cross-section of the main blade 52 is a reverse trapezoid as shown in Fig. 15(C), the pressing angle is from 3 degrees to 70 degrees. The cross-section of the main blade 52 may also be circular or have a rounded corner as shown in Fig. 15(D). The material of the main blade has wear-resistant properties, and is formed for example by thermal spraying with tungsten or carbide using SUS.

The surface of the main blade 52 opposite to the advancing direction

(direction of pressurizing and sliding) is designed in such manner that it runs almost perpendicularly to the bottom surface and at an acute angle. As a result, when the main shaft 521 is rotated in reverse direction, the mixture 50 can be collected on the periphery of the main shaft 521.

If there are plural bottom parts on the bottom surface 5111, the center parts of the main blade 52 are also disposed in positions of the bottom part corresponding to their number.

Dispersing blade

The dispersion blade 53 disperse the mixture 50 which is press-slid by the main blade 52. The dispersion blade 53 is disposed in a position at which the mixture 50 can be dispersed, and it rotates at a high speed such as 1000 to 4000 rpm by the sub-motor 531. By rotating it at high speed, the ion conductive polymer 16 or its raw material adhered on the surface of the particles of the powdery electrode material 13 are evenly dispersed over the entire powdery material.

In the following, description will be given on a method for manufacturing the electrode raw material sheet:

Example 1 for manufacturing an electrode raw material sheet (example for manufacturing a positive electrode structure)

Into a pressurizing, grinding, and kneading device, 9.1 weight parts of $LiCoO_2$ with average particle size of 5 μ m, i.e. powdery electrode active material, and 0.6 weight part of graphite powder with average particle size of 4 μ m, i.e. powdery conductive material, were placed, and the mixture was pressurized and ground for 20 minutes. Then, 0.546 weight part of an ion conductive polymer raw material (A1) and 3.5 weight parts of acetonitrile were added. The ion conductive polymer raw material (A1) is a mixture, and its composition and mixing ratio are as shown in Table 1.

Table 1

Ion-conducting polymer raw material (A1)

Substance	Mixing ratio (weight parts)
Difunctional (propylene glycol/ethylene glycol) random copolymer, SANNIX FA-103 (PO/EO=2/8, Mw=3,282, Sanyo Chemical Industries, Ltd.)	8.36
Difunctional 1, 4-butanediol	0.34
Ethylene cyanohydrin	1.27
Reaction catalyst NC-IM (Sankyo Air Products K.K.)	0.03
Total	10

The pressurized product added with the ion conductive polymer raw material (A1) was pressurized and ground for 5 hours in the pressurizing, grinding and kneading device. The pressurized product was turned to paste-like state. To the pressurized product, 0.254 weight part of polymeric MDI (MR-220; manufactured by NPU) was added, and the mixture was agitated for 5 minutes in the pressurizing, grinding and kneading device. The pressurized product was taken out, and this was placed on an aluminum foil of 20 μm in thickness and was cast using a doctor knife applicator with gap of 100 μm. This was left to stand at room temperature for 15 minutes and was then heated at 80℃ for 1 hour. The positive electrode structure thus prepared had thickness of 80 μm.

Example 2 for manufacturing an electrode raw material sheet (example for manufacturing a negative electrode structure)

Into a pressurizing, grinding and kneading device (volume capacity: 300 cc), 9.1 weight parts of graphite powder with average particle size of 5 μm, i.e. powdery electrode active material, 0.682 weight part of ion conductive polymer

raw material (A1), and 3.0 weight parts of acetonitrile were placed, and the mixture was pressurized and ground for 7 hours. The pressurized product was turned to paste-like state. Then, 0.318 weight part of polymeric MDI (MR-200; manufactured by NPU) was added, and the mixture was pressurized and ground for 5 minutes. The pressurized product was taken out and was placed on a copper foil of 20 μm in thickness and was cast using a doctor knife applicator with gap of 100 μm. This was left to stand at room temperature for 15 minutes and was then heated at 80℃ for 1 hours. The electrode thus obtained had thickness of 80 μm.

Example 3 for manufacturing an electrode raw material sheet (example for manufacturing an electrode structure for a capacitor)

To prepare an electrode for capacitor, 1.03 weight part of carbon black was added as powdery conductive material to 9.02 weight part of phenol derived activated carbon (manufactured by Kansai Chemical Co., Ltd.) as electrode material. This was processed by dry mixing using a mixer. Then, 0.48 weight part of polymer A1 was added as a binder and was mixed. Further, 5.6 weight part of acetonitrile as a solvent was added and was mixed. After mixing, the material was coated onto the collector element with a doctor knife applicator. The samples were then heated by infrared radiation or by heated air. The thickness of the electrode thus prepared was 75 μm.

The details of the procedure for manufacturing the electrode structures as described above are given in the patent applications filed by the applicants of the present invention (Japanese Patent Applications 11-262501, 11-262502, 11-2691124, and 2000-38744). In addition, the ion-conducting polymer coated on the electrode material layer is not limited to what is used in the embodiments here.

Example 4 of electrode raw material sheet (coating of the coating material for forming ion conductive polymer layer on positive electrode structure of the

battery)

One weight part of cyanoethylated dihydroxypropyl cellulose and lithium perchlorate were dissolved in tetrahydrofurane. This solution was left to stand under reduced pressure to evaporate tetrahydrofurane. Then, 0.2 weight part of polyethylene glycol dimethacrylate (oxyethylene unit number = 9) and 0.2 weight part of methoxypolyethylene glycol monomethacrylate (oxyethylene unit number = 9) were added. Further, 0.002 weight part of azobis-isobutyronitrile was added so that lithium perchlorate was to be 1 mol per 1 kg of total weight containing all components. The complex product thus prepared was viscous solution. Cyanoethylated dihydroxypropyl cellulose as described above is disclosed in JP-A-8-225626. The materials are described in: Macromolecules, 24, 4691 (1991) and Makromol. Chem. 193, 647 (1992).

Specifically, the components were added so that lithium perchlorate was to be 1 mol per 1 kg of the total weight of the mixture of lithium perchlorate + cyanoethylated dihydroxypropyl cellulose + polyethylene glycol dimethacrylate + methoxypolyethylene glycol monomethacrylate + azobis-isobutyronitrile, and the coating material 22 for forming the ion conductive polymer layer of the complex product of polymer electrolyte – lithium perchlorate was prepared.

The coating material 22 for forming the ion conductive polymer layer of the polymer electrolyte – lithium perchlorate complex product thus prepared was cast on a positive electrode structure (the electrode structure 1 prepared by coating the positive electrode material on the current collector) using a doctor knife applicator. It was left to stand at 80 ℃ for 0.5 hour, and an ion conductive solid macromolecular electrolyte film layer in semi-solid state (ion conductive polymer layer 2) was prepared.

Example 5 of electrode raw material sheet (coating of the coating material for forming ion conductive polymer layer on negative electrode structure of the battery)

On the negative electrode structure, the complex product of polymer electrolyte – lithium perchlorate (coating material 22 for forming ion conductive polymer layer) prepared in Example 4 was cast using a doctor knife applicator. This was left to stand at 80℃ for 0.5 hour, and ion conductive solid macromolecular electrolyte film layer (ion conductive polymer layer 2) was formed, and a negative electrode structure with the ion conductive polymer layer 2 was prepared. Then, the same procedure as in Example 1 was performed except that the negative electrode structure was used.

In addition, the details of the above-procedure of obtaining the ion-conducting polymer layer may be referred to the patent applications, the Japanese Patent Application No. 2000-141687, filed by the applicants of the present invention

Example 6 for manufacturing an electrode raw material sheet (electrode for a lithium-ion battery utilizing polyvinylidene vinylidene as a binder)

Regarding the preparation of the positive electrode, for example the lithium carbonate and cobalt carbonate are mixed at the ratio of 0.5 mol-0.5mol and baked at a temperature of 900℃ for 5 hours in order to obtain the positive active material. Then, the obtained 91 weight parts of $LiCoO_2$, 6 weight parts of graphite as a conductive material, and 10 weight part of polyvinylidene vinylidene as a binder are mixed to prepare the negative mixture. This mixture is dispersed in N-methyl-2-pyrrolidinone-to be slurried. The obtained slurry was evenly applied on one side of an aluminum foil of 20 μ m in thickness up to the thickness of 100 μ m, and after drying an adhesion device was used to conduct press form thereon.

To prepare a negative electrode, 90 weight parts of the grinded graphite and 10 weight parts of polyvinylidene vinylidene as a binder were mixed to prepare a negative mixture, and the mixture was dispersed in N-methyl-2-pyrrolidinone-to be slurried. This slurry is evenly applied on one side of the copper foil, as a current collective member, of 10 μ m in the thickness, and after

drying an adhesion device was used to conduct press form thereon.

This invention as described above, renders the advantages of providing an electrode with an excellent quality for an electrical component, an electrical component with less possibility of defects, and a slitter with an excellent accessibility.

It is readily apparent that the above-described invention has the advantages of wide commercial utility. It may be understood that the specific form of the invention hereinabove described is intended to be representative only, and certain modifications within the scope of these teachings will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS

1. A slitter for an electrode raw material sheet (4) comprising an unwinding section (31) to supply an electrode raw material sheet (4) for an electrical component, a slitting section (32) having a slitter (3) for the electrode raw material sheet (4), and a winding section (36) to wind the slit electrode (41), wherein the unwinding section (31), the slitting section (32), and the winding section (36) are positioned apart from each other so as to increase the operability.

2. A slitter for an electrode raw material sheet (4) comprising an unwinding section (31) to supply an electrode raw material sheet (4) for an electrical component, a slitting section (32) having a slitter (3) for the electrode raw material sheet (4), a forming section (35) to form a convex portion of the slit electrode (41), an electrode cleaning section (33, 34) to clean fragments (42) adhered on the electrode, and a winding section (36) to wind the slit electrode.

3. The slitter according to claim 2,
wherein the cleaning section (33, 34) employs a blade cleaning section to remove fragments (42) using an air flow.

4. The slitter according to claim 2 or 3,
the slitter (3) further comprising a first electrode cleaning section (33) to remove fragments adhered on the electrode between the slitting section (32) and the forming section (35).

5. The slitter according to claim 4,
wherein the first electrode cleaning section (33) comprises a brush (331) to contact fragments and a suction device to suck and to remove the fragment (42).

6. The slitter according to claim 5,
wherein the first electrode cleaning section (33) has a pair of brushes (331) indirectly facing each other, one standing after the other in the electrode feeding

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direction.

7. The slitter according to claim 5 or 6,
wherein adjacent slit electrodes (41) are orthogonally separated up and down relative to a pre-slit electrode surface.

8. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36).

9. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) to remove the same.

10. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) and a suction device (3420) to suck and to remove the fragments (42).

11. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) to remove the same, and the sheet roll (341) of the second electrode cleaning section (34) is fed by a roller (343) to be pressed against the electrode.

12. The slitter according to claim 2,

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wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) to remove the same, the sheet roll (341) of the second electrode cleaning section (34) is fed by a roller (343) to be pressed against the electrode, and the rollers (343) are positioned to face each other so that one roller sits after the other roller in the electrode feeding direction.

13. The slitter according to claim 11,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) to remove the same, the sheet roll (341) of the second electrode cleaning section (34) is fed by a roller (343) to be pressed against the electrode, and the roller (343) has a plurality of vents on an circumferential surface from which suction is conducted by a suction device.

14. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) to remove the same, and the sheet roll (341) having a plurality of vents is a nonwoven fabric.

15. The slitter according to claim 2,
wherein the cleaning section (33, 34) has a slit electrode cleaning section to remove fragments (42) adhered on the electrode between the forming section (35) and the winding section (36), and a second electrode cleaning section (34) comprises a sheet roll (341) to contact the fragments (42) and a suction device (3420) to suck and to remove the fragments (42), and the sheet roll (341) having a plurality of vents is a nonwoven fabric.

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16. The slitter according to any of claims 2 to 15,
wherein the forming section (35) has a pair of rollers (351, 352) between which the electrode is fed to conduct smoothing on the convex portion of the electrode.

17. A method of slitting an electrode raw material sheet of an electrical component, comprising the following steps:

- slitting the electrode raw material sheet (4) of the electrical component by a blade section,
- forming convex portions on the slit electrode (41), and
- removing fragments (42) adhered on the slit electrode (41).

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