NihonSpindle

Nihon Spindle Technical Report

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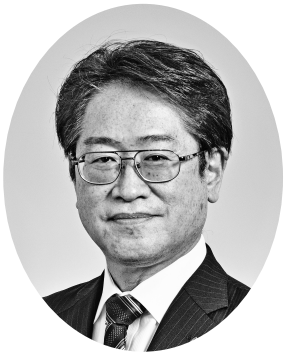
Foreword

KONDO Shigeo, President



In August 2021, we heard a news that the highest temperature in Greenland within the Arctic Circle exceeded the average temperature at this time of year as much as by 18 degrees and it rained for the first time in the history of observation. In the same month, a temperature of 48. 8 degrees, the highest in Europe, was recorded in Sicily, Southern Italy. Among the environmental issues in the world reported almost every day, measures for the carbon neutrality to deal with global warming is especially required. In such circumstances, EV shift is rapidly progressing. The number of EVs（BEVs＋PHVs）in the world finally exceeded 10 million and became 10.2 million last year, and it is said that it will be far beyond 100 million in 2030, ten years later. In the world, this EV shift is especially accelerating in Europe, and the EU announced their policy to virtually prohibit sales of gasoline vehicles including hybrid vehicles in 2035. On the other hand, Japanese automobile manufacturers, which had a lead in hybrid vehicles, fall behind overseas manufacturers in BEVs not using gasoline. They have announced plans for large investment in BEV development one after another to recover from the delay. In addition, since parts used for EVs tend to be modularized often compared to the parts of gasoline vehicles and the barriers to enter the market are low, many manufacturers including new manufactures strive to take initiative in the industry and make efforts in development.

In such circumstances, we also advance development to respond to EV shift. In this issue, we focus on flow forming, one of the processing methods of automobile parts. Leifeld Metal Spinning GmbH that participated in our group in June last year is a company that has the world’s top share in the flow forming industry with their history of 130 years and excellent technology and is an ultimate partner for our company to respond to EV shift in the future, as well as to aim to build a company group to contribute to carbon neutrality. I expect that we will continuously learn from each other to grow.

In this issue, we also introduce technologies concerning JET PASTER, which is manufacturing equipment of secondary battery materials, and dry thermal, which is equipment to support its manufacturing environment, in addition to the contents described above. Let’s work on actively in the future as well to create new products one after another that contribute to realization of a decarbonized society and resolution of various other social issues.

Company Profile of Leifeld Metal Spinning GmbH (LMS)

Leifeld Metal Spinning

NILLIES Benedikt, HILTROP Beate

Abstract

Leifeld Metal Spinning (LMS) was established in Germany in 1891 as a pioneer of spinning machines, and joined Nihon Spindle Group in June 2020. The company manufactures machine tools and delivers them from four bases to about 60 countries around the world. In this report, we introduce the history, the latest technology, and the main products of LMS.

1. Company Portrait

Strength. Trust. Certainty.

Leifeld Metal Spinning GmbH develops, manufactures, and distributes machine tools for chipless metal forming. More than 150 employees work at locations in Germany, the USA, China, and Russia. The company is present in all the major global markets due to numerous branches on all the continents. The core industries are automotive, aerospace, energy, and industrial applications. The production sites and headquarter are located in Ahlen, Germany.

The product range includes machine tools for the manufacture of various intermediate or end products. The machines are equipped with multifaceted automation solutions and can be individually adapted to suit the customer's requirements. In 130 years of business, Leifeld Metal Spinning has manufactured over 6, 125 machines and delivered them to 60 countries.

Leifeld Metal Spinning also supports its customers with a comprehensive range of services which cover the entire product lifecycle. The company offers all the services: ranging from research & development, technical service, spare parts procurement, consulting, and training to the retrofitting of second – hand machines. Leifeld develops new processes, technologies, and products, and has filed for patents on more than 140 inventions to date.

2. History

Beginning as a manufacturer of wooden barrels 130 years ago, Leifeld has advanced to become an industry–leader.

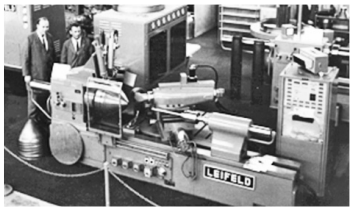
1891-1920: The beginnings

It was in 1891 that Josef Leifeld established the 'Böttcherei Leifeld' ('Leifeld Cooperage') for producing tubs, vats, butter centrifuges and straw cutters. In

Fig. 1 Overview of the head office factory

1920, Josef Leifeld II transforms the cooperage into a metalworking shop: 'Josef Leifeld Blechwarenfabrik' ('Josef Leifeld Sheet Metal Goods Factory').

1921-1967: Leifeld revolutionizes spinning machines



The world's first manual spinning lathe is developed by Leifeld in 1930. The first hydraulic spinning machine in the world follows in 1945. Fifteen years later, the first hydraulic spinning machine with copy control and an automatic program comes onto the market. Finally, in 1967, Leifeld develops the world's first NC spinning lathe.

1968-1999: Years of innovation

The first CNC-controlled metal spinning machine in the world is developed by Leifeld in 1971. In 1988, Leifeld develops the first machine for producing multiple-component aluminium wheels, and a year later a new process for manufacturing one-piece, weight-optimised cast aluminium wheels, which display a similar strength to forged wheels. The first machine for producing clutch plate supports is launched in 1995.

2000-2010: World market leader in chipless metal forming

Leifeld develops the first machine for producing one-piece, weight-optimised forged aluminium wheels and the first machine for the vertical production of aluminium and steel wheels as well as cast and forged aluminium wheels. In 2007, the Georg Kofler Group takes over Leifeld Metal Spinning GmbH. In 2010, Leifeld builds the longest flow-forming machine in the world with a length over 30 m.

2011-2019: International growth

In 2011, Leifeld expands to China and establishes the company Leifeld Machinery Trading in Shanghai. In 2013, a branch plant is set up in Artern. In the same year, Leifeld develops the strongest flow-forming machine in the world, followed one year later by the world's biggest horizontal CNC metal spinning machine. In 2015, Leifeld expands into the USA and establishes Leifeld USA Corp. In 2016, the year of its 125th anniversary, Leifeld delivers its 6,125th machine. In 2017, a new site is opened in Russia. A further production facility in Ahlen is being built and opened in 2018.

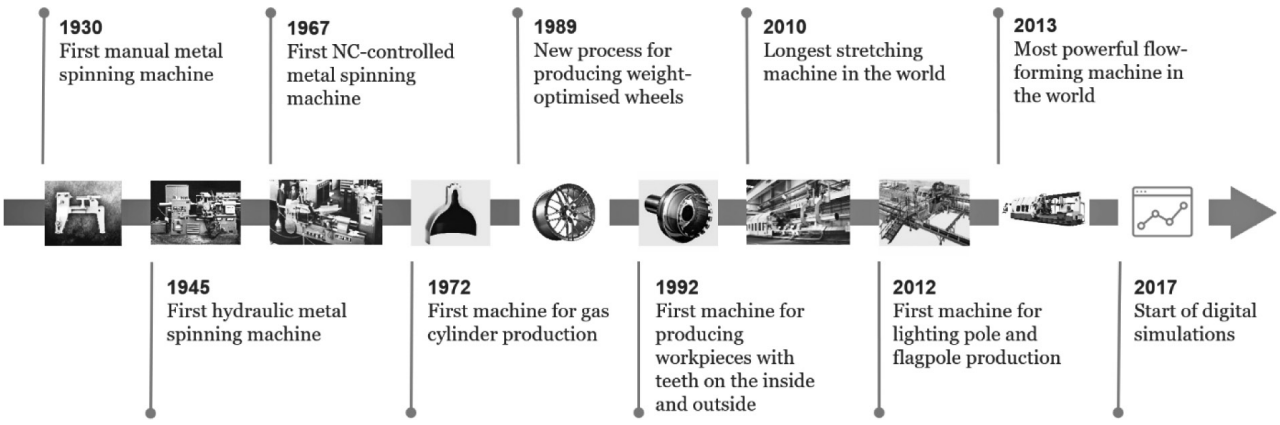


Fig. 2 Milestones in Research & Development

2020- today: Pioneering spirit

Leifeld is awarded as "World Market Leader–Future Champion" and "Innovation Leader" for its continuous pioneering spirit. Leifeld expands its digital solutions as well as its online presence in the social media. In 2020, Nihon Spindle Manufacturing enters a strategic partnership with Leifeld and takes over the company. Besides two strong brands and the extended product portfolio, Nihon Spindle and Leifeld strengthen their joint sales and service network worldwide. New technologies and machines with smart control are close to being launched on the market.

3. Market leading metal forming technologies

According to the German Industry Norm, Leifeld divides between five metal forming technologies.

3.1 Metal spinning

Metal spinning pursuant to DIN 8584 consists of transforming a circular blank by chipless forming with a roller into a rotationally symmetrical hollow body.

A preform is clamped against a spinning chuck and set in rotation. The spinning roller forms the preform step by step until the material has been brought onto the spinning chuck. Rotating tools generate a variety of surface lines on the work piece, which is also rotating, so that the final form of the work piece is generated and the surface is smoothed.

A variety of other, additional machining processes can be performed in the same clamping setup, such as the subsequent profiling of contour areas, the separation of marginal or base areas, the bordering of external edges, etc. In this way, virtually any type of hollow body can be produced with complicated or complex geometries, very narrow tolerances and excellent surfaces.

Advantages of metal spinning

Metal spinning displays obvious advantages in terms of cost–effectiveness and flexibility. Savings in material and the possibility of creating any kind of form changes at low tool cost and in fast production runs make metal spinning for smaller and medium batches to one of the most competitive alternatives for rotation symmetric parts to other processes, such as deep drawing. The high work – hardening rate enables the use of more cost – effective materials, while nevertheless guaranteeing the stability of the finished article and the required increased strength. This results in an enormous savings potential in terms of material and weight. Metal spinning tools (spinning rollers) are primarily not bound to the geometry of the work piece. This means that changes in geometry can be made in virtually any areas of the work piece by implementing simple programming changes.

3.2 Flow forming

With flow forming pursuant to DIN 8583, rotationally symmetrical hollow bodies with a cylindrical, conical or curved surface line are formed from a tube or bowl.

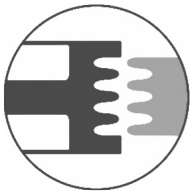
A preform is slid onto the mandrel and clamped securely. As a rule, two, three or even more rotating flow – forming rollers press radially onto the rotating work piece, such that the material flows in an axial direction. The wall thickness is thus reduced and the work piece is lengthened. The process is also frequently referred to as cylinder flow forming, whereby a distinction is made between forward and backward flow forming. An essential criterion regarding the process to be used is the question of whether the workpiece is solely of tubular form or if it has a bottom and can be clamped. In the case of forward flow forming, it is also possible to form teeth and so to produce a range of different internally toothed gear components.

Advantages of flow forming

The aim of flow forming is always to achieve a reduction in wall thickness. The final state is attained by pure compressive loading. The pressure applied to the material first of all serves to plastify the material and lengthen the work piece's and also increases the strength of the material. The result is an extended work piece with enhanced material properties, a higher load – bearing capacity and a longer service life than components

produced by metal cutting processes.

3.3 Profiling



Profiling consists of forming notches, grooves, etc. into a round blank or preform over several stages. The most important variants are the splitting, bending, compressing, thickening and rolling procedures. Hub moulding is also associated with profiling technology.

A preform or round blank is clamped between the main spindle and the tailstock spindle and set in rotation. A variety of profiling forming rollers are now applied in several consecutive work steps and brought towards the work piece. The profiles of the rollers are coordinated in such a way that they build on each other and ultimately generate the material distribution and the final contours of the work piece.

Advantages of profiling

Chipless profiling results in optimum material and surface properties and narrow tolerances, which is essential for safety–relevant parts in particular, such as pistons for brake components. The enormous cost savings resulting from the low material input, creation of wear–resistant or installation–ready surfaces, lowest machining remachining of the material overflow and very short cycle times should also be emphasised.

3.4 Shear Forming

In shear forming, a round blank or preform is placed onto the external tool contours through shear forming rollers. Shear forming is an incremental forming process that is related to metal spinning.

A round blank or preform is clamped between the spinning chuck and the tailstock pressure disc and set in rotation. The round blank is formed parallel to the external contours of the tool by the shear forming rollers and applied to the tool. In contrast to the gradual metal spinning process, the material is applied in a single overflow: the metal is projected from one level to another.

Advantages of shear forming

The advantages of shear forming lie in the simplicity of the process. All conically tapering components with an angle of more than 18° can be made by shear forming in a single clamp. Since the process consists purely of material displacement, the change in the wall thickness of the finished part can be optimally calculated. While the shear forming roller moves parallel to the spinning chuck, the wall becomes increasingly thin in relation to the cone angle ($S_1 = S_0 \sin \alpha$). The process results in narrow tolerances and polishable surfaces.

3.5 Necking–in

Necking–in consists of gradually reducing the diameter of the preform. The procedure is particularly suitable for forming necks at pipes or hollow parts for pressurised vessels, gas cylinders or other metal bottles. Necking–in is suitable for both vessel bottoms and necks, bottoms in steel resulting in a permanently gas–tight seal.

The preform is heated in an induction unit outside the necking–in machine, clamped in the jaw chuck of the machine by an automatic feeding facility, and set in rotation. A necking–in roller installed on a 100° swivel support gradually moves material from the pipe to the centre of rotation. The number of swivel steps determines the wall thickness of the evolving bottom or neck of the vessel. A wall thickness bulge of up to 4x t0 is possible. To avoid slag inclusions in the centre of steel bottom, an optional cutting torch can be used to ensure a homogeneous material distribution and the vessel's ultimate gas tightness.

Advantages of necking–in

Necking–in allows optimum determination of the wall thickness progression in the diameter reduction zone. Short cycle times, process reliability in production, highest machine availability and constant product quality result in cost–effective manufacture.

4. Machines and processes for the production of weight–optimised wheels

Less weight means fewer CO_2 emissions – this applies to both cars and trucks. There is a lot of saving potential in wheel rims. With Leifeld Metal Spinning GmbH's flow–forming machines, the chipless production of weight–optimised wheels will be possible–without loss of payload.

With our machines and technology, we can design steel rims for cars and trucks so that they're significantly lighter than conventional wheels and yet just as strong. Leifeld Metal Spinning GmbH develops machine tools for chipless metal forming, which are used worldwide in the automotive industry, aerospace technology, the energy industry and in various consumer and industrial goods sectors. One of our customers was able to use our technology to produce rims with a payload of 580 kilograms, which is almost 900 grams lighter than with other manufacturing processes. This pays off, especially in terms of fuel consumption. And the more wheels are used, the better the result. We think here of truck with a tractor unit with six wheels, plus spare wheels and trailer wheels.

Surely, aluminium wheels are much prettier than their steel alternatives and are very popular with car buyers when they've been painted, mirror–finished, matt brushed and sometimes chrome–plated. But they are also more expensive–and more vulnerable, e.g. to road salt or impacts. Repair is costly and/or sometimes impossible. Steel rims are much more resilient, and with the right manufacturing process they can actually be even lighter in the car sector. This is different than the truck sector. But here, too, the weight savings can be attractive to manufacturers and buyers who are less concerned with design and more with economy.

4.1 Less weight and still more resilient

If aluminium rims are often cast or forged in one piece, steel rims usually consist of a rim ring and a wheel disk. The rim ring can be produced in the car sector, and both parts can be produced in the truck sector using the flow – forming process. Work hardening improves the microstructure in the material and thus increases the final strength. We have the possibility of reducing the material cross section at certain points and flexibly adjusting it to the load requirements of the wheels.

4.2 Weight–optimised rim rings

Leifeld Metal Spinning GmbH offers two different machine production series and flow–forming processes– the FFM series (Fig. 4) for backward flow forming and the RSC + RC machines (Fig. 5) for biconical forward flow forming. The difference here is the feed direction of the rollers and the flow direction of the material. Both of them form tubeless steel wheels in large or small quantities.

Manufacturers can produce cylindrical components

Fig. 3 The rim ring is produced weight–optimised by flow–forming technology.

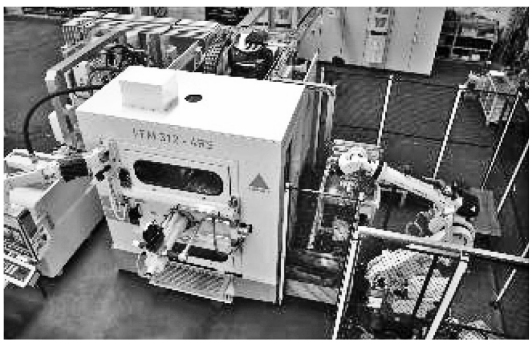


Fig. 4 The FFM machines use the backward flow–forming process to form weight–optimised rim rings. The cycle time is approximately 12 seconds.

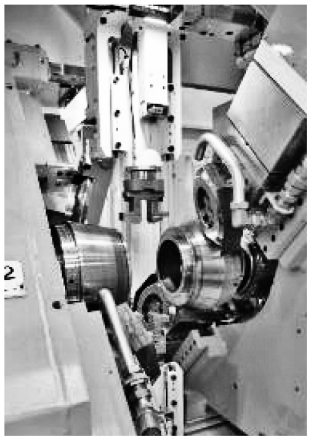


Fig. 5 View into the working area of the Leifeld RSC Series with 4 flow–forming rollers: The machine ensures a symmetrical distribution of forces and a very high degree of rotational accuracy for the component.

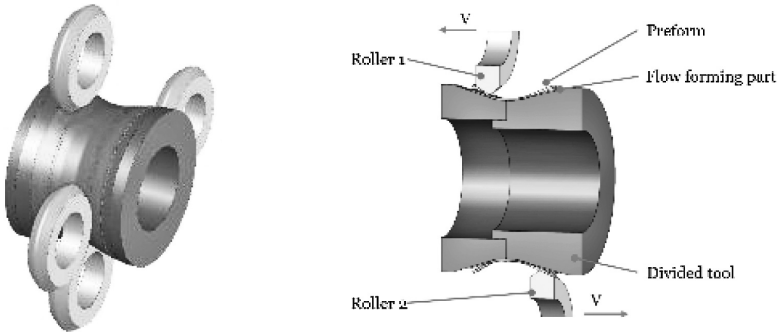
such as the rim rings on the FFM machine (Fig. 3). To get exact ring widths, measuring devices record tolerances in the circular ring, which are compensated by the machine control system–without additional trimming. A modified cross–section of the output sheet metal ring saves weight. Here is the actual process. A conveyor belt transports the preform, which was cut from stripe, rounded, and welded into a sheet metal ring, to the measuring device. If everything fits, a robot picks up the component and places it in the machine's loading device. There, the preform is automatically pushed onto a mandrel and fixed. The main spindle drive sets the mandrel with preform in a turning motion. Under CNC control, the roller, which runs in the opposite direction, flow–form the material in an axial direction. The wall thickness of the preform is reduced to the desired thickness. The final component length is permanently monitored and stopped in the machining program when the final rim ring width is reached. A scraper on the machine side then removes the finished part from the tool mandrel onto the unloading chute. Finally, a robot takes the flow–formed component out of the machine. The automatic quick–clamping device for tool mandrels and rollers minimises set–up times and thus increases cost–effectiveness.

With cylindrical counter–rotating flow forming, we can use universally applicable tools for different wheel widths. The preform is easy to measure; there is a high degree of work hardening and no need to cut off excess material. That's what makes this machine so popular at our customers.

4.3 Forward flow forming for car wheel rims

With biconical forward flow forming (Fig. 6), the preforms for rim rings can be produced not only at an optimised weight, but also at an optimal weight. However, this is only possible for biconical components with a cylindrical inner diameter and axial clamping range–such as the drop–centre area.

Leifeld offers the RSC + RC series for this purpose. A loading device or a robot picks up the preformed component and places it in the machine. There, it is picked up by two mandrels in a form–fit and force–locked manner. Two co–rotating rollers each press the material in the direction of the axial feed in opposite directions. The area not yet involved in the forming process is pushed in front of the roller. The machine thus ensures a symmetrical distribution of forces and a very high degree of rotational accuracy for the component. With forward flow forming, no additional calibration expansion and no section length measurement are required. Greater preform and sheet metal tolerances can also be used. The excess material is then removed in



Arrangement of the rollers Process

Fig. 6 The biconical forward flow forming is proceeded by Leifeld's RSC and RC series.

Fig. 7 SC Series

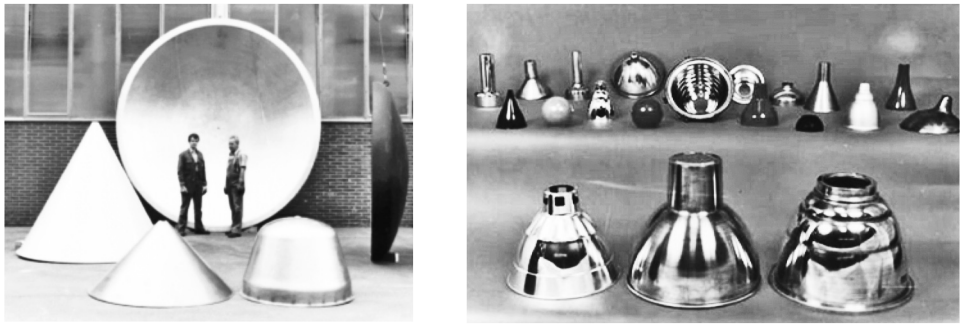


Fig. 8 Examples of processed products

another machine so that the desired material thickness and length are achieved exactly. The component is therefore free of weight differences resulting from the sheet metal thickness tolerance of the pre-material.

Manufacturers can use our machines to design the wheels as they are required by vehicle producers-light with a high payload. They can thus safely withstand increasing competitive pressure in the future as well.

5. Flagship models

Among all the models, two of Leifeld Metal Spinning GmbH's flagship models are introduced here.

5.1 SC Series (Fig. 7)

Features

- The spinning machine series with a wide variety of machines is covering the blank diameter up to 5000 mm.
- Manufacturing of rotationally symmetrical hollow shapes from circular blanks, tubes or preforms (Fig. 8)
- Universal, flexible applicability from household applications to wind generators

More than 950 Leifeld automatic Spinning Machines worldwide are evidence of quality and success.

5.2 WSC Series (Fig. 9)

Features

- Flow forming, splitting, and profiling of cast and forged wheel preforms

Fig. 9 WSC Series

Fig. 10 Examples of processed products

- Processing of steel, aluminium, and other metals
- Warm or cold working, depending on raw material
- Output of more than 500,000 wheels per year
- The use of flow forming to create cylindrical rings that are later formed into weight-optimised rims results in a significant reduction in weight and CO_2 emissions for cars, trucks, and buses.

Leifeld's solutions developed for the wheel industry enable the production of highly stress-resistant and yet light wheel rims and discs as well as rim rings (Fig. 10).

Manufacture by flow forming of automobile motor parts

Industrial Machinery Moriyama Division

HIGAKI Koji, SUZUKI Takashi

Abstract

We introduce an example of using the flow forming method for the structural parts of automobile motors, mainly for motor shafts. And we introduce an example of using flow forming for forming a high–cost raw tube.

1. Introduction

Currently, electrification of automobiles is rapidly progressing. In China, new vehicle sales will be limited to electric vehicles（hereinafter referred to as EVs）and hybrid electric vehicles（hereinafter referred to as HEVs）in 2035, and sales of gasoline vehicles and diesel vehicles will be prohibited. Such movement is also seen in France and some states in Canada and the US. The UK even announced that it would be advanced and implemented in 2030. Also in Japan, a government view that sales of gasoline vehicles and diesel vehicles will be prohibited in the middle of 2030s as one of the approaches to achieve carbon neutral status（total of exhaust and absorption of greenhouse effect gas will be zero）by 2050 has been announced, which makes the automobile industry in Japan more perplexed.

As we are in such a revolutionary transition period, most automobile manufacturers that have mainly adopted internal－combustion engines promote development by changing from HEVs to EVs, and as for batteries and motors, development competition is intensifying in every organization from motor manufacturers to electrical manufacturers, as well as supplies related to automobiles. For development of these units, they face a dilemma that the weight of each part cannot be increased very much while capacity enlargement and improvement of efficiency are desired, which has become a great challenge. Approx. a half of the weight of a motor is that of structural parts, and as for rotating parts such as motor shafts, hollowing with the flow forming method is a technology that has started attracting attention because reduction of weight can be achieved while a high torque is aimed at. In addition, when the diameter reduction of a pipe material is carried out by forging, the side that is not processed should be open because of the condition of the die, however, it is possible to carry out diameter reduction on both sides with flow forming. It is also possible to easily accommodate flange processing and relatively complicated shapes such as a groove set on a raw tube as necessary by changing the tools and the program.

In this technical report, we will first introduce the structure and issues of the previous automobile motors and summarize the current situation of the manufacturing method of motor shafts（rotor shafts）that exist in motors of most types. Next, we will introduce cases we are working on concerning the items in which the flow forming method can contribute to the function improvement and manufacturing cost reduction of motor shafts. It also includes a case in which the splitting method used in hybrid unit parts（rotor shafts）that Nissan Motor Co., Ltd. developed with us approx. ten years ago was adopted. Finally, we will briefly introduce processing cases of parts（stator housing, water jacket）other than motor shafts that we worked with.

2. Structure of Automobile Motors

Fig. 1 shows a typical structure of brushless motors installed in HEVs/EVs. In the structure of a motor shown here, coils are placed on the external stator, and a rotor is positioned inside. The rotor consists of a core that supports the magnetic body and a shaft that transmits torque as an output shaft. Since normal on–board motors should be installed in limited vehicle space, permanent magnets that easily allow size reduction and

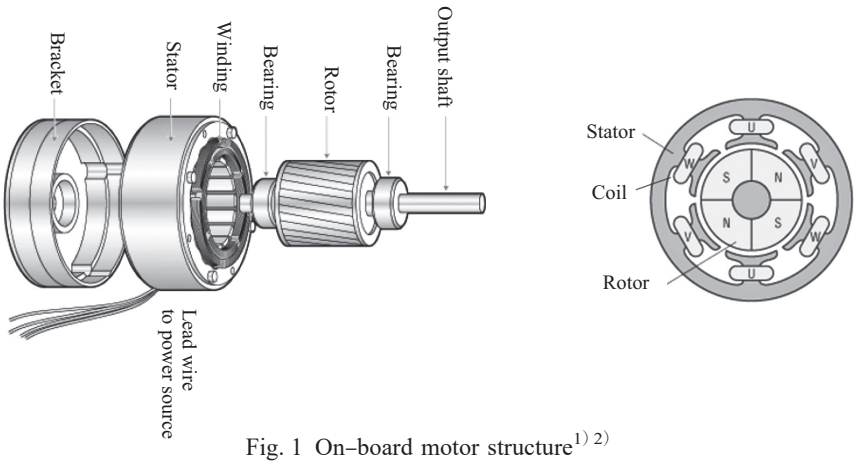


Fig. 1 On-board motor structure[1) 2)]

improvement of efficiency are used for rotors in many cases.

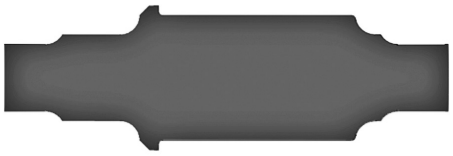
3. Issues of EV motors

It is feared that future new vehicle sales will be limited to EVs because of restrictions implemented in various countries. One of the performance goals of EVs is the "cruising distance." The target cruising distance in a fully charged state is approx. 600 km, which is equivalent to the average cruising distance of current internal combustion vehicles. The cruising distances of current EVs are said to be 6 to 7 km per 1 kWh of battery. The capacity of the battery installed in Model S in 2020 of Tesla Motors is 100 kWh, and the cruising distance is 647 km (catalogue value). The battery weight of this Model S is as much as 700 kg, and the weight of an EV taken up by the battery is significant, considering that the gasoline tank weight of an internal combustion vehicle is approx. 35 kg. When the battery capacity is increased to achieve the target cruising distance, the vehicle weight and cost increase accordingly, so vehicle manufacturers are eager for "development of highly efficient motors," "improvement of cooling performance," "improvement of battery energy density," and "reduction of weight."

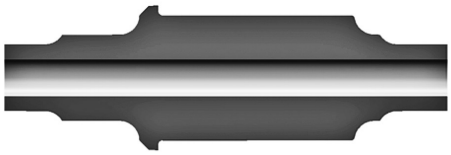
In the current automobile motor development, for size reduction and improvement of efficiency, copper wires are changed from round wires to rectangular wires to improve the space factor to reduce copper loss in the coil part, and the laminated core in the rotor part is made thinner to reduce iron loss. As for improvement of the battery energy density, solid-state batteries attract attention. To reduce the weight of parts, hollowing of the output shaft of the motor is considered, for example. This is because among the components of the motor unit, weight reduction of the permanent magnets and coils is difficult, and the shaft that has been manufactured with a solid material takes up great weight in the motor unit. For this hollowing of the motor shaft, the flow forming method is considered in various places. We will explain the effectiveness of this method in the following.

4. Motor Shaft Shape

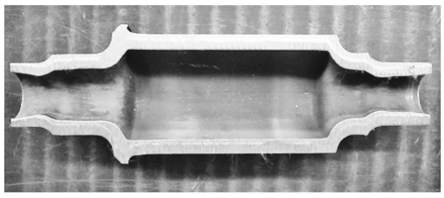
First, we will introduce motor shafts installed in EVs in the early days. In many cases, the external shape was formed by hot forging or cutting from a round bar material, and a solid material was used as it was (Fig. 2 (a)). On the outside of the motor shaft, a rotor core was inserted, and the cooling unit was installed only on the outside of the stator. When EVs were initially released in Japan around 2010, the battery cost was enormous in any case, and the capacities of the batteries installed in the initial type EVs were about 16 to 24 kWh, and the motor output was around 80 kW. Since EVs were mainly driven in town, the cooling unit may have just needed to meet such usage. After that, for improvement of the practicability of EVs to emphasize the global environment described at the beginning of this report, a cruising distance equivalent to that of internal combustion vehicles and improvement of mobility have been pursued, and the output of on-board motors has been dramatically increasing. While not only increase of the motor size but also high-speed rotation is considered to increase the output, suppression of heat generation that accompanies increase of output has become a constant challenge. Especially with EV motors in which permanent magnets are installed, performance as a motor



(a) Solid state produced with (forging and) cutting



(b) (Forging and) cutting + Drilling



(c) Flow forming

Fig. 2 Motor shaft cross section for each method

is damaged by demagnetization caused by temperature rise of the neodymium magnet used. Therefore, currently, shafts that were originally solid but drilled to cool from the inside are seen (Fig. 2(b)). However, such formation of hollow shafts has a problem that the manufacturing cost increases significantly because the drilling process is added to the conventional process (solid).

5. Hollow Shaft Formation with Flow Forming Method

If the flow forming method is used for manufacturing of motor shafts, the hollow space can be made bigger than that of products manufactured with forging + cutting, which allows inexpensive shaft formation. Shaft formation with the flow forming method allows formation from two kinds of materials: a pipe material and a disk material.

5.1 Formation from hollow pipe material (Fig. 2(c))

Reduce the diameter of the one side of the pipe material, invert the material, and reduce the diameter of the opposite side. By doing this, a shaft with a large hollow on the inner diameter side can be formed. Since a material with high hardness such as S45C is selected for the material for motor shafts, the warm method in which the material is preheated is used during processing. It is also possible to form a flange that serves as a stopper when the rotor core is inserted by processing with a dedicated roller after diameter reduction is carried out on both ends. Because of the warm method, the formation load is also small, and formation from a pipe material with a plate thickness of approx. 10 mm is relatively easy. However, as described in the following, there is a problem that the material cost of the pipe material is high compared with a forging material.

5.2 Processing from disk material

Motor shafts are used with a high rotation speed, and extremely high accuracy is required for its concentricity and cylindricity for the rotation performance. Therefore, the raw tube becomes a seamless pipe, and the material can be often expensive, including the thermal

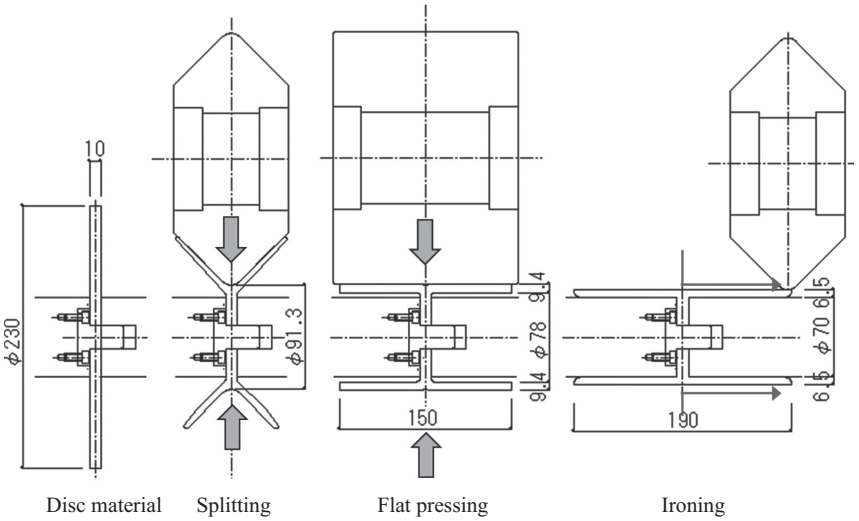


Fig. 3 Raw tube formation with splitting method

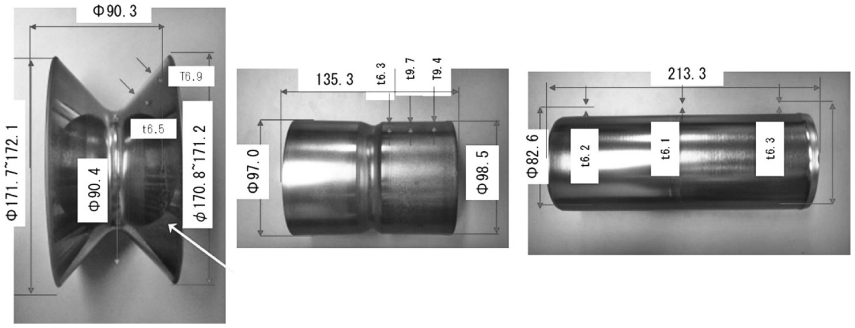


Fig. 4 Each process of raw tube formation

processibility after processing. As a manufacturing method of a seamless pipe, processing from a disc material with use of the flow forming method is possible in addition to the drawing process.

Fig. 3 shows a process to process a thick cylindrical material from a disc material by using a splitting method. We developed this method on the assumption of a hub shape that is not originally very long. The following is an example where the raw tube of a motor shaft was formed by using this method.

We adopted carbon steel of S35C to S45C class for the material of the disc material. In this case, the plate thickness is 10 mm. Because of the large material volume, splitting is carried out with an R roller with a relatively large width. If high carbon steel is split with cold working, it will be broken during processing, so warm working (700℃ or above at the time of preheating) is applied. The plate thickness of the processed part is 6 to 7 mm when splitting has been done, however, the plate thickness becomes 9 mm or more except for the part around the center when flat-pressing (processing of the processed part in parallel with the rotating shaft with a flat roller) in the next process is carried out. Finally, the inner diameter is extended along the die with the R roller used at the beginning. Ironing is carried out to have a uniform plate thickness of approx. 6.5 mm.

After that, since the plate thickness near the tip where the diameter was reduced with diameter reduction described previously becomes larger, we think we can apply this processing example to typical motor shafts for EVs and HEVs at present. The advantages of this method are that a shaft material can be manufactured from small equipment by using an inexpensive material, post-processing for the inner diameter is not required because it is pressed against the die, and a length and plate thickness that are arbitrary to a certain degree can be selected by changing the program only if the die diameter is changed. The disadvantages are that the wall for chucking remains in the center, and the processing time is longer because there are many processes in successive forming. In the case of the former disadvantage, if the wall is not necessary, it can be removed only in another process after raw tube formation. However, as for the latter disadvantage, we aim to make the processing time as short as possible as a challenge in the future.

Fig. 5 Stator structure[3)]

6. Efforts for Other Motor Parts

6.1 Processing of Stator Housing

Fig. 5 shows an example of the stator structure of a motor. (The outer shell part of the stator is called a housing.) In this structure, the flange part is integrated into the end of the cylindrical part, and the flange part is used as a piece of the attachment bolt in the machining in the post-process.

Generally, the plate thickness of the flange part in a product state is set larger than that of the cylindrical part, however, the plate thickness of the flange part is reduced because the diameter is larger than that of the cylindrical part.

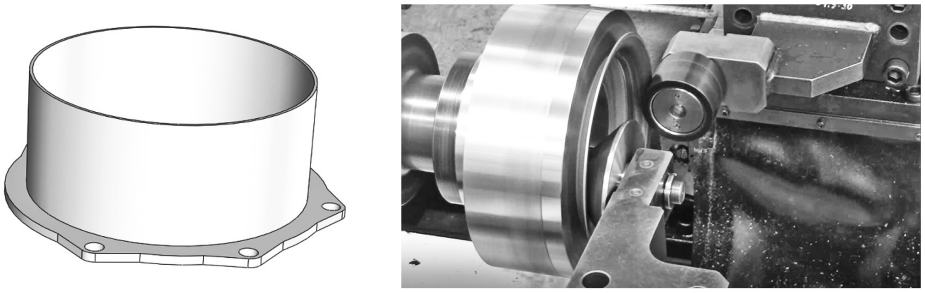


Fig. 6 Stator housing structure and example of flange processing with flow forming

In the processing carried out this time, the thickness reduction ratio was suppressed to 80% by bringing down the material diagonally with a taper roller in the first process and then bringing it down orthogonally with a flat roller in the second process.

6.2 Water Jacket

A water jacket is a part positioned outside the housing to form a hollow part between the housing and cool the motor by letting cooling water pass. It was common to process both ends of a cylindrical material, which was made by rolling an iron plate and welding it, with a press from a viewpoint of the material yield, however, processing with a press has become difficult as the outer diameter has become larger. With processing with flow forming, an eccentric die is used as shown in Fig. 7, however, there is a problem that distortion in the material stage cannot be corrected completely while strict accuracy is required for circularity, etc. of motor parts and processing in the tolerance range is difficult. In addition, we can propose to process only one side of the water jacket by setting one level difference as shown in Fig. 8 in flange processing of the stator housing described above. One – side processing is highly effective as it makes dimension adjustment easy, and distortion is expected to be reduced eventually.

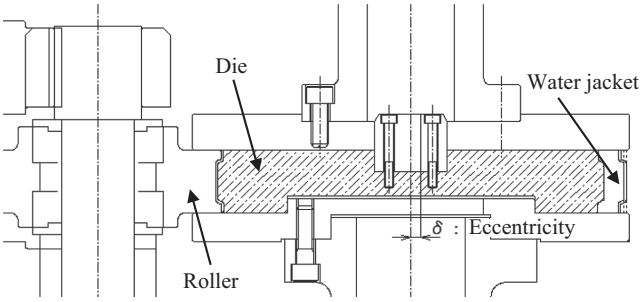


Fig. 7 FF processing of water jacket

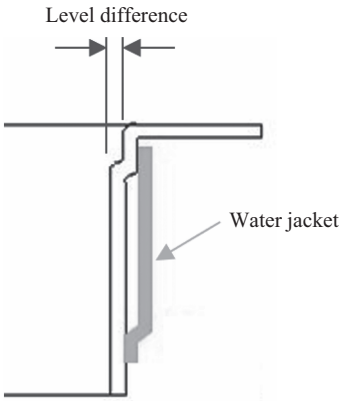


Fig. 8 Level difference processing of housing

7. Future Prospect

To reach the great goal to achieve the carbon neutral status by 2050 described at the beginning, replacement of gasoline vehicles with EVs is mainly carried out globally at present. In the automobile industry in Japan, not only the generation rate of carbon dioxide gas during driving but also reduction of CO_2 in the life cycle including manufacturing, transportation, disposal, and recycling of automobiles has started attracting attention. In the future, the entire manufacturing industry including all the suppliers, equipment manufacturers, material manufacturers, etc. will be required to contribute to realize a carbon neutral status in their manufacturing processes respectively.

8. Related Patent

Patent No. 5707624 March 13, 2015

9. Sources

1）Nidec Corporation homepage
2）Oriental Motor Co., Ltd. homepage
3）Mitsubishi Electric Corporation homepage

Introduction of the exhaust parts processing machine SRS150E- T4

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Industrial Machinery Moriyama Division SOTODATE Katsuya

Abstract

We have released new model of spinning machine for exhaust system parts which is hydraulic–free（fully electric）, more compact than the conventional model, and has shorter cycle time. In this report, we introduce the details.

1. Introduction

One of our major products is the machine to process exhaust parts, such as mufflers and catalytic converters for automobiles. While the automobile industry is rapidly shifting towards EV, there are voices saying that the internal combustion engines will not be obliterated completely in the immediate future because there are issues remaining in the battery and infrastructures. However, amid the decreasing demand, companies are shying away from the conventional mainstream production method of large press because of the need for a very large initial investment including the mold and, on the contrary, the demand for spinning machines, for which the investment required is relatively small, is steady for the time being. This exhaust parts processor is one of the VARIFORMA® series products and a machine to form automobile mufflers and catalytic converters from tube – like works by spinning. Exhaust parts processors are roughly classified into those exclusively designed for concentric parts and eccentric and oblique parts. Fig. 1 shows examples of concentric parts and eccentric and oblique parts that have been processed.

（a）concentric parts

（b）eccentric and oblique parts

Fig. 1 Product example after processing

We have released a new model SRS150E－T4, an improved version of concentric parts processor SRS150–T4. This paper introduces its features（Fig. 2）.

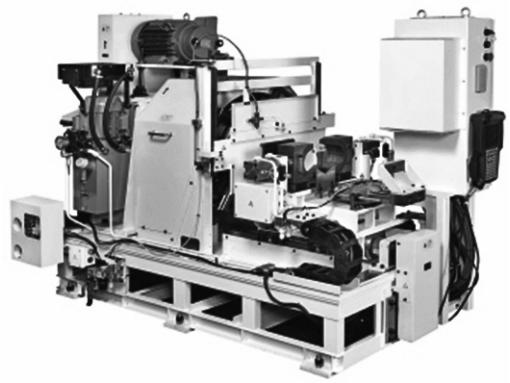


Fig. 2 SRS150–T4（Conventional model）

2. Features of SRS150E–T4

This section introduces features of SRS150E－T4 focusing on improvements made from the conventional model SRS150–T4.

2.1 Hydraulic–free

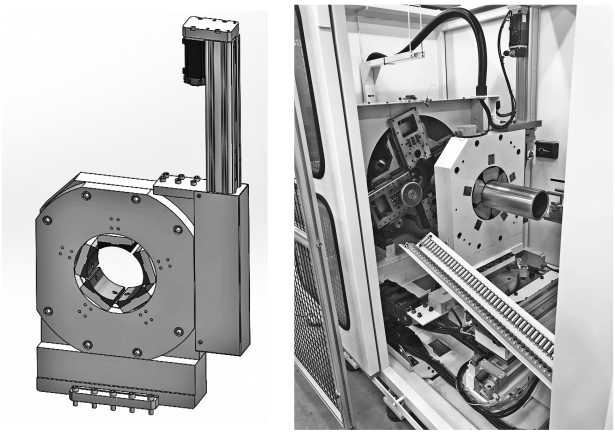
With the development of an electric work clamp, the hydraulic system used for the hydraulic clamp in the

conventional model has been eliminated to drive the entire system with electrical power. For this reason, the letter “E” has been added to the model number to indicate it is driven electrically. Compared to the electric motor capacity of 1.5 kW for the conventional hydraulic unit, the new model makes it possible to clamp the work with a 0.5 kW servo motor and, with a reduction in the standby power consumption and the elimination of need for hydraulic fluid, is an energy and resource saving machine.

2.2 Electric thin scroll chuck

There are two types of hydraulic work clamps for the conventional model ... one using semicircular split clamp blocks and another using a collet chuck with eight jaws. While the semicircular type is economical with a simple construction, it only allows tolerance in the product’s outer diameter up to about ±0.3 mm. Although tolerance up to ±2 mm in the outer diameter are tolerated by the 8–jaw collet chuck, it is big and relatively expensive.

On the other hand, the newly developed electric scroll chuck allows tolerance in the outer diameter up to ±2 mm and is capable of processing both sides of the work with a single chucking by reducing the clamp width to 100 mm and adopting a construction to allow the clamp to turn 180 degrees. Fig. 3 illustrates the construction of the electric scroll chuck.



(a) Overall view of the chuck (b) Picture of chuck part

Fig. 3 Electric scroll chuck

2.3 Space–saving

By miniaturizing the control panel and unifying it with the machine, a significant reduction of 40% in the footprint of the machine has been achieved compared to conventional machines with similar specifications (Fig. 4).

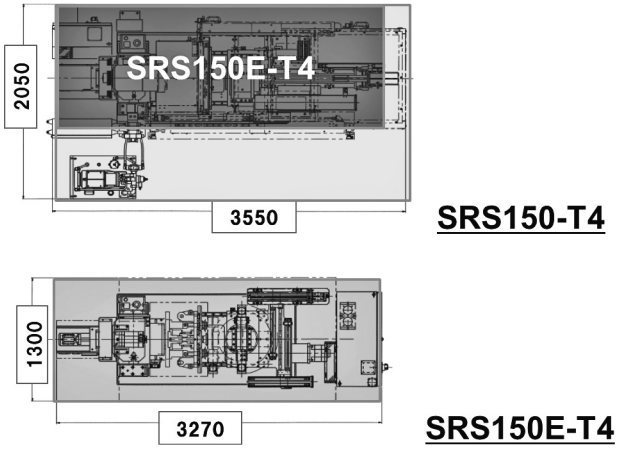


Fig. 4 Space saving

2.4 Reduction in the cycle time

With the adoption of electric scroll chuck described above, both sides of the work can be processed with a single chucking and this reduces the cycle time by about 15 seconds. The processes underlined in Fig. 5 are no longer necessary.

Loading the work → Positioning → Clamping → Processing → *Unclamping* → *Pulling out the work* → 180–degree reversal → *Positioning* → *Clamping* → Processing → Unclamping → Unloading the work

Fig. 5 Exhaust parts processing cycle

3. Conclusion

With the significant reduction in the cycle time and savings in the space, the new SRS150E–T4 is a machine that can enhance CSR activities of our customers in saving energy and resources, in addition to those of our company. We will aim to expand the sale of SRS150E–T4 in the future and, at the same time, make an effort to develop new products with a similar perspective.

VF-LMS New Brand “Global Metal Forming Group”

Leifeld Metal Spinning HILTROP Beate
Planning Division SAITO Ayako

1. Introduction

On May 29, 2020, Leifeld Metal Spinning (hereinafter referred to as LMS) of Germany, a pioneer in spinning and flow forming, had been added to our group. An umbrella brand was built to communicate and underline the unity as a globally operating group with the associated brands to the outside world.

We play a decisive role in writing the future of the metal forming sector. We aim to shape our industry for the better, representing a driving force in its transformation and adaptation to new paradigms. Through innovative strength and dedication to excellent execution, we set standards for future solutions in forward-looking fields. Our role as a market leader means an obligation: to take on the challenge of advancing technology as well as the industry as a whole-for the benefit of our clients.

2. VF–LMS new brand “Global Metal Forming Group”

The logo of the new umbrella brand that is named “Global Metal Forming Group” combines elements of the Nihon Spindle logo (red curve) and the LMS logo (triangle) to represent our joint team, the history, and the values of both companies (Fig. 1).

Fig. 1 Global Metal Forming Group brand logo

The new brand is positioned as an umbrella brand for our LMS business and for our VF business (VARIFORMA® brand) within the Machinery Moriyama Division, this means for spinning and flow forming machines (Fig. 2).

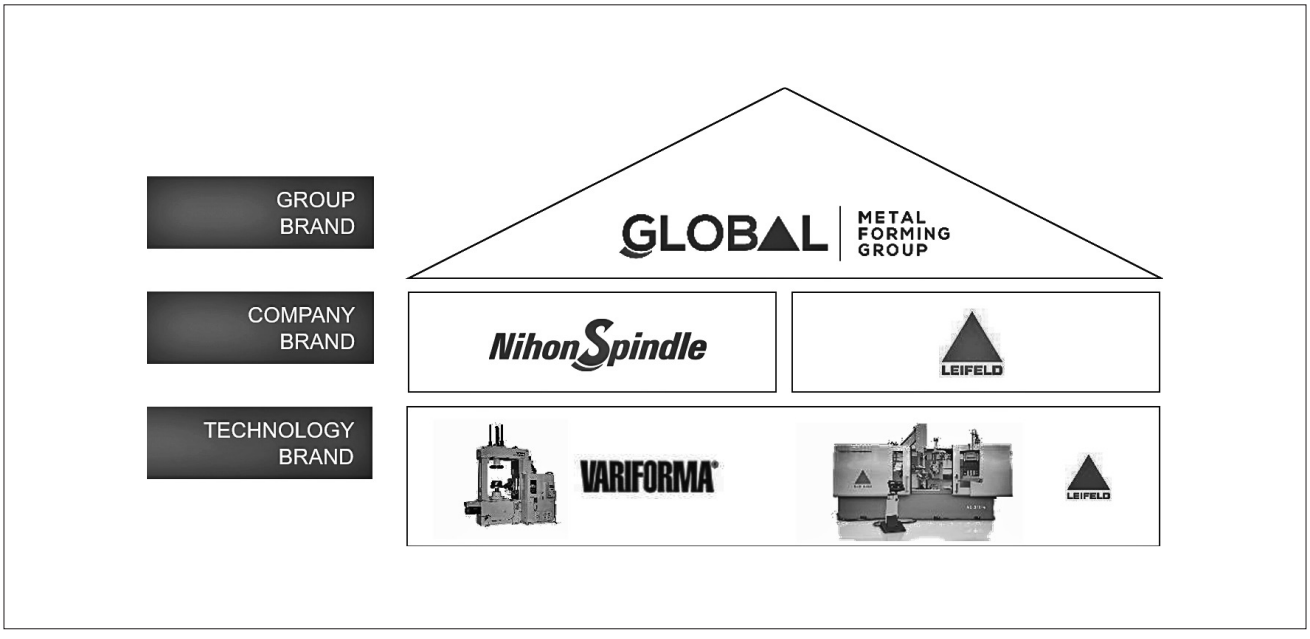


Fig. 2 Positioning of Global Metal Forming Group brand

3. Brand insights and brand launch

The Global Metal Forming Group brand was officially registered by the European Union Intellectual Property Office in May 2021 (trademark no. 18357801), followed by further international trademark registrations. The core of our newly built brand are four values: strength, trust, aspiration, and transformation (Fig. 3).

In the course of the brand launch we published a new group website (globalmetalforming.com) and processed a corporate design relaunch. The new brand design combines the best of both worlds–Nihon Spindle and LMS–and is present in various communication channels, such as print and online media (Fig. 4).

» Strength
beyond shear force

Our machines are rendering maximum levels of performance. With our effective chipless forming methods using minimum force we follow our eco-friendly approach. But it's not just about mechanical power. Today, resilience, endurance and willpower are just as much signs of a strong company. Building on these qualities, we stand as a reliable partner to our clients. Our strength creates advantages and opens up new ways of metal forming.

» Trust
based on integrity

We are partners you can rely on. Our strong stance creates the trust that's necessary for long-term, successful partnerships. This is confirmed every day by our technological leadership, determination as high performers, and long-term cooperations. On the inside, it is about trust in the people working for us, enabling them to do their best work.

» Aspiration
achieving together

We set high standards for our work, trying to achieve best results in everything we do. This passion to deliver high value for our clients is first and foremost driven by our own aspirations, grounded in the personal ambitions of our staff. And it is built on a culture of teamwork and commitment, allowing us to meet and oftentimes excel expectations.

» Transformation
never standing still

The transformation of one form into another is part of our day-to-day work – the core of what our machines do. But transformation is about more. It is about being open-minded and embracing change: advancing technological progress, reacting to shifting markets, meeting new client needs. To meet the challenges these transfomations pose, it is essential to constantly challenge and thus transform ourselves.

Fig. 3 Core values of the Global Metal Forming Group

New presentation layout

New website www.globalmetalforming.com

Fig. 4 Examples of brand commuication

“JET PASTER” using Hydrodynamic Cavitation Effect

Mixing Business Center

ASAMI Keiichi

Abstract

In this report we explain about the next generated lithium ion battery slurry and polymer electrode fuel cell (PEFC) slurry by “JET PASTER” using Hydrodynamic Cavitation Effect.

1. Introduction

“JET PASTER” is a unique mixing / dispersing device that utilizes the expansion / contraction effect of bubbles (microbubbles) generated by hydrodynamic cavitation.

Cavitation can be classified into two types: hydrodynamic cavitation and acoustic (ultrasonic) cavitation. Acoustic cavitation is a method in which a gas dissolved in a solvent is aggregated by ultrasonic vibration to form bubbles. When the bubbles collide with an object, the bubbles explode to be dispersed by the generated impact force. Therefore, erosion of the device is likely to occur.

On the other hand, the hydrodynamic cavitation is a method in which bubbles generated by the rotation of the rotor repeat expansion and contraction due to atmospheric pressure fluctuations in the device to promote dispersion. Bubbles disappear naturally at atmospheric pressure.

2. Hydrodynamic Cavitation Effect and JET PASTER

Figure 1 shows a high-speed camera picture of bubbles (microbubbles) generated by hydrodynamic cavitation (hereinafter, hydrodynamic cavitation is abbreviated as cavitation in this report) flowing out of the outflow part

It is observed that uniform and very fine bubbles are discharged from the outflow port. By this bubble aggregates of electrode active material, carbon nanotubes, carbon black and carbon black with a platinum catalyst can be dispersed relatively easily.

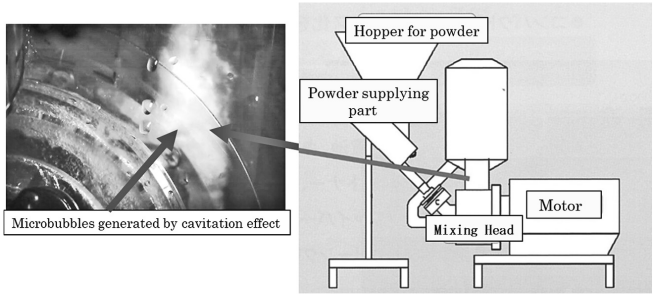


Fig. 1 “JET PASTER” using cavitation effect

It is an epoch-making JET PASTER that does not require the kneading process for producing lithium-ion battery slurries.

As a result of a joint research with Associate Professor Hosokawa of Kobe University, we found that the bubbles generated by cavitation greatly contribute to the dispersion.[1)]

Figure 2 shows the dispersion mechanism by bubbles generated by cavitation. The dispersion mechanism by cavitation proceeds as follows.

Aggregates such as the electrode active material at the left end of Fig. 2, carbon nanotubes, and carbon black with platinum catalyst used in fuel cells become nuclei and bubbles by cavitation are generated from inside the aggregates and expand. The bubbles contract approaching atmospheric pressure. By repeating these cycles, dispersion proceeds from the inside of the aggregate.

Therefore, fibrous materials such as entangled carbon nanotubes can be uniformly come loose and dispersed without damage.

3. Comparing of conventional mixers and JET PASTER

Table 1 shows the features of the conventional mixers problems with conventional mixers are below.

1. Difficult to dissolve poorly soluble polymers（eg CMC, flour, etc.）.
2. Difficult to disperse fine carbon materials such as acetylene black and carbon nanotubes.
3. Since it depends on a strong shearing force, the active material is easily destroyed.

In addition to the conventional mixers listed in Table 1, in－line mixers and vertical high－speed mixers that utilize strong shearing force have been put on the market, but there are 1 to 3 problems as with the above devices.

“JET PASTER” has the following features.

1. High－speed dispersion
   - Short－time dissolution of poorly soluble polymers and dispersion of minute carbon materials are possible.
   - Continuous supply or simultaneous supply of various powder materials is possible by vacuum suction force
2. Soft and uniform dispersion
   - Dispersion of secondary aggregation is possible
   - Primary particles are not destroyed
3. Compact design saves space
4. Completely disassemble structure

Very important points are the short－time dissolution of poorly soluble polymers and the simultaneous supply of powder materials. These features are created by the cavitation effect.

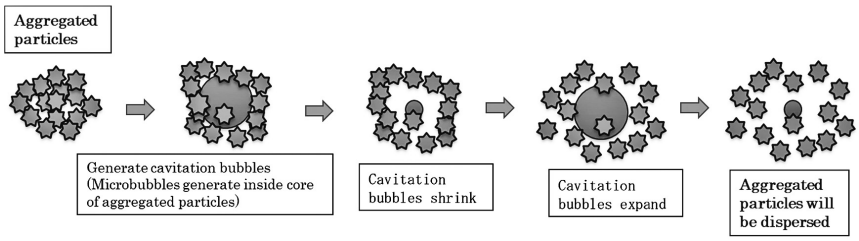


Fig. 2 Dispersion mechanism by bubbles generated by cavitation effect

Table 1 Features of the conventional mixers

Mixer	Planetary Mixer	Premixing⇒High Shear Mixer⇒Coating step	*Horizontal twin-screw mixer*
Dispersing Technique	Shearing Power	Shearing Power	Shearing Power
Method	Batch	Batch	Continuous
Thickener solution・binder solution	Necessary	Necessary	Necessary
Crushing of active material	Easy to crush	Easy to crush	Easy to crush
Supplied powder	Accumulates on the circumference of the gas-liquid interface	・Premixing is difficult for powders with a small specific gravity ・Accumulates on the circumference of the gas-liquid interface	It may be difficult to supply a fixed amount depending on the powder.
Kneading Process	Necessary	Unnecessary	Necessary
Procedure	Complicated	Easier than Planetary Mixer	Easier than Planetary Mixer
Productivity	Not good	Good if premixing is easy	Not bad if conditions are decided
Others	Many orders	-	-

4. Electric Vehicles (EV) and Fuel Cell Vehicles (FCV)

Due to Volkswagen's clean diesel fraud, EU has made a major shift from clean diesel to EV as an environmental issue. Currently in EU, Sweden's Northvolt is building a Gigafactory. There are plans at several more locations and the development of lithium-ion batteries for EV has been actively carried out.

Also in China, lithium-ion battery makers such as CATL and BYD are planning to expand Giga Factory in order to supply lithium-ion batteries to automobile makers around the world.

In Japan, Toyota Motor Corporation announced that it will produce 1 million EVs and 4.5 million HVs/PHVs in 2025, and has a battery supply tie-up with CATL and others.

In April 2020, Toyota Motor Corporation and Panasonic Corporation established a joint venture "Prime Planet Energy & Solutions" to construct a lithium-ion battery supply system for mass production of EVs.

In addition to the globalization of EVs centered on EU, it is expected that the competition for the initiative of EV technology will begin in earnest, mainly among automobile manufacturers including Japan, the United States, and China.

As for fuel cell vehicles (FCVs), Toyota Motor Corporation has developed and launched "Mirai" in Japan. In China, following EVs, FCVs are receiving large subsidies, and development competition is intensifying.

5. Next-generation Lib slurry

For in-vehicle lithium-ion batteries, increasing the capacity of batteries for the purpose of improving the cruising range has been a big issue.

High-capacity high-nickel/ternary materials are required for positive electrode active materials and alloy-based materials such as Si and SiO are required for negative electrode active materials.

However, the high-capacity high-nickel compound expected as a next-generation positive electrode active material has a drawback that an electrode slurry can be produced only with an organic solvent such as NMP. Further, there is a problem that polyvinylidene fluoride (PVdF) used as a binder is gelled due to lithium hydroxide dissolved in a very small amount of water in an organic solvent.

Therefore, complicated steps such as a step of removing the alkaline component from the active material and a step of completely removing a trace amount of water present in the organic solvent are required. There is also the problem that a low dew point environment with as little water as possible is required.

In addition, since an organic solvent is used, a large amount of capital investment is required, and the running cost is very high to recover and reuse the evaporating organic solvent when coating.

The large impact of organic solvents on the environment and the human body (special medical examination is essential) is a major issue.

Since Si and SiO, which are silicon-based high-capacity negative electrode materials replace graphite, have extremely large volume expansion and contraction (2 to 5 times) during charging and discharging. So, only 5 to 10% of active material is currently added to graphite. There is also a problem that the performance is not fully brought out because of limited use.

Under these circumstances, we are focusing on making water-based slurries of high-nickel compounds as next-generation positive electrode active materials, and silicon-based negative electrode materials as next-generation negative electrode active materials.

6. Water-based slurry of next-generated High-Nickel positive electrode active material[2) 3)]

Research and development of high-nickel positive electrode active materials like ternary systems (NCM=6/2/2, 8/1/1, etc.) and NCA have been developing in order to extend the cruising range of EVs.

However, when such high-nickel compounds contact with water, the excess included lithium hydroxide is eluted and becomes strongly alkaline with pH 12 or higher.

Since this strong alkali reacts with the aluminum foil as a current collector to generate hydrogen, the coated electrode becomes porous to make it impossible to manufacture batteries.

In order to suppress such strong alkalization, a method of adding a strong acid such as sulfuric acid or

hydrochloric acid or a weak acid such as oxalic acid, citric acid and ammonium sulfate to neutralize has been proposed.

However, in the case of strong acids such as sulfuric acid, it is very difficult to neutralize the slurry and if it is added a little excessively, it becomes strongly acidic and the aluminum foil for the current collector is dissolved. In the other case of weak acids, the salt produced by the reaction with Li may adversely affect battery performance and for the ammonium sulfate, there is a problem of odor such as ammonia generated during drying. There are many problems to be solved.

In this report, we were able to achieve an aqueous slurry of high nickel–based active material by combining the cavitation effect of "JET PASTER" and carbon dioxide gas instead of the above acids to suppress strong alkalinity.

6.1 Superiority of Carbon Dioxide gas

Even if carbon dioxide gas is added to water in excess under normal pressure or reduced pressure, the pH is at most 4, so it does not become strongly acidic and the aluminum foil does not dissolve even if the slurry is coated on the aluminum foil.

As shown in Fig. 3, the aluminum foil does not react and dissolve if the slurry has a pH in the range of 3 to 10.

6.2 High Nickel active material : NCA

An example of producing a slurry neutralized with "JET PASTER" using the strongest alkaline NCA as a high nickel compound will be described.

The device is JPSS–X shown in Fig. 4 and is a small laboratory device capable of producing 150 to 300 ml of slurry with a carbon dioxide gas supply jig attached.

6.3 Preparation of electrode slurry and electrodes

Add a predetermined amount of NCA, CB, VGCF and acrylic binder to the JPSS–X cup with the following composition, NCA : CB : VGCF : acrylic binder = 92 : 3.5 : 0.5 : 4, and then supply carbon dioxide gas to prepare a slurry having a pH of 8.3. By the way, the pH was 12.2 in the system without carbon dioxide gas.

When JPSS–X is operated, the pressure inside the device becomes negative and carbon dioxide gas is sucked into the device to dissolve quickly in water with the same effect as cavitation and neutralize. Figure 5 shows the carbon dioxide neutralization mechanism by

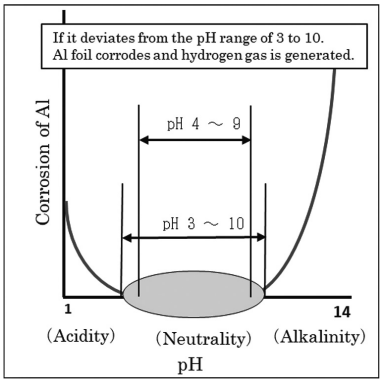


Fig. 3 Aluminum foil non–corrosion area

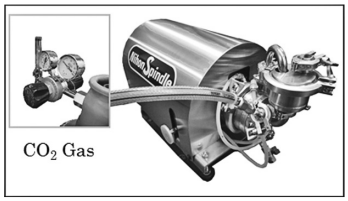


Fig. 4 JPSS–X

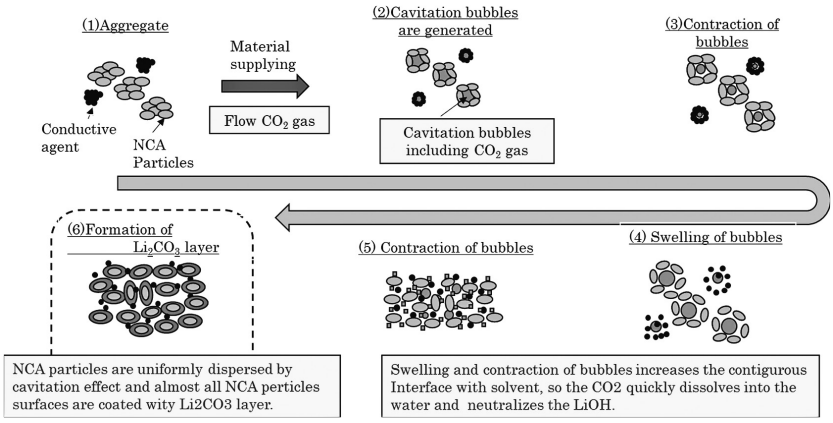


Fig. 5 Carbon dioxide neutralization mechanism using cavitation effect

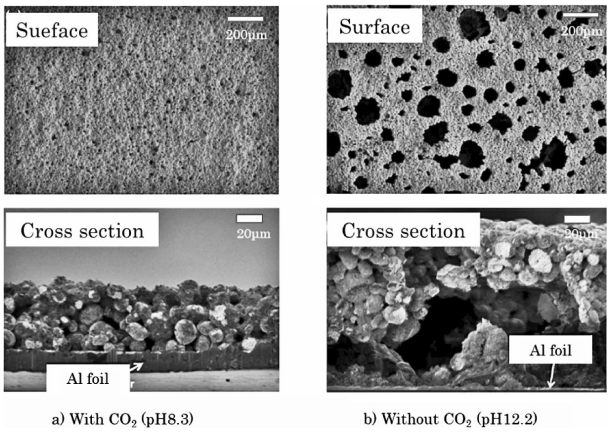


Fig. 6 Electrode SEM after application with / without carbon dioxide neutralization

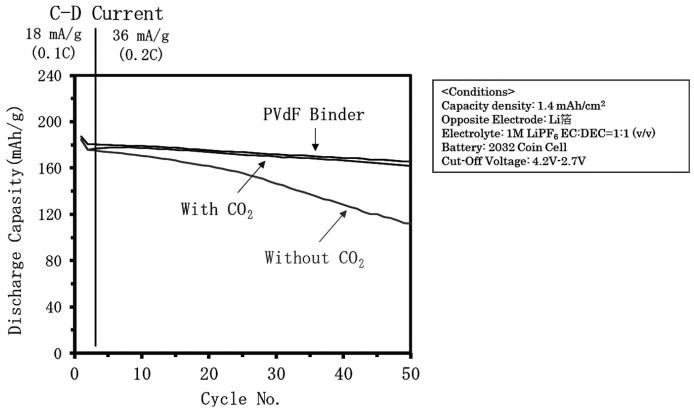


Fig. 7 Cycle characteristics with / without carbon dioxide neutralization

the cavitation effect.

1. Supply carbon dioxide gas using the suction power of “JET PASTER”
2. Inside of “JET PASTER”, cavitation bubbles containing carbon dioxide expand and contract. As a result, the interface volume of bubbles with water increases much carbon dioxide gas to dissolve rapidly and neutralize lithium hydroxide.
3. The excess carbon dioxide gas is removed by the cavitation effect and hardly remains in the slurry, so that it can be applied immediately after the slurry is prepared

Figure 6 shows SEM of the electrodes obtained by applying these slurries to aluminum foil and drying them.

When a slurry of pH = 12.2 without carbon dioxide gas is applied, the aluminum foil reacts to generate a large amount of hydrogen gas and make many holes. But at pH 8.3, it does not react with the aluminum foil at all and electrodes with a smooth surface and cross section can be produced.

6.4 Electrode characteristics

A CR2032 coin cell was made using NCA electrode with Li metal as the counter electrode. The result of the electrode characteristics is shown in Fig. 7. For comparison, the cycle characteristics of a battery made of electrodes prepared by using PVdF as a binder in an organic solvent are also shown.

Although the initial characteristics of the two water-based electrodes are similar, the deterioration is more severe without carbon dioxide gas.

This is because the internal resistance (coating resistance and charge transfer resistance) of the unneutralized slurry increases significantly as the cycle is repeated. (Fig 9)

In the carbon dioxide gas-neutralized slurry, it is presumed that the produced lithium carbonate coats the surface of the active material and thus suppresses the reaction with the electrolyte.

This can be understood from the TEM image of lithium carbonate covering the surface of the active

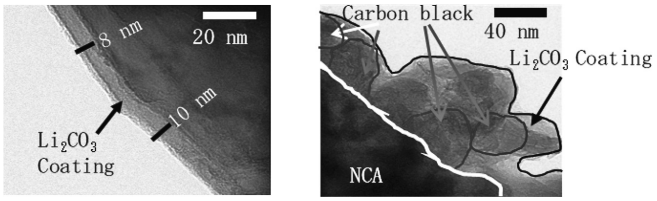


Fig. 8 TEM of lithium carbonate on the surface of NCA

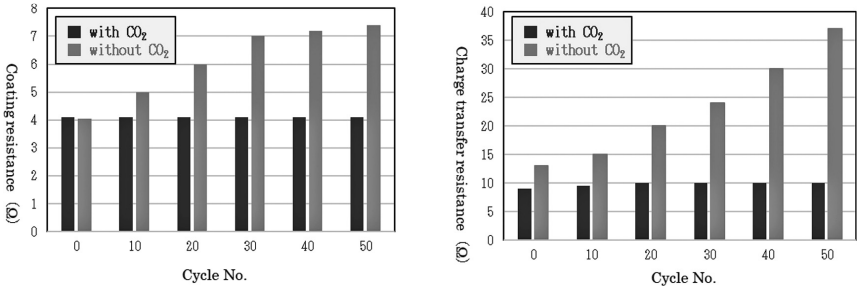


Fig. 9 Internal resistance of coin cell（Coating & Charge transfer resistance）

material shown in Fig. 8.

Furthermore, it is considered that the reason why the resistance does not increase is that carbon black is also incorporated in the lithium carbonate layer. From these facts, it is possible to easily obtain an aqueous slurry of high nickel–based active material that can be applied to aluminum foil and exhibits good battery characteristics by combining “JET PASTER” with carbon dioxide gas. Further, even if carbon dioxide gas is applied, the high–speed dispersibility of “JET PASTER” is not impaired.

As high nickel active materials, not only NCA but also NCM622 and 811 are under development and study. We have also found that each active material has optimal carbon dioxide neutralization conditions.

We believe that the cavitation – based “JET PASTER” is ideal device for producing highly productive, water–based high–nickel electrode slurries, and is fully compatible with future giga factories.

6.5 Application of next – generation high – capacity negative electrode active material to water–based slurries

We have also been developing water–based slurries for next–generation negative electrode materials such as SiO.

The theoretical capacity of SiO is 2007 mAh／g which is much larger than that of graphite 372 mAh/g. It is expected as a next – generation negative electrode material.

However, it has a drawback that the volume expansion and contraction during charging and discharging is too big around two to three times and the adhesion with the metal foil used as a current collector cannot be maintained.

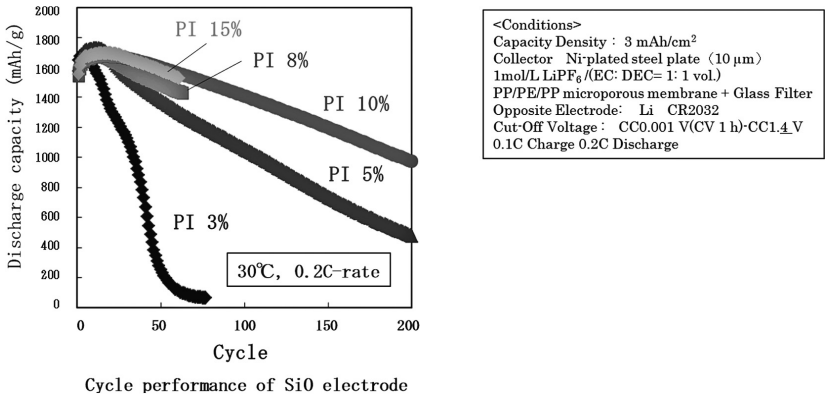
Therefore, it is often used in combination with graphite. However, the amount used is about 3% with respect to graphite and at most about 10%. So, the capacity of SiO cannot be fully utilized.

An electrode was prepared and evaluated by “JET PASTER” using SiO as a high – capacity negative electrode active material and an aqueous polyimide binder.

Furthermore, full cell combined with the positive electrode made of the high nickel–based aqueous positive electrode slurry described in the previous section were also evaluated.

7. SiO high – capacity water – based negative electrode slurry

SiO : KB : Water–based polyimide（PI）binder = 97–x : 3 : x wt%（x = 3, 5, 8, 10, 15 wt% slurry was prepared with a small laboratory device（JPSS–X）and stainless–steel foil and the electrode performance was evaluated. When making a SiO slurry in an organic system, 15 to 18% of PI binder is used. We changed it to 3 to 15% to confirm the optimum amount of aqueous PI binder. The electrode performance was the best when 10% of the aqueous PI binder was added. The results are shown in



Cycle performance of SiO electrode

Fig. 10 Amount of water-based polyimide binder and electrode performance

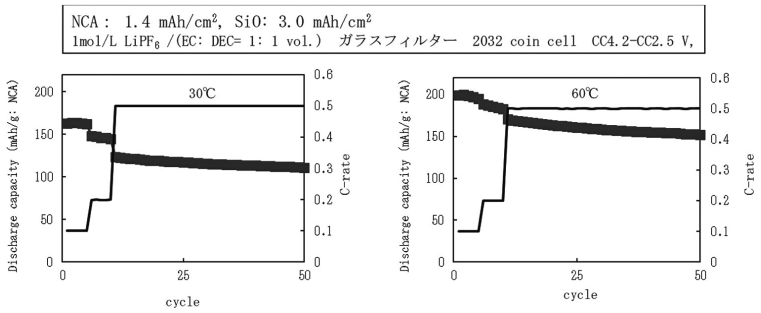


Fig. 11 NCA/SiO Full Cell cycle characteristic

Fig 10.

It is presumed that this is because the dispersibility was improved by the cavitation effect and a slurry having good electrode performance could be produced with a small amount of aqueous PI binder. It is estimated that when the PI is 15%, the surface of the active material is thickly covered and charging / discharging becomes difficult, so that the performance deteriorates. Since the dispersibility of the conventional mixers is not so good, it is considered that the electrode morphology cannot be maintained eve if 15 to 18% is used.

8. Full Cell consisting of high nickel aqueous slurry and SiO aqueous slurry

By using JPSS-X, carbon dioxide neutralized slurry was prepared using NCA: CB: VGCF: acrylic binder= 92: 3.5: 0.5: 4 as a high-capacity high-nickel aqueous slurry composition for the positive electrode.

Similarly, for the negative electrode, a slurry was prepared using SiO: KB: aqueous polyimide (PI) binder =97: 3: 10.

Full cells were assembled and evaluated using positive and negative electrodes using these slurries. The results are shown in Fig. 11.

The charge/discharge characteristics were evaluated at 30℃ and 60℃. Both show good cycle characteristics. At 60℃, the ionic conductivity of the electrolytic solution and the ion diffusion rate of the electrodes are higher than 30℃, so it is estimated that the capacity has improved.

Full cell "NCA/SiO batteries" made from water-based slurries in this way have good cycle characteristics. The possibility of creating water-based slurries for high-capacity positive and negative electrodes of lithium-ion batteries has greatly expanded.

We have been developing an aqueous slurry of the next generation negative electrode active material Si metal that does not use a polyimide binder.

9. Application to platinum – supported carbon black slurry for polymer electrolyte fuel cells (PEFC)[5)]

The structure of the polymer electrolyte fuel cell (hereinafter abbreviated as PEFC) is shown in Fig. 12 (A) MEA for a PEFC, (B) catalyst layer structure and (C) three-phase boundary at the cathode using Pt/C and a proton.

PEFCs have begun to spread as stationary fuel cells

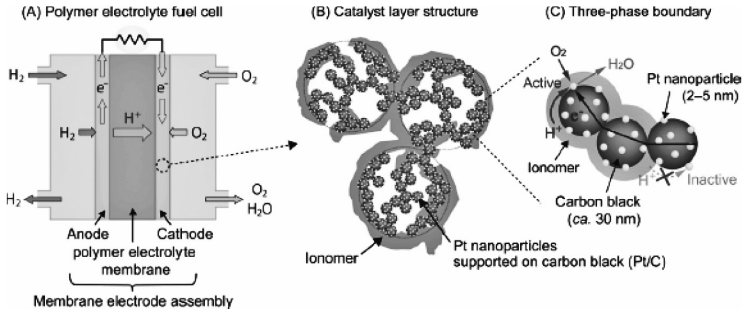


Fig. 12 (A) MEA for a PEFC (B) catalyst layer structure
(C) three-phase boundary at the cathode using Pt/C and a proton

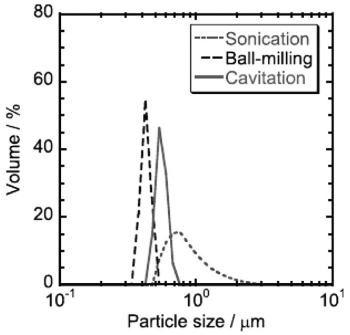


Fig. 13 Particle size distribution

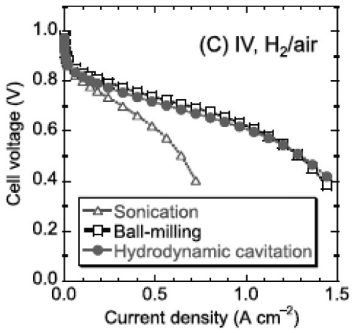


Fig. 16 Cell properties of MEA

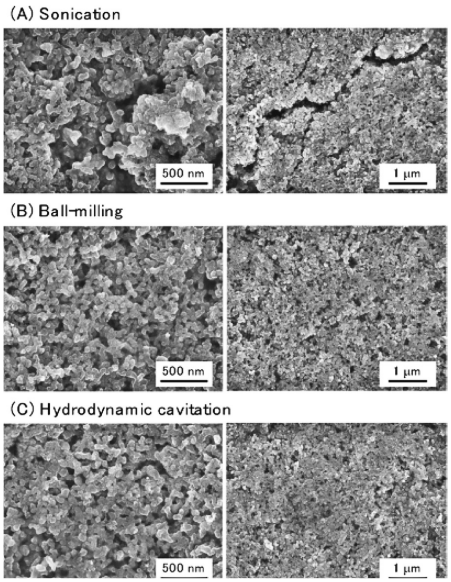


Fig. 14 SEM of electrode surface

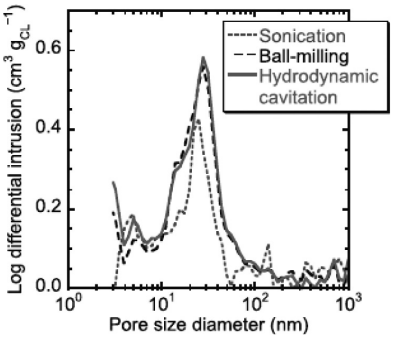


Fig. 15 Pore size distribution

for automobiles and homes, but there are still problems to be solved before they become widespread.

One of the issues is the establishment of a mass production process for a membrane–electrode assembly (MEA), which is the core of PEFC.

MEA has a structure in which both sides of an electrolyte membrane are sandwiched between anode and cathode electrodes (catalyst layer and gas diffusion layer). In MEA, the catalyst layer is the part where the fuel cell reaction occurs which is composed of platinum nanoparticle – supported carbon (Pt/C) and proton – conducting ionomer and the catalyst layer structure has a great influence on the battery performance.

Therefore, as a control of the catalyst layer structure, the dispersion method of the catalyst slurry has been energetically researched and the ball mill method has achieved high power generation performance. But the ball mill method can produce only a small volume of slurry.

In order to mass–produce MEA, it is important to prepare the slurry and to apply and dry the slurry to form a catalyst layer.

In this chapter, we report the results of making a slurry using “JET PASTER” in collaboration with Tokyo Institute of Technology, Prof. Yamaguchi and evaluating

Table 2 Line–up and How to use of “JET PASTER”

Power Source	AC200V 50/60Hz		
Motor	2.2 k W	5.5 k W	18.5kW
Materal	Material contact slurry : SUS304		
Application	Development		Pilot
	Lab	Small quantity	Production
Volume	150～300ml	5L～10L	40L～
Outlook	JPSS-X 	JP-S 	JP-L 

the battery characteristics. The comparison devices are commonly used ball mill and ultrasonic disperser.

The particle size distribution of the dispersion – treated catalyst slurry is shown in Fig. 13, and the SEM is shown in Fig. 14.

From Fig. 13, when the ball mill and the cavitation method are used, large aggregates were not found.. On the other hand, in sonication, although the size of the agglomerates was similarly reduced, large agglomerates of several mm still existed.

From the SEM shown in Fig. 14, sonication affected the formation of the catalyst layer and many aggregates and cracks were observed. On the other hand, when a ball mill or a cavitation method was used, a smooth catalyst layer was observed.

From the mercury injection measurement of the catalyst layer, it was confirmed that the ball mill and the cavitation method have almost the same pore structure（Fig. 15）.

Fig. 16 shows the battery performance（80℃, H2/air） of MEA prepared using different dispersion treatments.

MEA using the cavitation method showed the same high power generation performance as the ball mill method which is an existing established technology. MEA with sonication showed lower performance than the other two dispersion methods.

From the electrochemical measurement of MEA, it was found that this difference in performance was mainly due to the mass transfer resistance of oxygen gas at the cathode and proper slurry preparation and catalyst layer formation are important for achieving high battery performance.

From the above results, it was demonstrated that a high – performance MEA can be produced by the cavitation dispersion method using the swelling and contraction of the cavitation bubble.

The dispersion method by cavitation can be expected to contribute to the MEA mass production process.

10. Line – up and How to use of “JET PASTER”

As shown in Table 2, we have several types “JET PASTER” that can respond to all kinds of applications from small laboratory equipment to mass production equipment. In addition to Table 2, JP – LL which can produce 1000 to 2000 L of slurry in 1 to 2 hours is scheduled to be launched near future.

1) How to use “JPSS–X”

This device has a capacity of 150 to 300 ml and is for small – scale production, and is for research and development such as composition study. Please note that it may take some time as the powder is supplied to the cup little by little from a spatula or bag.

2) How to use “JP–S” and “JP–L”

JP – S and JP – L are for pilot plants and mass production, respectively. As shown in FIG. 17, dissolution / dispersion is promoted by circulating operation with a JET PASTER through an external stirring vessal and a pump. The powder is sucked together with air by the depressurizing force generated by

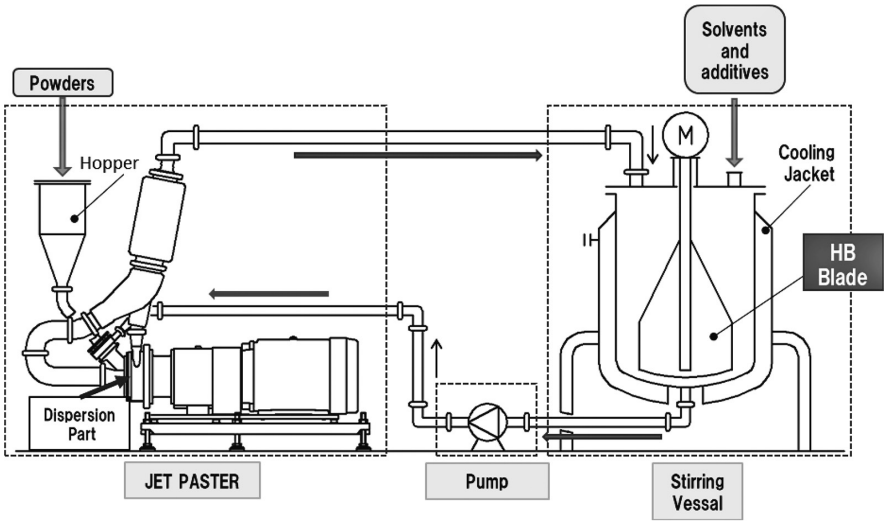


Fig. 17 Combination of stiiring vessal with HB blade and JP

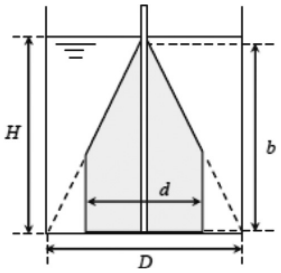


Fig. 18 Shape of HB blade

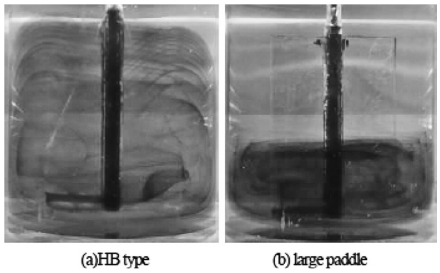


Fig. 19 Dispersion state of iodine in HB and paddle blades

the JET PASTER from the hopper. At the initial stage, dispersion and dissolution have not yet progressed sufficiently. Therefore, if blades (paddle blade, anchor blade, etc.) having insufficient stirring capacity is used, a short pass occurs in the stirring vessal. So, it is difficult to obtain a uniform solution/slurry only by the performance of the JET PASTER.

For the above reasons, JP-S and JP-L have adopted the "Home Base (HB) blade" researched and developed in the Professor Kato's Laboratory, Graduate School of Engineering, Nagoya Institute of Technology.[6)]

HB blade has the following three features.

1. Shape: Simple
2. Mixing performance: Speedy
3. Flow: Stable

Fig. 18 shows the shape of the HB blade. Fig. 19 shows the stirring state. The left side of Fig. 19 is the HB blade and the right side is the paddle blade. Iodine can be stirred more uniformly in the HB blade than in the paddle blade.

Prof. Kato has clarified that the HB blade have the same or better stirring performance of the Max Blend blade and the Full Zone blade and so on.

3) Carbon Dioxide Neutralization Method

The "JET PASTER" is a device that can easily neutralize carbon dioxide gas by installing a carbon dioxide gas generator (carbon dioxide gas cylinder, etc.) and a flow rate control device.

4) Other

We believe that by supplying ultra-dry air, argon, and nitrogen into the JET PASTER in the same way as carbon dioxide, it may be possible to produce sulfide-based all-solid-state battery slurries without using a glove box.

Further, since the "JET PASTER" has a structure in which the powder is sucked under reduced pressure to work on the dispersed portion, the suction force decreases when the viscosity becomes high, so that there is an upper limit to the viscosity that can be produced.

Please be aware that it is difficult to handle high-viscosity materials such as clay.

A test site "Techno Stage" has been set up in Amagasaki City, Hyogo Prefecture Japan. Evaluation equipment such as rheometers and particle size

distribution analyzers are also available to prepare for witness tests.

11. Conclusions

By “JET PASTER” using the cavitation effect, the following became clear:

1) At the LiB positive electrode, carbon dioxide neutralization technology has made it possible to make an aqueous slurry of high nickel active material.
2) For the negative electrode, high capacity was achieved by combining a high capacity SiO material with a less amount of water-based PI binder.
3) By combining the two electrodes, the possibility of developing and launching an unprecedented high-capacity lithium-ion battery has expanded.

   Hwever, there remains the problem that it is difficult to use the current drying furnace for water-based graphite because a high temperature of over 250℃ is required to cure the water-based PI binder. In order to solve this problem, we have been proceeding with technological development for next-generation Si metals.
4) Biologging batteries has been under development in collaboration with the Atmosphere and Ocean Research Institute, The University of Tokyo as an application for full-cell batteries consisting of slurries produced by “JET PASTER”.

   We would like to report when the data is available.
5) Slurries for fuel cells can also be produced with “JET PASTER” and have good electrode characteristics.

By “JET PASTER”, not only the cruising range of EV can be extended but also the initial capital investment such as solvent recovery equipment in the battery manufacturing process can be suppressed. The environmental load caused by organic solvents and the adverse effect on the human body can be reduced.

High productivity of “JET PASTER” can be expected to reduce running costs.

We also feel great potential for application to PEFC slurries.

We will strive to expand not only to Japan but also to China, EU, and USA.

Development competition is taking place around the world for both EVs and FCs as a departure from gasoline engines.

It may be affected by the coronavirus but we don’t think there is any change in the big trends. We hope that our “JET PASTER” can make a big contribution in the fields of Lib and FC.

12. Citations

1) S. Hosokawa “2014: Joint research report (in Japanese)” Kobe University
2) K. Kimura, T. Sakamoto, T. Mukai, Y. Ikeuchi, N. Yamashita, K. Onishi, K. Asami and M. Yanagida,: “Improvement of the Cyclability and Coulombic Efficiency of Li-Ion Batteries Using Li［Ni0.8Co0.15Al0.05］O_2 Cathode Containing an Aqueous Binder with Pressurized CO_2 Gas Treatment” *Journal of The Electrochemical Society*, *165*, *A16 (2018)*.
3) K Kimura, K Onishi, T Sakamoto, K Asami and M Yanagida ：“Achievement of the High-Capacity Retention Rate for the Li［Ni0.8Co0.15Al0.05］O_2 (NCA) Cathode Containing an Aqueous Binder with CO_2 Gas Treatment Using the Cavitation Effect (CTCE)” *Journal of The Electrochemical Society*, *166 (3) A5313-A5317 (2019)*
4) Keiichi Asami “LIB next generated water-based slurry by high-speed dispersion device with cavitation effect (in Japanese)” *Kagaku Sochi*., *No. 9. p 31-35. 2020*
5) Hidenori Kuroki, Keiichiro Onishi, Keiichi Asami and Takeo Yamaguchi “Catalyst Slurry Preparation Using a Hydrodynamic Cavitation Dispersion Method for Polymer Electrolyte Fuel Cells” *Ind. Eng. Chem. Res. 2019*, *58*, *19545-19550*
6) Y Kato, H Furukawa, Y Ikeda, T Nakanishi, T Sano and K Tomioka “Development of a Mixing Process Using an HB-Type Impeller to Easily Achieve Scale-UP by Maintaining Geometrical Similarity” *International Journal of Chemical Engineering Vol 2018*

Static elimination function of NS Dry Booth

HVAC Division

MASUDA Katsuhiro

Abstract

We have developed a system that improves the capability of the current dry thermal and achieve a blowing dew point temperature of －80℃ or less.

1. Introduction

In the manufacturing process of lithium－ion batteries that are currently the mainstream in the secondary battery market, a dew point temperature of －40℃ or less is required, but it is obvious that a dew point temperature of －80℃ or less will be required in the next－generation solid－state battery manufacturing process. However, the blowing dew point temperature is limited to －55℃ with the current dry thermal. Therefore, to meet the next–generation solid–state battery manufacturing process, it is necessary to improve the ability of the dry thermal to achieve a blowing dew point temperature of －80℃ or less. Consequently, we achieved a blowing dew point temperature of －80℃ or less by developing an air controller to dehumidify outside air taken in that affects the dry thermal blowing dew point temperature and combining it with the dry thermal. Here, we will report the development and the outline of the equipment.

2. Outline of Dry Thermal

A dry thermal is a space–saving low dew point air controller with a blower, refrigerator, cooler, heater, and dehumidifier contained in one housing. Fig. 1 shows a schematic drawing. In addition, Fig. 2 shows the layout of the devices described above that are contained in the dry thermal.

3. Basic Specifications

Table 1 shows the basic specifications of the current dry thermal.

4. Points of Development

It is known that the blowing dew point temperature varies depending on the amount of moisture contained in

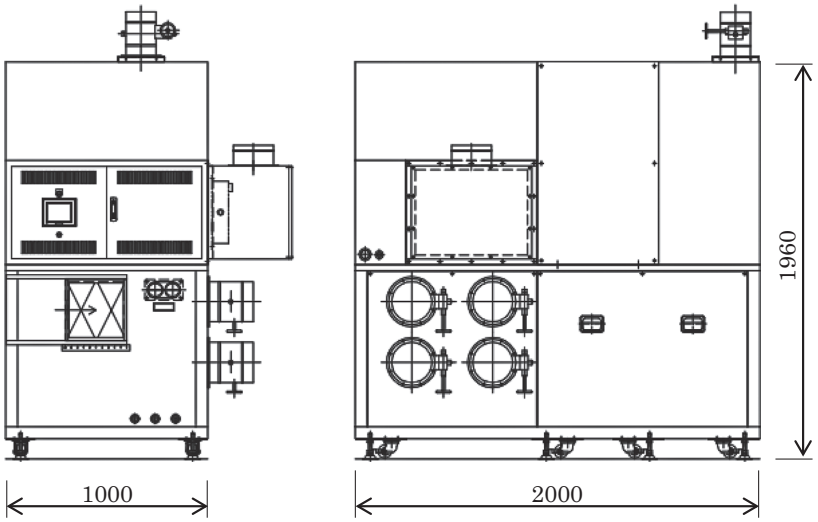


Fig. 1 Schematic drawing of dry thermal

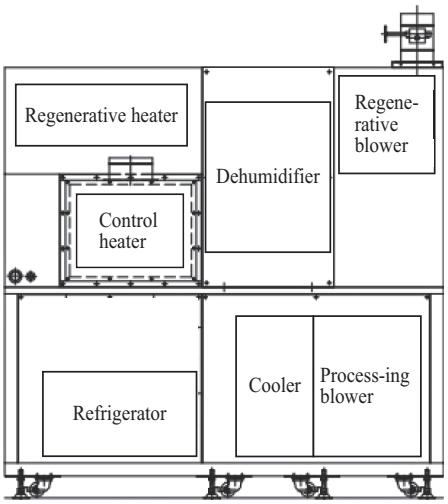


Fig. 2 Device layout in dry thermal

outside air (OA) taken in by the current dry thermal. We assumed that the blowing dew point temperature could be reduced if the amount of moisture of outside air could be reduced and supplied to the dry thermal, and carried out development and design of an air controller (hereinafter referred to as the pre dry) to dehumidify outside air (OA) taken in by the current dry thermal and verification of improvement of the blowing dew point temperature performance of the current dry thermal with connection of the current dry thermal and the pre dry (see Fig. 3). We set a goal that the blowing dew point temperature of the current dry thermal would be −80℃ or less.

4.1 Pre Dry Basic Specifications

Table 2 shows the basic specifications of the pre dry.

4.2 Features of Pre Dry

The features of the developed pre dry are that it is space saving, and the connection method with current dry thermal can be selected between two patterns (integrated or separated), which allows placement suitable to the installation location.

Table 1. Basic specifications of current dry thermal

Name	Item	Unit	Specifications
Specifications	Blowing dew point temperature	℃ D.P.	55 ※1
	Blowing dry-bulb temperature	℃ D.B.	Ambient temperature −1 to +4
	Supply air volume	m^3/min	16～20
	Exhaust air volume	m^3/min	8～9
	Outside air intake volume	m^3/min	8～10
	External dimensions	—	1000 W × 2000 D × 1960 H
	Body material	—	Steel plate
Ambient conditions	Temperature	℃ D.B.	20～26
	Humidity	% R.H.	30～70

*1 The blowing dew point temperature varies depending on the ambient conditions.

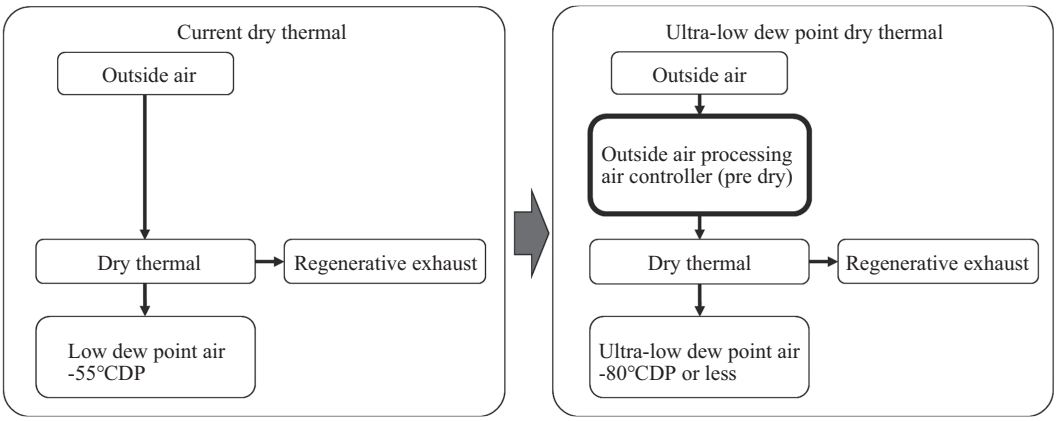


Fig. 3 Connection schematic drawing of outside air processing air controller (pre dry)

Table 2 Pre dry basic specifications

Name	Item	Unit	Specification
Specification	Processing air volume	m^3/min	12～15
	Exhaust air volume	m^3/min	2～3
	Dehumidifying amount	g/kg	2.5
	External dimensions	—	900 W × 1400 D × 1340 H
	Body material	—	Steel plate
	Weight	kg	600
Ambient conditions	Temperature	℃ D.B.	20～26 ※1
	Humidity	% R.H.	30～70 ※1

*1 The ambient condition range should be a wet-bulb temperature of 19℃ or less.

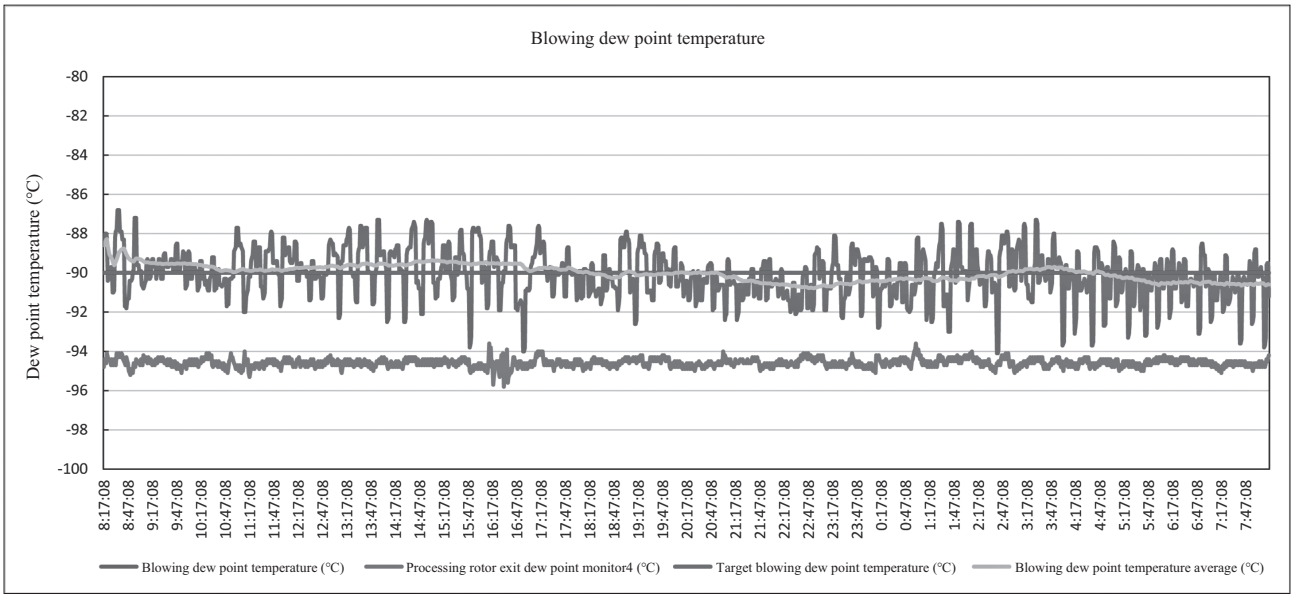


Fig. 4 Performance measurement result

5. Development Result

5.1 Performance Measurement Result

The measurement result of the blowing dew point temperature shows that a minimum ultimate dew point temperature of －94.1℃ was achieved, －90℃ was mostly maintained during the operation for 24 hours, and the target blowing dew point temperature of －80℃ or less was achieved. Fig. 4 shows the performance measurement result.

5.2 Outline Drawing

Fig. 5 shows the outline drawing of connection of the pre dry fabricated in this development and the current dry thermal. This drawing shows a utility unit with bult-in supply air（SA）and return air（RA）ducts to connect the pre dry and the current dry thermal. This utility unit also allows to improve the operability of the booth connection of the SA and RA ducts and to rotate the connection direction of the pre dry by 90 degrees.

6. Conclusion

We could make supply of ultra-low dew point dry air possible by focusing on processing of outside air taken in by the current dry thermal as a necessary element to supply dry air with an ultra-low dew point, developing an outer air processing air controller（pre dry）and combining it with the current dry thermal. Since we could also obtain data indicating that the blowing dew point temperature can be decreased also in the current dry thermal alone, we believe we can propose objectively the

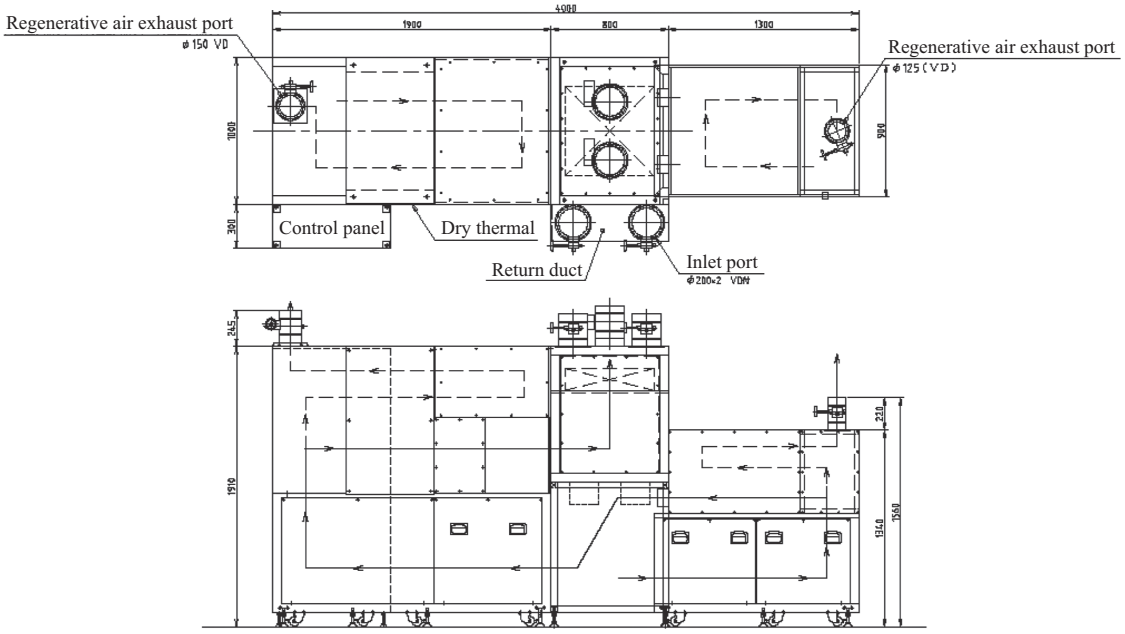


Fig. 5 Outline drawing of ultra-low dew point dry thermal

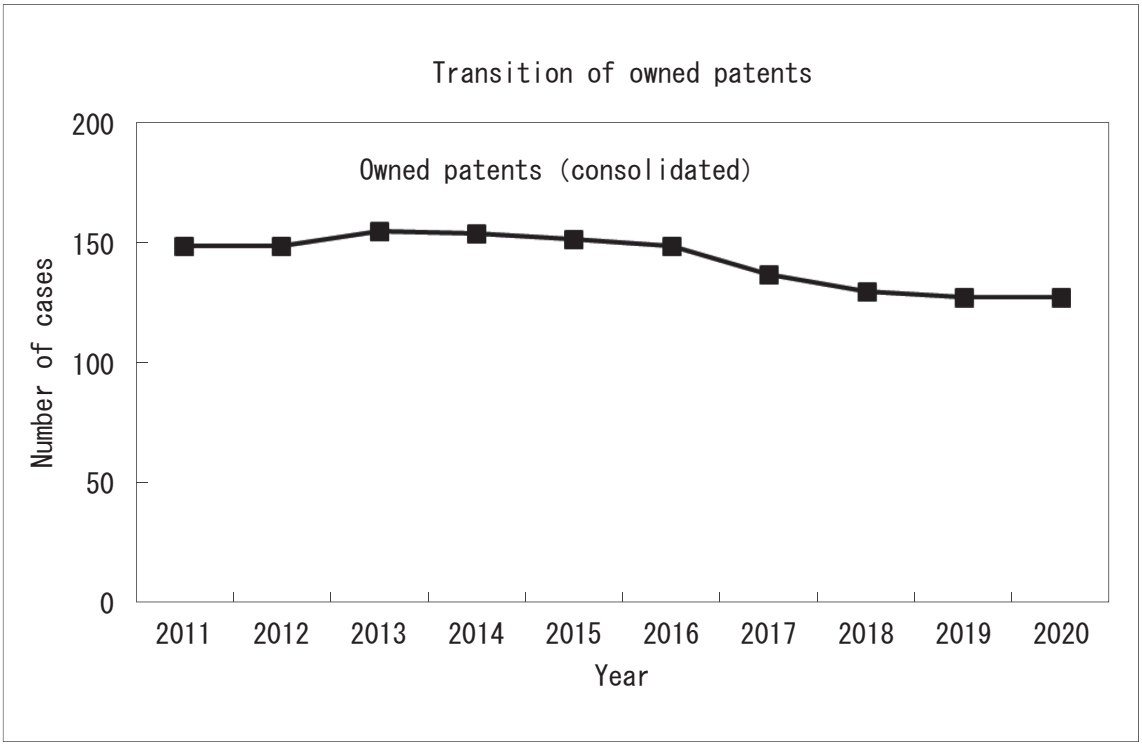
necessity to set up a dry thermal installation environment.

7. Related Patents

1) National Institute of Advanced Industrial Science and Technology (AIST) and Nihon Spindle Manufacturing Co., Ltd., Static Electricity Removal Structure in Low Humidity Space, Patent No. 6376577
2) Nihon Spindle Manufacturing Co., Ltd., Dry Booth, Patent No. 6080202
3) Nihon Spindle Manufacturing Co., Ltd., Dry Booth, Patent No. 6066188

Intellectual Property Report

◆ Transition of domestically owned patent rights



◆ Introduction of registered patents in 2018

【Industrial Machinery Moriyama Division】

Patent number	Title of the invention
6426664	Disc rotor and its manufacturing equipment, a roller, and method for manufacturing disc rotor
6426930	Screen changer
6430902	Closed kneader

【Environment Division】

Patent number	Title of the invention
6436459	Filter cloth structure
6462453	Exhaust gas treatment device using filter cloth

【HVAC Division】

Patent number	Title of the invention
6376577	Static electricity removal structure in low humidity space

◆ Introduction of registered patents in 2019

【Industrial Machinery Moriyama Division】

Patent number	Title of the invention
6532694	Rotating plastic processing equipment
6562504	Straining mechanism and screw extruder equipped with the straining mechanism
6583884	Spinning device and spinning molding method for cylindrical materials

【Environment Division】

Patent number	Title of the invention
6660267	Member for protective mounting of ceramic filter
6664847	Control device and control method for injection operation of compressed air in dust collector

【HVAC Division】

Patent number	Title of the invention
6654330	Filling plate for gas-liquid contact
6673702	Cooling tower equipped with axial flow air blower

【Mixing Business Center】

Patent number	Title of the invention
6576452	Method for producing positive electrode slurry of non-aqueous electrolyte secondary battery and positive electrode slurry of non-aqueous electrolyte secondary battery
6610851	Method for producing paste containing carbon
6666668	Fine particle dispersion method and fine particle dispersion device
6671683	Method and equipment for sterilization of liquid substance

◆ Introduction of registered patents in 2020

【Industrial Machinery Moriyama Division】

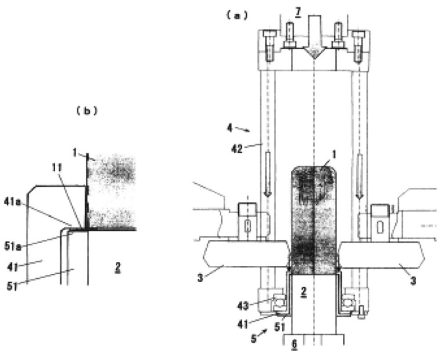
Patent number	Title of the invention
6751008	Kneading state judgment system, kneading state judgment device, operation screen of kneading state judgment system, and kneading state judgment assisting system
6759112	Rotating plastic processing equipment
6815160	Rotating plastic processing equipment, rotating plastic processing system and processing roller support unit
6837312	Rotating plastic processing system and unit transfer wagon

【Mixing Business Center】

Patent number	Title of the invention
6687422	Dispersion system
6693668	Separation device and separation method
6698998	Nanoparticle synthesis device
6707779	Dispersion method and dispersion device for substance to be treated and method of producing liquid in which the substance to be treated generated by them and dispersion medium are mixed
6744569	Method for producing negative electrode slurry of non-aqueous electrolyte secondary battery and negative electrode slurry of non-aqueous electrolyte secondary battery
6817719	Dispersion mixing device and its operation method
6843894	Liquid-submerged plasma device

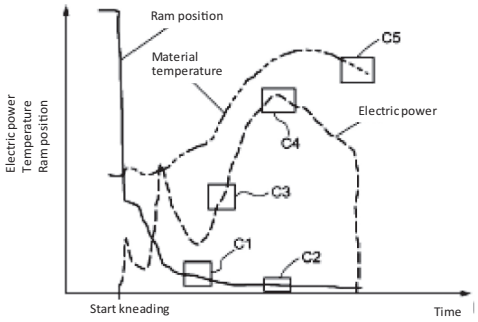
◆ Introduction of overview of notable patents

Patent No. 6583884 “Spinning device and spinning molding method for cylindrical material”



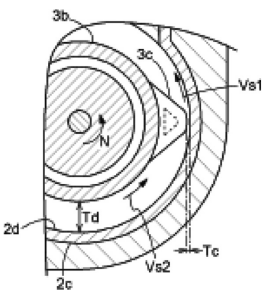
［Technical field］ The present invention relates to a spinning device and a spinning molding method for a cylindrical material.
［Claim 1］ A spinning device for a cylindrical material, in which a cylindrical material is mounted so as to cover a mandrel, and the cylindrical material is stretched and thinned by performing a squeezing process in which the cylindrical material is pressed by a roller from the outer peripheral side while applying tension in the axial direction of the cylindrical material, wherein the device has a tension applying mechanism that applies tension in the axial direction of the cylindrical material via a holding portion projecting from the outer periphery of the cylindrical material, and a support mechanism for holding the holding portion of the cylindrical material with the tension applying mechanism, the support mechanism has a moving mechanism, and the holding portion of the cylindrical material can be supported in the axial direction by the moving mechanism, and, by moving the holding portion of the cylindrical material in the axial direction of the mandrel while being held between the tension applying mechanism and the support mechanism, the squeezing process is performed while applying tension in the axial direction of the cylindrical material.

Patent No. 6751008 “Kneading state judgment system, kneading state judgment device, operation screen of kneading state judgment system, and kneading state judgment assisting system”



［Technical field］ The present invention relates to a kneading state judgment system, a kneading state judgment device, an operation screen of the kneading state judgment system, and a kneading state judgment assisting system.
［Claim 1］ A kneading state judgment system having a kneading unit and a determination unit, wherein the kneading unit kneads a kneading material, and transmits a kneading state value indicating the kneaded state to the determination unit, and the determination unit determines the kneading of the kneading material in the kneading unit according to the set determination conditions based on the kneading state value transmitted from the kneading unit, and the determination conditions include the determination period and the state value range, and the state value range is set as a range for the kneading state value, and the determination period is a partial period in the period from the start to the end of kneading in the kneading unit, and the state value range is a range in which the kneading state value is included in the partial period.

Patent No. 6430902 “Closed kneader”

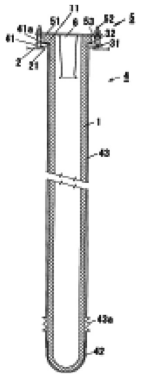


［Technical field］ The present invention relates to a closed kneader having a kneading tank for storing a kneading material and a pair of rotors arranged in the kneading tank.
［Claim 1］ A closed kneader having a kneading tank for storing a kneading material and a pair of rotors arranged in the kneading tank, wherein the rotors have a cylindrical rotor shaft and a rotor blade formed on the surface of the rotor shaft, and constitute a tangential mode in which the rotor blades do not overlap each other between the pair of rotors facing each other, and the blade tip shear deformation speed at the tip of the blade, in kneading the kneading material by rotating the rotors, is defined as a value obtained by dividing the turning speed of the tip of the rotor blade by the distance between the tip of the rotor blade and the inner surface of the kneading tank, and the shaft surface shear deformation speed on the surface of the rotor shaft is defined as a value obtained by dividing the turning speed of the surface of the rotor shaft by the distance between the surface of the rotor shaft and the inner surface of the kneading tank, and the shear deformation speed ratio, which is the value obtained by dividing the blade tip shear deformation speed by the shaft surface shear deformation speed, is 5.0 or more and 40 or less, and the diameter of the rotor shaft is 0.65 times or more and 0.80 times or less the diameter of the inner surface of the kneading tank.

Patent No. 6660267 “Member for protective mounting of ceramic filter”

［Technical field］ The present invention relates to a member for protective mounting of a ceramic filter, for example, to a member for protective mounting of a ceramic filter, which is used in a partition wall type dust collector.

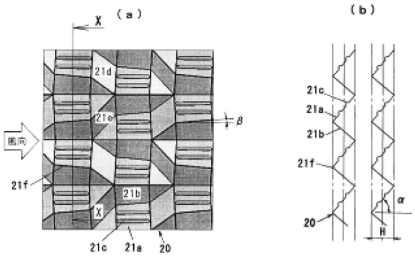
［Claim 1］ A member for protective mounting of a ceramic filter, which is used for mounting a ceramic filter on a thimble plate, wherein the member is constituted of a fixing member which is interposed between the flange of the ceramic filter and the thimble plate and mounted on the thimble plate, a support member that is placed on the outer surface of the ceramic filter on the opposite side of the flange, to support the ceramic filter, and a connecting member which couples the fixing member and the supporting member, and the connecting member has a tension adding member for adding tension in the longitudinal direction of the ceramic filter as a coupling portion in the middle or at the end of the connecting member.



Patent No. 6654330 “Filling plate for gas–liquid contact”

［Technical field］ The present invention relates to a filling plate for gas–liquid contact, which is used as a filler in a cooling tower.

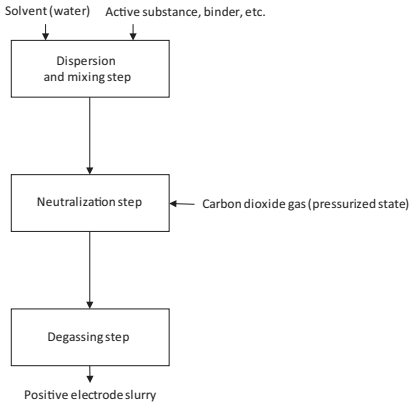
［Claim 1］ A filling plate for gas–liquid contact that exchanges heat by direct contact with air while flowing treating water along the surface of a sheet–shaped plate material, wherein on the surface of the plate material, an upward inclined surface and a downward inclined surface having a zigzag shape in a vertical cross section are repeatedly formed in the vertical direction, and the rows of upward inclined surfaces and downward inclined surfaces repeatedly formed in the vertical direction are arranged in parallel with a phase shift in the width direction of the filling plate for gas–liquid contact, and, the ridgeline where the upward inclined surface and the downward inclined surface intersect is formed at an angle with respect to the horizontal plane, and a flow resistance imparting portion that acts as a resistance to the flow of the treating water is formed on the surface of the plate material.



Patent No. 6576452 “Method for producing positive electrode slurry of non–aqueous electrolyte secondary battery and positive electrode slurry of non–aqueous electrolyte secondary battery”

［Technical field］ The present invention relates to a method for producing a positive electrode slurry of a non–aqueous electrolyte secondary battery and a positive electrode slurry of a non–aqueous electrolyte secondary battery.

［Claim 1］ A method for producing a positive electrode slurry of a non–aqueous electrolyte secondary battery containing an alkali metal composite oxide, comprising a neutralization step to neutralize an alkaline component in the slurry by introducing a carbon dioxide gas at a pressure of 0.12 MPa or more and 100 MPa or less, and a degassing step to degas inorganic carbon in the slurry as a carbon dioxide gas after the neutralization step.



＜Products＞

Industrial Machinery

- VARIFORMA (Spinning Machines & Flow Forming Machines)
  - Spinning Machine for Exhaust Products
  - Aluminum Wheel Forming Machine
  - Playback NC Spinning Machine
  - Pulley Processing Machine
  - Drive Plate Processing Machine
  - Clutch Case Processing Machine
  - Special Spinning Machine and Flow Forming Machine, Thickening Machine
- Coolant Cleaning Devices
  - Spiclon
  - Clonace
  - Uzu Eco
- Powder Absorbing, Dissolving & Dispersion Devices (Jet Paster)
  - JPSS-X (for Laboratory use)
  - JPSS (for Experiment, Preproduction, Development)
  - JPS (for Small lot pilot line)
  - JPL (High productivity)
- Mixers
  - Double-Arm Kneader (G・Vacuum type: GV)
  - Double – Arm Kneader with Discharge Valve (GB・Vacuum type: GBV)
  - Double – Arm Kneader – Ruder (KR・Vacuum type: KRV)
  - Dispersion Kneader-Ruder (KRD)
  - Small Capacity Double-Arm Kneader (S・Vacuum type: SV)
  - Dispersion Kneader (DS・DX・DP)
  - Wonder Kneader (WD)
  - High Speed Mixer (HS)
  - Mix-Labo (ML)
- Under Mixer
  - Sheet Preforming Machine (SPM)
- Pellet/Sheet Manufacturing Equipments
  - Feeder Ruder (FR)
- Extruders
  - Twin Taper Single Extruder (2TR)
  - Twin Taper Screw Extruder (2TE)
- Others
  - Hot Melt Manufacturing Machine
  - Rubber Cutting Machine
  - Batch off Machine
  - Bucket Conveyor (BKC)

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  - Brake Components
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  - Drive Components
  - Airframe Components
  - Pressure Vessels
- Wind & Energy
  - Drive Components
  - Precision Pipes
  - Pressure Vessels
- Pipes, Oil, Gas
  - Tanks
  - Pipes
- Agriculture & Construction
  - Transmission Parts
  - Wheels
  - Tanks
  - Work Implements
- Lighting
  - Pipes
  - Poles
  - Components
- HVAC
  - Air-conditioning Components
- Food & Chemical
  - Separating Technology Components
  - Mixing Technology Components
- Other industries
  - Components

Dust Collector

- Dust Collectors
  - For Blast Furnaces
  - Exhaust Gas Processing System for Electric Furnaces
  - For Garbage Incinerators
  - Eco Pulser
  - Wet Dust Collector
  - Dust Collector Peripheral Equipments
  - Multi Cyclone
  - SP Filter
- Small Dust Collector
  - Dustop
- NS Mist Dust Collector
  - NS Oil Mist Dust Collector ODB
  - Collision Inertia Type Mist Dust Collector SMT
- Electrostatic Dust Collector
- Pneumatic Conveying System
- Dust Treatment Equipments
  - Pan Pelletizing System for Fly Ash/collected dusts

Precision Air Controller and Air Filter

- Clean Room Systems
  - Clean Room System
  - Clean Room Equipments Air shower, Clean booth, Pass box, Relief damper, Clean supply, HEPA filter, Clean bench, Clean unit
  - Precision Air Controller Unit (Thermal Cube, Thermostatic Booth)
  - Dry Room and Dry Booth
- Air Filter
  - NS Air Filter NU Type (Charging Filter), EX Type, P Type, PK Type, CG Type, E Type
  - NS Air Filter F Series 30/30 Type, GF Type, KF Type
  - NS Air Filter Selfresh (Automatic Regeneration Air Filter)
  - NS Roll Filter
- Cooling Tower
  - Open Circuit Cooling Tower (Round Shaped) : NE/NL series

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  - Precision Screw
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  - Plain Washer
  - Toothed Washer
- Cold Headings
  - Pin
  - Rivet
  - Multi-Stage Products
- Special Products
  - Cutting Products
  - Pressed Products
  - Composite Processed Product

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