【DESCRIPTION】

【Invention Title】

Method for Manufacturing PTFE Fiber and PTFE Membrane Catalyst Filter Using Same

【Technical Field】

This invention pertains to a method for manufacturing PTFE fibers and to PTFE membrane catalytic filters produced using PTFE fibers. More specifically, it relates to a method of manufacturing PTFE fibers for the production of PTFE membrane catalytic filters with improved performance through optimized blending processes during fiber production, and concerns PTFE catalytic filters.

【Background Art】

As a background for the development of a catalytic filter that simultaneously reduces particulate matter and NOx in exhaust gas, there is a growing trend of tightening emission standards for harmful gases in exhaust gas. There is a high level of interest in the development of high-performance materials and process improvements for simultaneous reduction of nitrogen oxides (NOx), sulfur oxides (SOx), and others. However, domestic technology is inadequate, and essential technology relies on advanced foreign technology. In particular, due to economic and spatial issues faced by small-scale facilities, such as small waste incineration plants, practical problems arise when using combinations of multiple unit facilities, including installation space and investment costs. Due to these circumstances, in Korea, large-scale equipment such as SCR and SNCR is currently used for the removal process of nitrogen oxides (NOx).

【Disclosure】

【Technical Problem】

The present invention aims to provide a method for manufacturing a PTFE membrane catalytic filter that reduces fine dust and NOx in exhaust gas to meet enhanced emission standards, particularly when applied to existing dust collection facilities operating in small waste incineration plants. Furthermore, the present invention aims to provide a method for manufacturing catalytic fibers for PTFE membrane catalytic filters. Additionally, the present

invention aims to provide optimized manufacturing process conditions for catalytic fibers.

【Technical Solution】

To achieve these objects and other advantages and in accordance with the purpose of the present disclosure, provided herein a method for mixing PTFE powder with De-NOx catalyst and lubricant to create a PTFE fiber manufacturing powder mixture. In this method, PTFE powder and De-NOx catalyst powder are placed inside a mixer where gravity and centrifugal forces are employed to repeatedly cause them to fall and mix. During this process, lubricant is sprayed onto the powders, creating a mixed powder. This method is characterized by the addition of lubricant to the powders during the rotation of the mixer.

According to one embodiment of the present invention, the lubricant is adjusted to be sprayed only onto the PTFE powder and De-NOx catalyst powder, not on the mixer walls, and this forms a specific feature of the PTFE fiber manufacturing powder mixture method.

According to one embodiment of the present invention, the De-NOx catalyst powder comprises 0.5% by weight or more and less than 0.7% by weight of the total weight, which is a specific feature of the PTFE fiber manufacturing powder mixture method.

According to one embodiment of the present invention, the lubricant comprises 27% by weight or more and 29% by weight or less of the total weight, which is a specific feature of the PTFE fiber manufacturing powder mixture method.

According to one embodiment of the present invention, the spraying speed of the lubricant is 150g/min or more and less than 250g/min, which is a specific feature of the PTFE fiber manufacturing powder mixture method.

According to one embodiment of the present invention, the rotation speed of the mixer is 10rpm or more and 14rpm or less, and the mixing time is 40 minutes or more and 70 minutes or less, which is a specific feature of the PTFE fiber manufacturing powder mixture method.

Furthermore, in the PTFE membrane catalytic filter manufacturing method using PTFE fibers produced by the above-described method, the mixing process employs gravity and centrifugal forces to repeatedly cause the powders to fall and mix inside the mixer, where PTFE powder and De-NOx catalyst powder are placed and rotated. During this process, lubricant is sprayed onto the powders, creating a mixed powder, and this forms a specific feature of the PTFE membrane catalytic filter manufacturing method.

According to one embodiment of the present invention, the lubricant is adjusted to be

sprayed only onto the PTFE powder and De-NOx catalyst powder, not on the mixer walls, and this forms a specific feature of the PTFE membrane catalytic filter manufacturing method.

According to one embodiment of the present invention, the De-NOx catalyst powder comprises 0.5% by weight or more and less than 0.7% by weight of the total weight, which is a specific feature of the PTFE membrane catalytic filter manufacturing method.

According to one embodiment of the present invention, the lubricant comprises 27% by weight or more and 29% by weight or less of the total weight, which is a specific feature of the PTFE membrane catalytic filter manufacturing method.

According to one embodiment of the present invention, the spraying speed of the lubricant is 150g/min or more and less than 250g/min, which is a specific feature of the PTFE membrane catalytic filter manufacturing method.

According to one embodiment of the present invention, the rotation speed of the mixer is 10rpm or more and 14rpm or less, and the mixing time is 40 minutes or more and 70 minutes or less, which is a specific feature of the PTFE membrane catalytic filter manufacturing method.

Furthermore, the present invention introduces PTFE fibers manufactured using the PTFE fiber manufacturing method described in the embodiments above.

Additionally, the present invention introduces PTFE membrane catalytic filters manufactured using the PTFE membrane catalytic filter manufacturing method described in the embodiments above.

【Advantageous Effects】

According to the present invention, it is possible to simultaneously remove NOx and particulate matter by using PTFE membrane technology to filter out dust from exhaust gas on the filter surface and by allowing NOx to react within a catalyst-containing bag filter, resulting in the removal of nitrogen oxides (NOx).

Furthermore, the invention enables the manufacturing of a catalytic filter with NOx reduction capability in the final product bag filter by imparting the function of the catalyst through a mixing method from the fiber manufacturing stage, rather than relying on foreign technology and products that use a coating method.

【Description of Drawings】

Figure 1 is a photograph of the mixing stage in the process of manufacturing fibers

according to the present invention.

Figure 2 is a photograph of the maturation stage in the process of manufacturing fibers according to the present invention.

Figure 3 is a photograph of the compression stage in the process of manufacturing fibers according to the present invention.

Figure 4 is a photograph of the extrusion stage in the process of manufacturing fibers according to the present invention.

Figure 5 is a photograph of the rolling stage in the process of manufacturing fibers according to the present invention.

Figure 6 is a photograph of the sintering stage in the process of manufacturing fibers according to the present invention.

Figure 7 is a photograph of the spinning/elongation stage in the process of manufacturing fibers according to the present invention.

Figure 8 is a photograph of the slitting stage in the process of manufacturing fibers according to the present invention.

Figure 9 is a photograph of the mesh-shaped catalyst fiber spread out after slitting.

Figure 10 is a photograph of the catalyst fiber wound on a bobbin.

Figure 11a is a photograph representing the billet of sample 1.

Figure 11b is a photograph representing the rolled sheet of sample 1.

Figure 12a is a photograph representing the billet of sample 2.

Figure 12b is a photograph representing the rolled sheet of sample 2.

Figure 13a is a photograph representing the billet of sample 3.

Figure 13b is a photograph representing the rolled sheet of sample 3.

Figure 14a is a photograph representing the billet of sample 4.

Figure 14b is a photograph representing the rolled sheet of sample 4.

Figure 15 is a photograph showing the catalyst detached during the slitting process of sample 7.

Figure 16 is a photograph showing the catalyst detached during the slitting process of sample 8.

Figure 17a is a photograph representing the billet of sample 9.

Figure 17b is a photograph representing the rolled sheet of sample 9.

Figure 18 is a photograph representing the billet of sample 10.

【Best mode】

Below, the invention will be described in more detail with reference to the drawings. In this specification, even for different embodiments, the same or similar components are given the same reference numbers, and their descriptions are omitted after the initial explanation, unless context clearly indicates otherwise. Also, singular expressions used in this specification encompass plural expressions unless context clearly indicates otherwise. Furthermore, in describing with reference to the attached drawings, for the sake of clarity, detailed explanations related to prior art techniques that could unnecessarily obscure the essence of the invention may be omitted.

Referring to Figures 1 to 8, the general PTFE Fiber manufacturing process consists of the following stages in order: mixing, maturation, compression, extrusion, rolling, sintering, spinning, elongation, and slitting.

In the catalyst fiber manufacturing process for producing PTFE membrane catalytic filters according to the present invention, in the mixing stage, PTFE powder and a lubricant are mixed in a certain ratio using a mixer. To manufacture catalyst fibers, De-NOx catalyst must also be added to the mixer for mixing.

In this process, due to the inclusion of De-NOx catalyst for imparting catalyst functionality, the proportions of raw materials change in the manufacturing of catalyst fibers. Consequently, variations in temperature, speed, and working time in each stage result in differences in workability (continuous operation), productivity (loss rate), and De-NOx effectiveness (nitrogen oxide removal function).

To manufacture catalytic filters, given the interrelated nature of these various conditions, research is required to produce the highest quality products most efficiently.

Additionally, as shown in Table 1 below, revised regulations have led to stricter standards for particulate matter and nitrogen oxide emissions.

【Table 1】

| | Current Emission Standards | Revised Emission Standards | Strengthening Rate |
|---|---|---|---|
| Particulate Matter | 10~70 mg/Sm3 | 5~50 mg/Sm3 | 33% |
| Nitrogen Oxides (NOx) | 20~530 ppm | 10~250 ppm | 28% |

| | |
|---|---|
| Emission Standards for Facilities with Incineration Capacity of 2 Tons or More | Particulate Matter : 10 mg/Sm3<br>NOx : 50 ppm |

In this section, we describe the optimal operating conditions during the mixing process in the fiber manufacturing process used to produce PTFE membrane filters, in order to meet these conditions.

Even though PTFE powder and De-NOx catalyst are mixed with a liquid lubricant in a powder form in the mixer, if the lubricant ratio is too low, problems occur during the billet formation in the extrusion process. Conversely, if the lubricant ratio is too high, it hinders the sintering process, leading to a high loss rate.

The right balance of these components during mixing is crucial to reduce issues related to operability and productivity in subsequent processes.

Additionally, the ratio of the De-NOx catalyst added for imparting catalytic functionality plays a crucial role. If the ratio of the catalyst is too low, it can result in a reduced De-NOx effect, causing issues with commercial viability. On the other hand, if the catalyst ratio is too high, it can lead to breakages during the drawing or slitting process, compromising operability and productivity.

Therefore, while the appropriate mixing ratio of PTFE powder, De-NOx catalyst, and lubricant is important in the manufacture of catalytic fibers, additional detailed working conditions are also necessary in the mixing process.

Additionally, the mixer utilizes gravity and centrifugal force to repeatedly alternate falling and mixing. If mixed too quickly, the PTFE powder can clump together, preventing the De-NOx catalyst from being properly mixed.

PTFE powder and De-NOx catalyst are both stable at high temperatures and physically stable, and they cannot chemically or physically bond with each other. Therefore, the role of the lubricant during the mixing process is vital.

Simply adding lubricant to the mixer is not sufficient for achieving a uniform mixture, so the method of lubricant mixing in the mixing process is a critical factor.

The lubricant is sprayed evenly into the mixture of two powders (PTFE, De-NOx catalyst) through the inlet of the rotating mixer. During this process, it's important to control the spray speed of the lubricant to avoid over-spraying. If too much lubricant is sprayed, it can clump in certain areas, resulting in an uneven mix.

The lubricant should be sprayed only onto the mixture of the two powders, and it should be controlled to prevent spraying on the walls of the mixer. If sprayed on the mixer walls, the powder mixture may stick and not fall off, leading to loss and potentially uneven mixing.

As the content of the De-NOx catalyst increases, the De-NOx effect also increases. In the mixing process, as the amount of De-NOx catalyst increases, both the quantity of lubricant and the mixing time need to be increased to enhance the dispersibility, workability, and productivity of the catalyst.

The experiment was conducted as follows, reflecting these conditions.

The conditions applied in the experiment are as follows:

In this invention, sintering occurs within a temperature range of 300°C to 500°C, preferably around 400°C. However, this invention focuses more on the ratio of catalyst and lubricant used in the mixing process, the speed of lubricant spraying, the speed of mixing, and the duration of mixing, rather than the conditions of the sintering temperature.

Whether the homogenization process has been successful is determined based on the degree of blending of the lubricant, PTFE, and catalyst. According to an embodiment of this invention, the specific assessment of this blending degree is made by checking factors such as the mixing ratio or color of the mixed powder.

In this invention, homogenization grades are differentiated by dividing into blend ratio analysis evaluation and operator evaluation. More specifically, scores are assigned based on the blend ratio analysis results of the sample, and these are averaged with the scores from operators to categorize the grades as 'Excellent', 'Good', or 'Poor'.

This approach compensates for any change in blend ratio due to vibration during the sample collection process for blend ratio analysis.

The analysis of the sample's blend ratio is carried out as follows.

When analyzing the blend ratio of a sample, a homogenization grade of 'Excellent' is given if the blend ratio is 80% or above. A grade of 'Good' is given if the blend ratio is between 50% and less than 80%. A grade of 'Poor' is given if the blend ratio is below 50%.

For the homogenization grade, 3 points are awarded for 'Excellent', 2 points for 'Good', and 1 point for 'Poor'.

The operator evaluation of the sample is carried out as follows.

Firstly, for operator evaluation, 20 operators involved in product manufacturing are selected.

Then, these selected operators are shown the mixed powder sample before sampling.

Each operator awards 3 points if they consider the blend of the mixed powder to be excellent, 2 points if good, and 1 point if poor. The average of the scores given by each operator is used to determine the homogenization grade of the mixed powder.

To ensure consistent evaluations, the following criteria were provided to the operators:

Firstly, the operators are shown samples with blend ratios of 90%, 60%, and 30%.

And if the operator judges that the blend ratio is above 80% and no clumping is visible in the powder color, they award 3 points. If the blend ratio is judged to be between 50% and less than 80%, and 1-2 clumps are visible in the powder color, they award 2 points. If the blend ratio is below 50% and more than 3 clumps are visible in the powder color, they award 1 point.

In operator evaluation, 3 points mean 'Excellent', 2 points mean 'Good', and 1 point means 'Poor'.

The final evaluation score is calculated by averaging the scores obtained from the blend ratio analysis and the average scores from the operator evaluations.

The final evaluation score is rounded off, where 3 points indicate an 'Excellent' homogenization grade, 2 points indicate a 'Good' grade, and 1 point indicates a 'Poor' grade.

The factors that are considered to have the most significant impact on the homogenization grade are the mixing speed (rpm) and mixing time (min).

Therefore, to determine how to adjust the conditions of mixing speed and time, homogenization grades were assessed by varying the mixing time and speed as shown in Table 2.

Table 3 is a table showing the homogenization grade evaluation criteria in this invention.

【Table 2】

| Mixer Speed | Mixing Time | Homogenization Grade |
|---|---|---|
| 20 rpm | 30 min | Inadequate |
| 20 rpm | 60 min | Inadequate |
| 18 rpm | 60 min | Good |

| | | |
|---|---|---|
| 16 rpm | 60 min | Excellent |
| 14 rpm | 60 min | Excellent |
| 14 rpm | 50 min | Excellent |
| 14 rpm | 40 min | Good |
| 14 rpm | 30 min | Inadequate |

According to Table 2, when the mixing speed is set to 20 rpm, the homogenization grade is 'Poor' regardless of the mixing time.

When the mixing speed was reduced to 18 rpm and the mixing time set to 60 min, the homogenization grade was found to be 'Good'.

Reducing the mixing speed to 16 rpm and setting the mixing time to 60 min resulted in an 'Excellent' homogenization grade.

When the mixing speed was reduced to 14 rpm, the homogenization grade was 'Excellent' for mixing times between 60 and 50 min.

At a mixing speed of 14 rpm, a mixing time of 40 min resulted in a 'Good' homogenization grade.

However, reducing the mixing time to 30 min at a speed of 14 rpm resulted in a 'Poor' homogenization grade.

Thus, although a lower mixing speed tends to increase the homogenization grade, if the mixing time is reduced to below 30 min, the grade decreases even with a lower speed.

As a higher homogenization grade of the powder improves the performance of catalytic fibers, in experiments with catalytic fibers (or PTFE membrane filters utilizing them), the mixing speed is set to below 20 rpm, and the mixing time is set to 60 min.

The PTFE membrane catalyst filter experiments were conducted based on catalyst attrition rate, workability, productivity, De-NOx efficiency, and catalyst dispersibility.

The catalyst attrition rate was measured in the range of 20% to 50%. If the attrition rate exceeded 50% during measurement, it was deemed excessively high for productization, making it meaningless to measure an exact figure. Therefore, if the catalyst attrition rate exceeded 50%, it was marked as 50%. Similarly, if the attrition rate was below 20%, it was sufficient for productization, thus making it meaningless to measure an exact figure. Therefore, if the catalyst attrition rate was below 20%, it was marked as 20%.

Productivity is categorized as 'Excellent', 'Good', or 'Poor'.

In this invention, the classification of productivity grades is based on the frequency of

errors.

Errors in the production process are judged based on the occurrence of the following three phenomena:

1) 'Breaking of billets'

2) 'Formation of holes in sheets'

3) 'Cracking of rods'

Additionally, 'uneven thickness of sheets' and 'strength of sheets' can also be included as criteria for error judgment, if necessary.

Based on these criteria, if no errors occur in the production process, the productivity is evaluated as 'Excellent'. If errors occur more than 0 but less than 2 times, productivity is considered 'Good'. If errors occur 2 or more times, productivity is evaluated as 'Poor'.

While productivity is based on the number of defects in product manufacturing, workability is based on the number of interruptions in the production process.

Specifically, workability is classified as 'Excellent', 'Good', or 'Poor', based on the number of times the production process stops due to breakages in the slitting process.

In the workability evaluation, the number of breakages that occur when working with a total of 10kg of PTFE mixed powder is checked. It is calculated that workability decreases by 5% for each occurrence of breakage.

Table 3 is a table summarizing the workability evaluation criteria of this invention.

【Table 3】

| Number of Interruptions | Workability % | Workability Evaluation |
|---|---|---|
| 2 or fewer | 90% or more | Excellent |
| More than 2 but less than 5 | 75% or more and less than 90% | Good |
| 5 or more | Less than 75% | Poor |

Referring to Table 3, workability is evaluated as 'Excellent' when it is 90% or above (occurring 2 times or less breakage). Workability is considered 'Good' when it is less than 90% but at least 75% (occurring more than 2 times but up to 5 times breakage).

Workability is evaluated as 'Poor' when it is below 75% (occurring more than 5 times breakage).

If workability is assessed as 'Poor', it becomes impossible to proceed with the process, necessitating a change in conditions.

The dispersibility of the catalyst indicates whether the catalyst is evenly distributed on the surface of the nonwoven fabric produced using PTFE fibers manufactured according to this invention.

The evaluation of dispersibility is done by observing five random spots on the nonwoven fabric sample under an optical microscope.

If clumping of the catalyst is observed less than 3 times among these random spots, the dispersibility is evaluated as 'Excellent'.

If clumping is observed 3 or more times but less than 6 times, the dispersibility is evaluated as 'Good'.

If clumping is observed 6 or more times, the dispersibility is evaluated as 'Poor'.

The De-NOx filtration efficiency was measured according to the Modified BS EN 1822-3 test method.

The filter fiber exhibits a filtration efficiency of more than 99.9% for 0.3 μm particles at 32 LPM, with a pressure loss of less than 100 mmAq. The nonwoven fabric made from such catalytic fibers, combined with a PTFE membrane, results in a final catalyst filter with an air permeability of more than 3 $cm^3/cm^2.s$.

If the De-NOx efficiency is above 7%, it is evaluated as 'Excellent'.

If the De-NOx efficiency is 3% or more but less than 5%, it is evaluated as 'Average'.

If the De-NOx efficiency is less than 3%, it is evaluated as 'Poor'.

The experimental results according to the criteria described above are as shown in Table 4 below.

【Table 4】

| Category | Mixing Process Catalyst Rati | Lubricant Ratio (Weight %) | Lubricant Spraying Speed (g/min) | Mixing Speed (rpm) | Mixing Time (min) | Catalyst Fiber Results | | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Catalyst Depletion Rate | Workability | Productivity | De-NOx Efficiency | Catalyst Dispersibility | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | o (Weight %) | | | | | | | | | | |
| #1 | 0.3 | 25 | 250 | 20 | 30 | 50% | Poor | Low | Poor | Low | Catalyst dispersibility is low, frequent breakage during slitting |
| #2 | 0.3 | 25 | 250 | 20 | 60 | 45% | Poor | Low | Poor | Medium | Partial improvement in catalyst dispersibility, The catalytic activity is very low |
| #3 | 0.3 | 25 | 250 | 18 | 60 | 40% | Good | Medium | Poor | Medium | Partial improvement in catalyst dispersibility, The catalytic activity is very low |
| #4 | 0.3 | 25 | 250 | 16 | 60 | 40% | Good | Medium | Poor | Medium | No significant change, very low activity |
| #5 | 0.4 | 25 | 250 | 16 | 60 | 40% | Good | Medium | Poor | Medium | No significant change, very low activity |
| #6 | 0.4 | 25 | 250 | 14 | 60 | 40% | Good | Medium | Poor | High | Partial improvement in catalyst dispersibility, The catalytic activity |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | is very low |
| #7 | 0.5 | 26 | 250 | 14 | 60 | 30% | Good | High | Average | Medium | Holes appear in the sheet, low activity |
| #8 | 0.5 | 28 | 200 | 12 | 30 | 20% | Good | Medium | Average | Low | Inequality in the catalyst, low activity |
| #9 | 0.5 | 28 | 250 | 12 | 60 | 20% | Poor | Medium | Average | Medium | Poor workability ( issues with billet, rod) |
| #10 | 0.5 | 28 | 200 | 12 | 60 | 20% | Excellent | High | Excellent | High | Overall excellent |
| #11 | 0.5 | 28 | 220 | 13 | 60 | 20% | Good | High | Excellent | High | Overall excellent |
| #12 | 0.6 | 29 | 180 | 13 | 60 | 20% | Good | High | Excellent | High | Overall excellent |
| #13 | 0.7 | 28 | 200 | 12 | 60 | 30% | Poor | Low | Average | Low | Increased catalyst depletion rate, increased frequency of breakage |
| #14 | 0.7 | 29 | 200 | 16 | 60 | 25% | Poor | Low | Excellent | Medium | Excellent stripping performance, frequent breakage |
| #15 | 0.7 | 30 | 200 | 8 | 60 | 20% | Good | Medium | Excellent | Medium | Excellent stripping performance, low productivity |
| #16 | 0.5 | 28 | 270 | 12 | 60 | 20% | Poor | Low | Poor | Low | Decreased dispersibility, poor workability |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | and productivity |
| #17 | 0.5 | 28 | 130 | 12 | 60 | 20% | Good | Medium | Poor | Low | Agglomeration of catalyst observed, holes and tearing in the sheet due to clumped catalyst |
| #18 | 0.5 | 25 | 200 | 12 | 60 | 25% | Poor | Low | Poor | Low | The sheet is hard, and it's difficult to adjust the thickness |
| #19 | 0.5 | 35 | 200 | 12 | 60 | 20% | - | Low | Poor | - | Lubricant adjustment required, production impossible (fire risk) |

Referring to Table 4, one can observe how the characteristics of PTFE catalyst fiber vary when adjusting the catalyst ratio, degree of homogenization (mixing speed and mixing time), lubricant ratio, and lubricant spray speed in a mixing process.

In the table, cases where fiber production was impossible and measurement could not be taken are indicated by '-'.

For Samples 1 to 3, the mixing process catalyst ratio was fixed at 0.3%, the lubricant ratio at 25%, and the lubricant spray speed at 250g/min, while the homogenization grade was varied.

Referring to Tables 2 and 4, for Sample 1, the mixing speed is 20 rpm and the mixing time is 30 minutes. Under these conditions, the homogenization grade is identified as 'inadequate'.

For Sample 1, the catalyst dropout rate is 50%, the operability is 'inadequate', the productivity is 'low', the De-NOx efficiency is 'poor', and the catalyst dispersion is 'low'. Thus, it was identified that due to low catalyst dispersion and very low catalyst activity (De-NOx efficiency), it has issues for commercialization.

Figure 11a shows a picture of the billet for Sample 1, and Figure 11b depicts a rolled

sheet of Sample 1.

Reviewing Figures 11a and 11b, one can observe faint stripes in the billet of Sample 1, which are likely due to catalyst agglomeration. Moreover, in the sheet, the catalyst clumps in a coarse dotted pattern, leading to a high dropout rate of the catalyst and a breakage phenomenon during fiber production.

For Sample 2, the mixing speed is 20 rpm and the mixing time is 60 minutes. The homogenization grade under these conditions is identified as 'inadequate'.

For Sample 2, the catalyst dropout rate is 45%, the operability is 'inadequate', productivity is 'low', De-NOx efficiency is 'poor', and the catalyst dispersion is 'medium'. Compared to Sample 1, Sample 2 showed improved catalyst dropout and dispersion, but its catalyst activity remains low, making it problematic for commercialization.

Figure 12a displays a picture of the billet for Sample 2, and Figure 12b portrays a rolled sheet of Sample 2.

From these figures, increasing the lubricant mixing time led to some improvements in catalyst agglomeration and breakage, but the catalyst's activity is still too low for commercialization.

For Sample 3, the mixing speed is 18 rpm and the mixing time is 60 minutes. The homogenization grade for these conditions is identified as 'good'.

For Sample 3, the catalyst dropout rate is 40%, operability is 'good', productivity is 'medium', De-NOx efficiency is 'poor', and the catalyst dispersion is 'medium'. Although Sample 3 shows improvements in catalyst dropout, operability, and productivity compared to Sample 2, its catalyst activity remains low, making it problematic for commercialization.

Figure 13a illustrates a picture of the billet for Sample 3, and Figure 13b shows a rolled sheet of Sample 3.

From these references, it's evident that improving the catalyst homogenization grade reduces the catalyst agglomeration seen in Samples 1 and 2, revealing the influence of catalyst homogenization on productivity.

For Sample 4, the mixing speed is 16 rpm and the mixing time is 60 minutes, with the homogenization grade identified as 'excellent'.

For Sample 4, the catalyst dropout rate is 40%, operability is 'good', productivity is 'medium', De-NOx efficiency is 'poor', and the catalyst dispersion is 'medium'. The results for Sample 4 are not significantly different from those of Sample 3, meaning that Sample 4 also has issues with low catalyst activity, making it problematic for commercialization.

Figure 14a depicts a billet of Sample 4, and Figure 14b shows an extruded sheet of Sample 4. By referencing these, it can be observed that reducing the mixing speed to improve the homogenization grade of the catalyst results in a more significant improvement in the agglomeration of catalysts in both the billet and the sheet.

For Sample 5, all other conditions were kept the same as Sample 4, but the catalyst ratio in the mixing process was increased from 0.3% to 0.4%, an approximate 33% enhancement.

For Sample 5, the catalyst fallout rate was 40%, with workability being 'good', productivity 'medium', De-NOx efficiency 'poor', and catalyst dispersion 'medium'. The results of Sample 5 did not differ significantly from Sample 4. This means that Sample 5 still had a low catalyst activity, making it challenging to commercialize.

In Sample 6, all other conditions were kept the same as Sample 5, but the mixing speed was reduced to 14 rpm.

For Sample 6, the catalyst fallout rate was 40%, with workability being 'good', productivity 'medium', De-NOx efficiency 'poor', and catalyst dispersion 'high'. The results for Sample 6 showed improved catalyst dispersion, but other metrics were not significantly different from Sample 5. Similarly, Sample 4 also showed issues with commercialization due to low catalyst activity.

For Sample 7, the catalyst and lubricant ratios were adjusted from Sample 6. The catalyst ratio was increased from 0.4% to 0.5%, and the lubricant ratio was increased from 25% to 26%.

Upon reviewing the results, Sample 7 had a catalyst fallout rate of 30%, with workability being 'good', productivity 'high', De-NOx efficiency 'average', and catalyst dispersion 'medium'. According to the results of Sample 7, the catalyst activity improved to an average level, but it was still insufficient for commercialization, and there was decreased catalyst dispersion. Additionally, issues like holes appearing in the sheet were observed.

Furthermore, referencing Figure 15, it was observed that a significant amount of catalyst was lost during the slitting process for Sample 7.

For Sample 8, the experiment was conducted under conditions of a 0.5% catalyst ratio, 28% lubricant ratio, 200g/min lubricant spraying speed, 12rpm mixing speed, and 30min mixing time.

Upon review, Sample 8 had a catalyst fallout rate of 20%, with workability being 'good', productivity 'medium', De-NOx efficiency 'average', and catalyst dispersion 'low'. For Sample 8, the catalyst was unevenly distributed, and its activity was low, indicating difficulties in

commercialization.

Referring to Figure 16, it can be observed that in Sample 8, there is a significant reduction in the catalyst separation rate compared to Sample 7.

For Sample 9, the mixing time was increased compared to Sample 8. Specifically, Sample 9 was conducted with a catalyst ratio of 0.5%, a lubricant ratio of 28%, a lubricant spraying speed of 250g/min, a mixing speed of 12rpm, and a mixing time of 60 minutes.

Upon examination, Sample 9 showed a catalyst separation rate of 20%, workability as 'poor', productivity as 'medium', De-NOx efficiency as 'average', and catalyst dispersion as 'medium'. It was confirmed that Sample 9 had a decreased workability, making product manufacturing challenging. Specifically, there were issues with the billet and rod, making it problematic for mass production.

Figure 17a is a picture depicting the billet of Sample 9, and Figure 17b shows the rolled sheet of Sample 9.

By examining Figures 17a and 17b, it was observed that the billets were breaking, and during the sintering/rolling process of the sheets, tiny holes were forming.

For Sample 10, the conditions were a catalyst ratio of 0.5%, lubricant ratio of 28%, lubricant spraying speed of 200g/min, mixing speed of 12rpm, and mixing time of 60 minutes.

The results for Sample 10 showed a catalyst separation rate of 20%, workability as 'excellent', productivity as 'high', De-NOx efficiency as 'excellent', and catalyst dispersion as 'high'. Overall, the desired characteristics were observed to be superior, confirming there were no issues with product mass production.

Figure 18 is a picture depicting the billet of Sample 10.

Referring to Figure 18, by reducing the lubricant spray speed for the experiment, it was confirmed that the breaking phenomenon in the billets was improved, enhancing productivity.

For Sample 11, the conditions were a catalyst ratio of 0.5%, lubricant ratio of 28%, lubricant spraying speed of 220g/min, mixing speed of 13rpm, and mixing time of 60 minutes.

Upon examination, Sample 11 showed a catalyst separation rate of 20%, workability as 'good', productivity as 'high', De-NOx efficiency as 'excellent', and catalyst dispersion as 'high'. By slightly altering the lubricant spraying speed and mixing speed compared to Sample 10, Sample 11 had a slightly decreased workability but was still graded as 'good', confirming there were no issues with product mass production.

For Sample 12, the conditions were a catalyst ratio of 0.6%, lubricant ratio of 29%, lubricant spraying speed of 180g/min, mixing speed of 13rpm, and mixing time of 60 minutes.

After reviewing the results, it was confirmed that for Sample 12, the catalyst stripping rate was 20%, workability was 'good', productivity was 'high', De-NOx efficiency was 'excellent', and catalyst dispersion was 'high'. Although Sample 11 showed slightly reduced workability compared to Sample 9, it was rated as 'good' and deemed suitable for mass production.

Thus, Samples 10 to 12 were all found suitable for mass production, but the conditions of Sample 10 were better than those of Samples 11 and 12.

In Sample 13, other conditions from Sample 10 were kept constant, and only the catalyst ratio was increased. Specifically, the conditions for Sample 13 were a catalyst ratio of 0.7%, lubricant ratio of 28%, lubricant spray speed of 200g/min, mixing speed of 12rpm, and mixing time of 60 minutes.

Upon evaluation, Sample 13 showed a catalyst stripping rate of 30%, 'poor' workability, 'low' productivity, 'average' De-NOx efficiency, and 'low' catalyst dispersion. It was observed that when the catalyst ratio exceeds 0.7%, the catalyst stripping rate increases, causing several breaks during the fiber production process, making product production problematic.

The significantly reduced workability and productivity in Sample 13 might be due to the constant lubricant ratio while only increasing the catalyst ratio. Also, the powder might not have been uniformly mixed. Therefore, in Samples 14 and 15, we adjusted the lubricant ratio and mixing speed.

For Sample 14, the conditions were a catalyst ratio of 0.7%, lubricant ratio of 29%, lubricant spray speed of 200g/min, mixing speed of 16rpm, and mixing time of 60 minutes.

The results showed that Sample 14 had a catalyst stripping rate of 25%, 'poor' workability, 'low' productivity, 'excellent' De-NOx efficiency, and 'medium' catalyst dispersion. Though Sample 14 exhibited excellent desulfurization performance, it had a high frequency of breaks.

In Sample 15, we increased the lubricant ratio further and decreased the mixing speed.

Specifically, the conditions for Sample 15 were a catalyst ratio of 0.7%, lubricant ratio of 30%, lubricant spray speed of 200g/min, mixing speed of 8rpm, and mixing time of 60 minutes.

The evaluation showed that Sample 15 had a catalyst stripping rate of 20%, 'good' workability, 'medium' productivity, 'excellent' De-NOx efficiency, and 'medium' catalyst dispersion. Although Sample 15 had excellent desulfurization performance, it showed lower

productivity.

In Samples 16 to 19, based on the favorable conditions of Sample 10, we explored the range of lubricant spray speeds (Samples 16, 17) and lubricant ratios (Samples 18, 19).

In Sample 16, all other conditions were kept consistent with Sample 10, but the lubricant spray speed was increased to 270g/min.

The results showed that Sample 16 had a catalyst stripping rate of 20%, 'poor' workability, 'low' productivity, 'poor' De-NOx efficiency, and 'low' catalyst dispersion. When the lubricant spray speed exceeds 270g/min, dispersion drops, and both workability and productivity decrease, making mass production challenging.

In Sample 17, all conditions were the same as Sample 10, but the lubricant spray speed was reduced to 130g/min.

The results showed that Sample 17 had a catalyst stripping rate of 20%, 'good' workability, 'medium' productivity, 'poor' De-NOx efficiency, and 'low' catalyst dispersion. When the lubricant spray speed is below 130g/min, catalyst clumping occurs, leading to holes or tearing in the sheet.

In Sample 18, while maintaining other conditions from Sample 10, the lubricant ratio was decreased to 25%.

The results indicated that Sample 18 had a catalyst stripping rate of 25%, 'poor' workability, 'low' productivity, 'poor' De-NOx efficiency, and 'low' catalyst dispersion. When the lubricant ratio is less than 25%, the sheet becomes stiff and challenging to adjust its thickness.

For Sample 19, all conditions were kept the same as Sample 10, but the lubricant ratio was increased to 35%.

This rendered production impossible and increased the risk of fire. Increasing the lubricant to more than 35% could pose a safety issue.

According to at least one embodiment described above, the present invention applies a PTFE membrane to filter the dust in exhaust gas on the filter surface, and NOx reacts with the catalyst in the back filter, effectively removing both NOx and dust. Additionally, instead of relying on foreign technology and products using the catalyst coating method, it becomes possible to manufacture a catalyst filter using the catalyst fiber method.

The embodiments and drawings described in this specification are merely illustrative examples of the technical idea included in the present invention. Therefore, the embodiments disclosed in this specification are not for limiting the technical idea of the invention but for

explanation. It's obvious that the range of the technical idea of the invention is not limited by these embodiments. Modifications and specific embodiments that can be easily inferred by those skilled in the art within the scope of the technical idea included in the specification and drawings of the present invention should be interpreted as being included in the rights range of the present invention.

【CLAIMS】

【Claim 1】

A method for mixing powder for the manufacture of PTFE fibers, where PTFE powder is mixed with De-NOx catalyst and lubricant, which is characterized:

PTFE powder and De-NOx catalyst powder are placed in a mixer which utilizes gravity and centrifugal force to repeatedly drop and mix the powders during rotation, and a lubricant is sprayed onto these powders to create a mixed powder.

And the spraying of the lubricant is controlled to ensure it is only applied to the PTFE powder and De-NOx catalyst powder, and not on the walls of the mixer, the De-NOx catalyst powder is more than or equal to 0.5% but less than 0.7% weight% of the total weight.

【Claim 2】

The method of Claim 1, wherein the lubricant comprises more than or equal to 27 weight% and less than or equal to 29 weight% of the total weight.

【Claim 3】

The method of Claim 2, wherein the spray speed of the lubricant is more than or equal to 150g/min and less than 250g/min.

【Claim 4】

The method of Claim 3, wherein the mixer's rotation speed is more than or equal to 10rpm and less than or equal to 14rpm, and the mixing time is between 40 minutes and 70 minutes.

【Claim 5】

A method for manufacturing PTFE fibers used for producing a PTFE membrane catalyst filter, which involves a sequence of processes including mixing, aging, compression, extrusion, rolling, sintering, drawing/strengthening, and slitting processes, the mixing process is characterized by:

PTFE powder and De-NOx catalyst powder are placed in a mixer which utilizes gravity and centrifugal force to repeatedly drop and mix the powders during rotation, and a lubricant is sprayed onto these powders to create a mixed powder, and the spraying of the lubricant is controlled to ensure it is only applied to the PTFE powder and De-NOx catalyst powder, and not on the walls of the mixer, the De-NOx catalyst powder is more than or equal to 0.5% but

less than 0.7% weight% of the total weight.

【Claim 6】

The method of Claim 5, wherein the lubricant comprises more than or equal to 27 weight% and less than or equal to 29 weight% of the total weight.

【Claim 7】

The method of Claim 6, wherein the spray speed of the lubricant is more than or equal to 150g/min and less than 250g/min.

【Claim 8】

The method of Claim 6, wherein the mixer's rotation speed is more than or equal to 10rpm and less than or equal to 14rpm, and the mixing time is between 40 minutes and 70 minutes.

【Claim 9】

A method for manufacturing a PTFE membrane catalyst filter using PTFE fibers, which involves a sequence of processes including mixing, aging, compression, extrusion, rolling, sintering, drawing/strengthening, and slitting processes, the mixing process is characterized by:

PTFE powder and De-NOx catalyst powder are placed in a mixer which utilizes gravity and centrifugal force to repeatedly drop and mix the powders during rotation, and a lubricant is sprayed onto these powders to create a mixed powder, and the spraying of the lubricant is controlled to ensure it is only applied to the PTFE powder and De-NOx catalyst powder, and not on the walls of the mixer, the De-NOx catalyst powder is more than or equal to 0.5% but less than 0.7% weight% of the total weight.

【Claim 10】

The method of Claim 9, wherein the lubricant comprises more than or equal to 27 weight% and less than or equal to 29 weight% of the total weight.

【Claim 11】

The method of Claim 10, wherein the spray speed of the lubricant is more than or equal to 150g/min and less than 250g/min.

【Claim 12】

The method of Claim 10, wherein the mixer's rotation speed is more than or equal to 10rpm and less than or equal to 14rpm, and the mixing time is more than or equal to 40 minutes and less than or equal to 70 minutes.

【Claim 13】

A PTFE fiber manufactured according to any one of Claims 5 to 8.

【Claim 14】

A PTFE membrane catalyst filter manufactured according to any one of Claims 9 to 12.