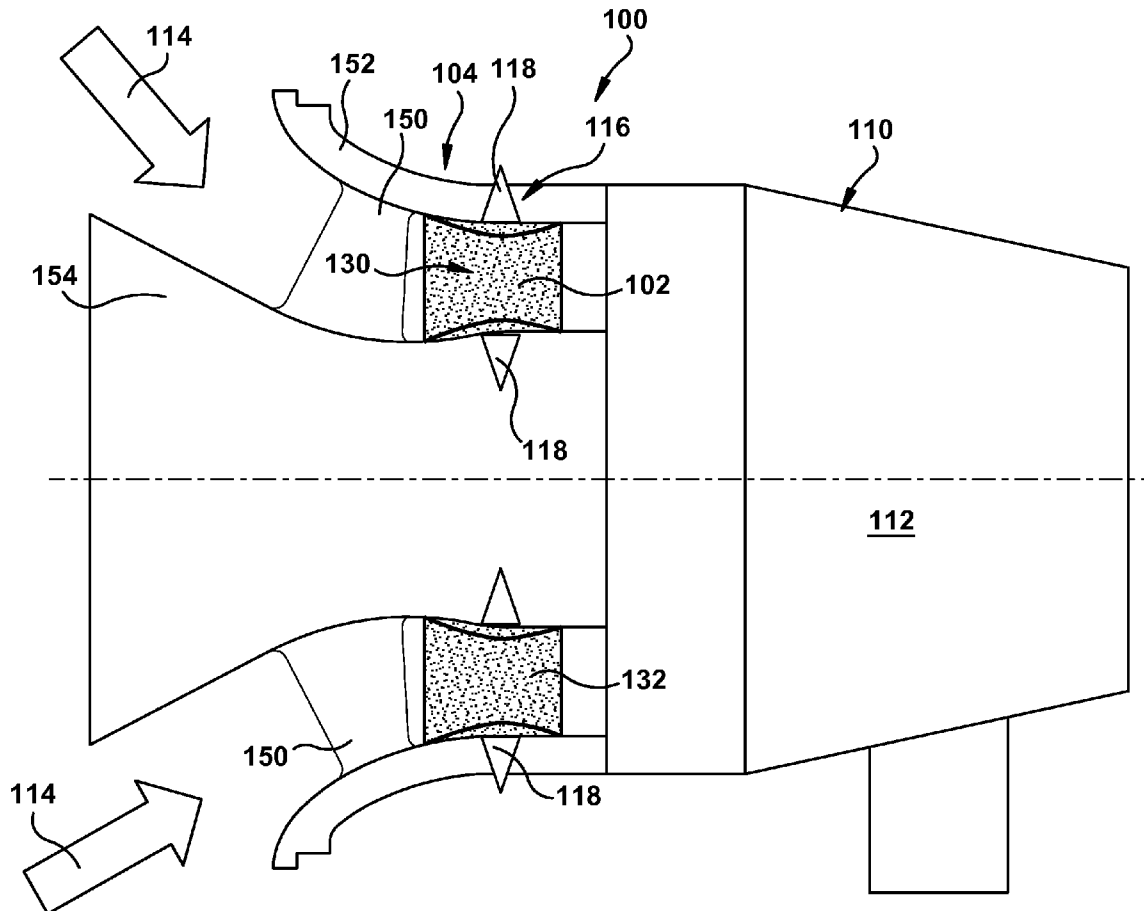


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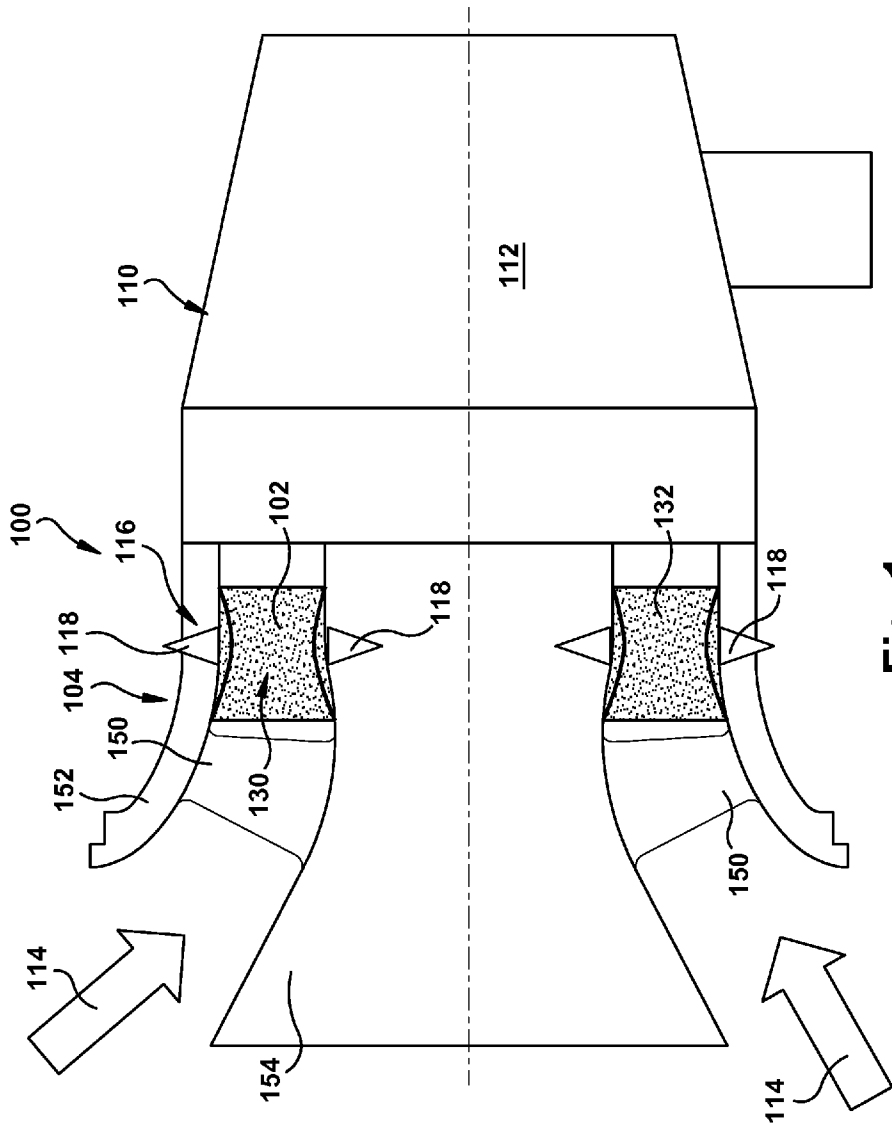


Fig. 1

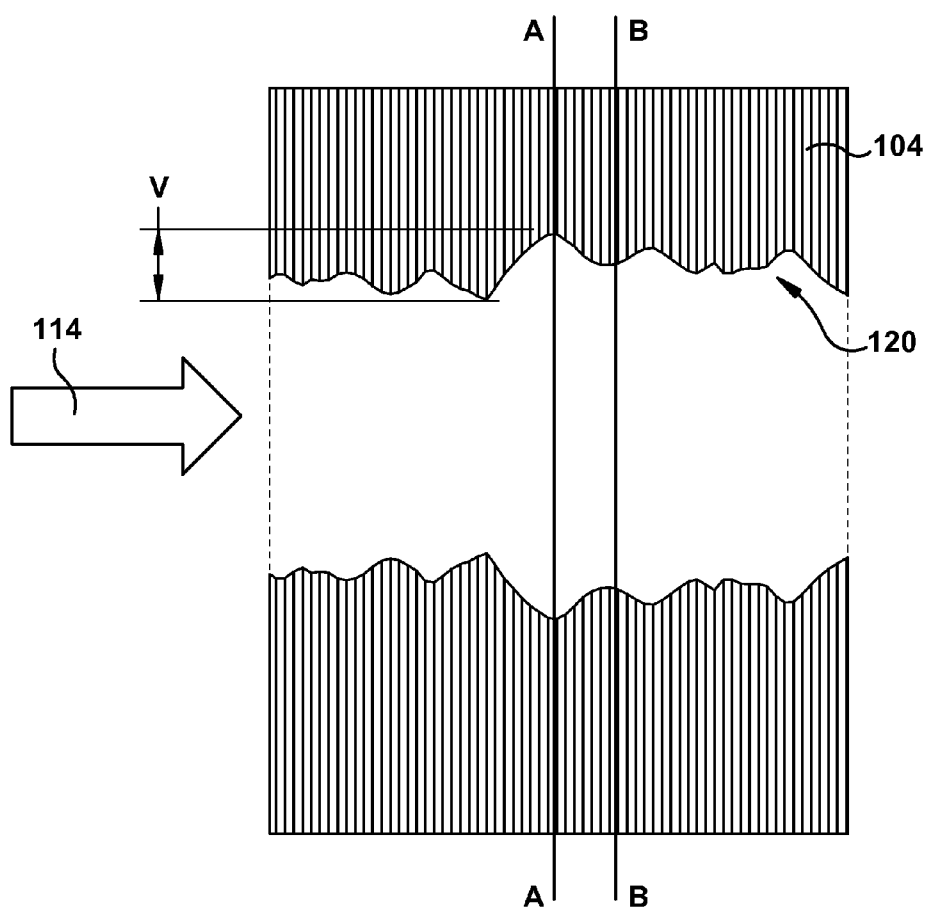


Fig. 2

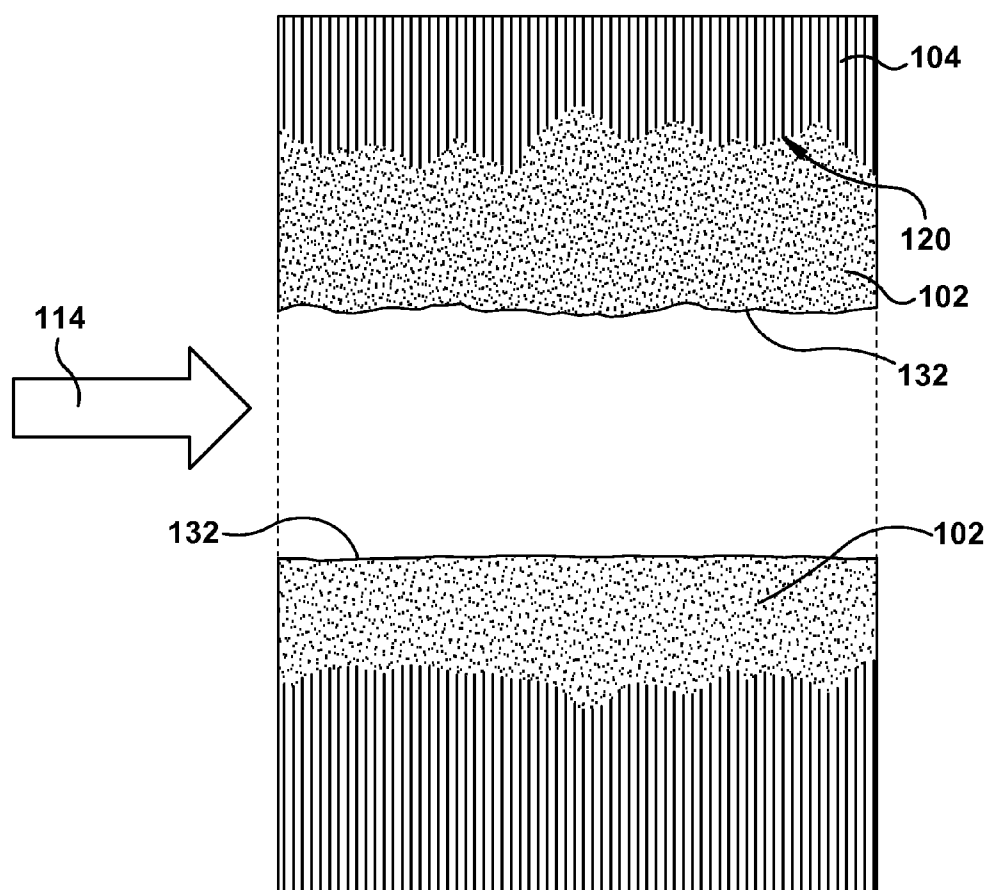


Fig. 3

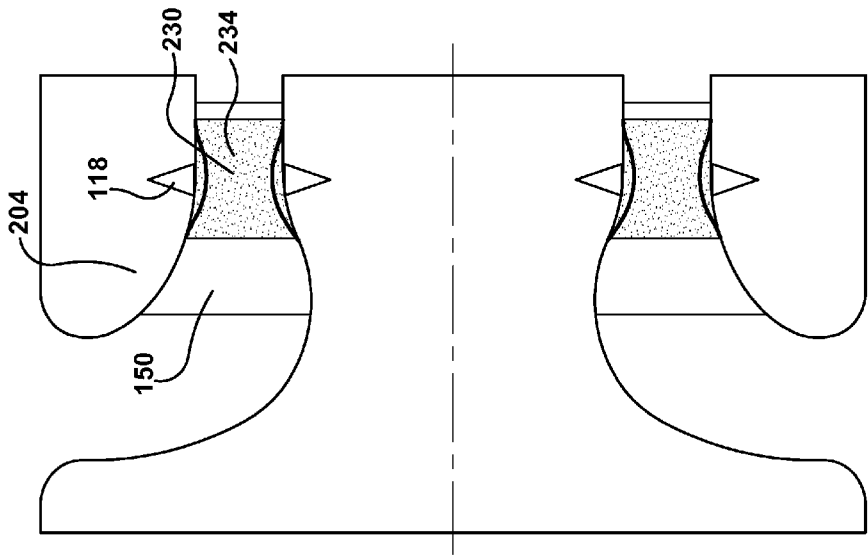


Fig. 4

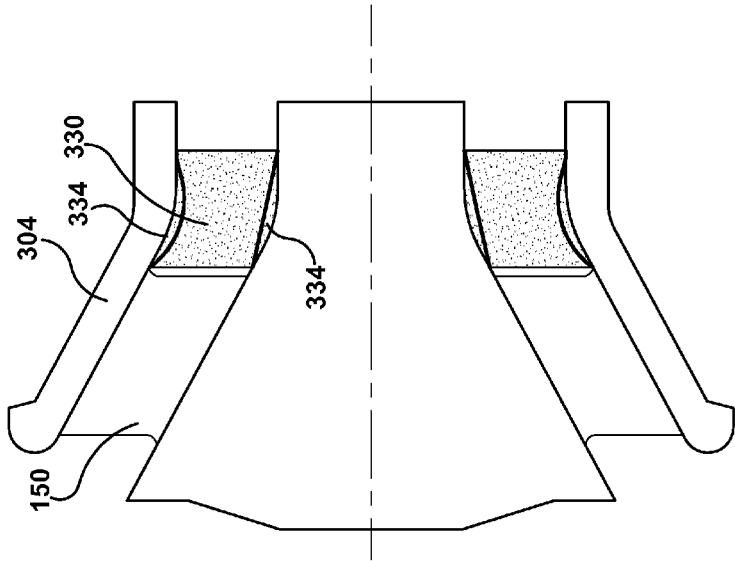


Fig. 5

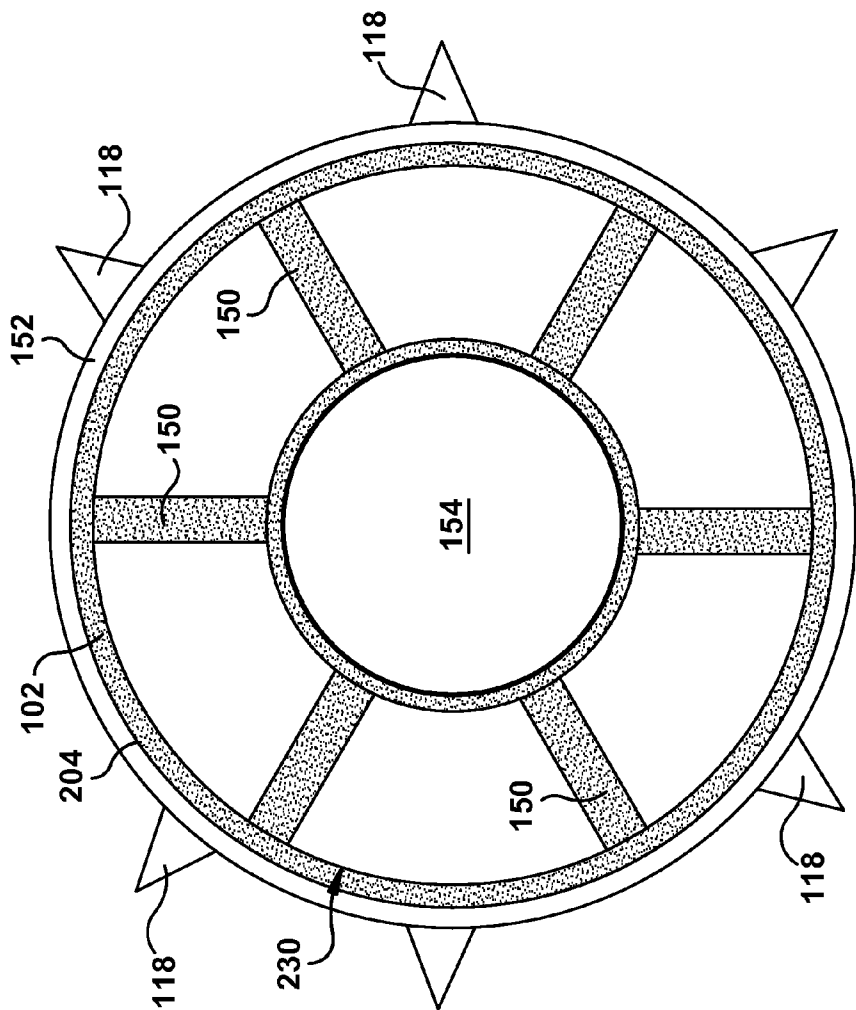


Fig. 6

INLET BELLMOUTH WITH COATING IN MEASUREMENT ANNULUS REGION

BACKGROUND OF THE INVENTION

[0001] The disclosure relates generally to airflow inlets, and more particularly, to an airflow inlet bellmouth having a coating thereon to reduce a surface roughness thereof, and a related method.

[0002] Airflow inlets to industrial devices such as gas turbine compressors include a bellmouth component that acts to collect, initially compress, and direct an airflow, e.g., toward a turbine portion of the compressor. In many settings, during operation, static pressure is measured in the inlet bellmouth component, for example, using a Pitot method. The static pressure may be used to determine a mass flow rate of air which is used to better control operation of other components, for example, controlling a firing temperature of a combustor of a gas turbine. In another example, mass flow rate may be used to determine a compressor operating limit degradation.

[0003] One challenge in determining the static pressure in the inlet bellmouth is that an inlet annulus area where the pressure is measured must be accurately known. However, conventional inlet bellmouths are oftentimes manufactured as a cast component having significant variation and large tolerances in an internal surface thereof, i.e., they are uneven or rough. The variations and large tolerances in the inlet bellmouth diminish static pressure measurement accuracy by a static pressure sensor system, and thus hinder accurate mass flow rate calculations. In order to address this situation, conventionally, a sampling of inlet bellmouth(s) is/are analyzed after manufacture and a calibrated correction factor is determined and employed in the static pressure calculation for all of the inlet bellmouths. However, since there are large variations between inlet bellmouths that are created, and the inlet bellmouth's internal surface may change over time, use of a correction factor based on a sampling is not ideal. While casting or machining an inlet bellmouth with less surface variation is feasible, it is generally not cost effective. Such an approach to manufacturing also does not correct the problem for previously installed inlets.

BRIEF DESCRIPTION OF THE INVENTION

[0004] A first aspect of the disclosure provides an airflow inlet, comprising: a bellmouth component having a substantially uneven internal surface; and a variable thickness coating in a measurement annulus region of the substantially uneven internal surface, the variable thickness coating configured to present a more even internal surface than the substantially uneven internal surface, wherein the measurement annulus region includes only an annulus about the internal surface of the bellmouth component.

[0005] A second aspect of the disclosure provides a bellmouth component for an airflow inlet, the bellmouth component comprising: a static pressure measurement annulus region configured for measuring a static pressure by at least one sensor system, the measurement annulus region including a variable thickness coating on a substantially uneven internal surface of the bellmouth component in only the measurement annulus region, the variable thickness coating configured to present a more even surface variation than the substantially uneven internal surface within the measurement annulus region.

[0006] A third aspect of the disclosure provides a method comprising: accessing a bellmouth component of an airflow inlet, the bellmouth component including a substantially uneven internal surface; and applying a variable thickness coating to a measurement annulus region of the substantially uneven internal surface of the bellmouth component to create a more even internal surface, wherein the measurement annulus region includes only an annulus about the internal surface of the bellmouth component.

[0007] The illustrative aspects of the present disclosure are designed to solve the problems herein described and/or other problems not discussed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] These and other features of this disclosure will be more readily understood from the following detailed description of the various aspects of the disclosure taken in conjunction with the accompanying drawings that depict various embodiments of the disclosure, in which:

[0009] FIG. 1 shows a cross-sectional view of an airflow inlet for a compressor, the airflow inlet including a coating on a measurement annulus region of the bellmouth component according to embodiments of the invention.

[0010] FIG. 2 shows an enlarged cross-sectional view of a substantially uneven internal surface of a bellmouth component of the airflow inlet.

[0011] FIG. 3 shows an enlarged cross-sectional view of an internal surface of the bellmouth component of the airflow inlet with the coating.

[0012] FIGS. 4 and 5 show cross-sectional views of airflow inlets having varied shaped bellmouth components and including a coating on a measurement annulus region according to embodiments of the invention.

[0013] FIG. 6 shows an end view of one embodiment of a bellmouth component including a coating on struts thereof according to embodiments of the invention.

[0014] It is noted that the drawings of the disclosure are not to scale. The drawings are intended to depict only typical aspects of the disclosure, and therefore should not be considered as limiting the scope of the disclosure. In the drawings, like numbering represents like elements between the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0015] As indicated above, the disclosure provides an airflow inlet having a coating in a measurement annulus region of a bellmouth component. Referring to FIG. 1, a cross-sectional view of an airflow inlet 100 including a variable thickness coating 102 on a bellmouth component 104 according to embodiments of the invention is illustrated. The illustrative setting for airflow inlet 100 includes a compressor 110 for, e.g., a gas turbine. Compressor 110 includes a turbine (or turbo-fan) 112 for drawing an airflow 114 into bellmouth component 104. Bellmouth component 104 may include any structure through which airflow initially passes as part of an intake. In most but not all cases, a bellmouth 104 acts to collect airflow 114, and direct it to turbine 112 in which extensive compression occurs prior to the airflow being passed to other components (not shown). Bellmouth component 104 may be referred to by various alternative names such as: intake, compressor intake, bellmouth, flow nozzle, etc. As will be described herein, a static pressure sensor system 116 may be provided that is configured to determine a static

pressure of airflow **114** through bellmouth component **104** in a measurement annulus or band region **130**. Other control systems (not shown) may employ the pressure measurement to determine a mass flow rate through airflow inlet **100** and/or control other components. Although the setting has been illustrated relative to a compressor **110**, it is understood that airflow inlet **100**, as described herein, can be used with a large variety of air intake systems.

[0016] FIG. 2 shows an enlarged cross-sectional view of bellmouth component **104** without a coating as taught herein. As illustrated, bellmouth component **104** exhibits a substantially uneven internal surface **120** having a large amount of surface variation **V**. As used herein, “substantially uneven internal surface” indicates a non-smooth or rough surface that generally prevents an accurate determination of an annulus area within a particular region of bellmouth component **104**. That is, the surface roughness creates a situation in which at any given cross-section, such as those at lines A-A or B-B in FIG. 2, a different annulus area is presented. Variation **V** may be, for example, up to 1.3 centimeters. Variation **V** makes accurate pressure and/or mass flow rate calculations difficult because an accurate annulus area, required for calculating the pressure and/or mass flow rate, is difficult to ascertain. Although the term “annulus” has been used to denote a particular cross-sectional area, it is understood that bellmouth component **104** may not have an exactly circular cross-section, e.g., it can be oblong, polygonal or oval in cross-section. Substantially uneven surface **120** can be created in a number of ways. One illustrative cause, however, is that bellmouth component **104** is created by casting, e.g., iron, steel, etc. Substantially uneven surface **120** is present at manufacture of bellmouth component **104**, and may change as airflow **114** wears on it over time due to its initially rough nature. Although airflow **114** may wear on surface **120**, the airflow typically does not act to smooth surface **120** in an acceptable manner.

[0017] Returning to FIG. 1, in order to address substantially uneven surface **120**, a variable thickness coating **102** is selectively provided in a measurement annulus region **130** of substantially uneven internal surface **102**. Coating **102** is not present on all surfaces of bellmouth component **104**, but only in measurement annulus region **130**. Measurement annulus region **130** may include any annulus area at which a static pressure of airflow **114** through bellmouth component **104** is measured. While measurement annulus region **130** is illustrated in FIG. 1 (and FIG. 6) as being substantially cylindrical, as will be described, this arrangement is not necessary in all cases. For example, as will be described in greater detail, struts **150** may be present within and form part of measurement annulus region **130**. As understood, struts **150** act to support an outer portion **152** of bellmouth component **104** relative to an inner portion **154** thereof.

[0018] As shown in FIG. 3, variable thickness coating **102** is configured to present a more even internal surface **132** than substantially uneven internal surface **120**. A variation of more even internal surface **132** may be, for example, up to 0.2 centimeters, which greatly improves the accuracy of an annulus area used for pressure calculations. Variable thickness coating **102** may include any material capable of fixed coupling with substantially uneven internal surface **120**, filling variations **V** (FIG. 2) and withstanding the environment of airflow **114** (e.g., maximum temperature such as about 60-64° C., particulate or moisture in the airflow, etc.). In one embodiment, coating **102** is non-metallic. Coating **102** may include

but is not limited to: an epoxy, a plastic or a fiberglass. Coating **102** may be applied using any appropriate method for the material used, e.g., spraying, infusion, injection, deposition, etc. Coating **102** may have a thickness, for example, in the range of approximately 1.3-2.5 centimeters.

[0019] As shown in FIGS. 1 and 6, in many situations, static pressure sensor system **116** includes a number of sensors **118** positioned about a particular circumference of bellmouth component **104**. In this case, static pressure sensor system **116** may also include a number of sensors **118** circumferentially positioned along bellmouth component **104**, i.e., about measurement annulus region **130**. Sensors **118** may include any now known or later developed pressure sensors. One or more sensors **118** measure static pressure only within measurement annulus region **130**. Annulus region **130** covers a preferred annulus area of bellmouth component **104** where access may be easier for sensor(s) **118**, airflow **114** is more laminar, etc. Static pressure sensor system **116** may use any now known or later developed methodology to determine the static pressure such as but not limited to that described in “Airflow Calibration of a Bellmouth Inlet for Measurement of Compressor Airflow in Turbine-Powered Propulsion Simulators,” Stephen A. Smith, National Aeronautics and Space Administration Technical Memorandum 84399, November 1985.

[0020] In another embodiment, bellmouth component **104** for airflow inlet **100** may include a static pressure measurement annulus region **130** configured for measuring a static pressure by at least one sensor **118**. Measurement annulus region **130** includes variable thickness coating **102** on substantially uneven internal surface **120** of the bellmouth component **104** in the measurement annulus region. Variable thickness coating **102** is configured to present a more even surface **132** variation (see FIG. 3) than substantially uneven internal surface **120** within the measurement annulus region. Consequently, a more accurate annulus area can be ascertained.

[0021] It is emphasized that in addition to the time bellmouth component **104** is initially manufactured, variable thickness coating **102** may be applied at a variety of points in time across the life of bellmouth component **104**. In particular, variable thickness coating **102** may be applied, according to an embodiment of a method of the invention, by accessing bellmouth component **104** of an airflow inlet, e.g., in the field and after some time of use by removing any protective filters, shielding, etc., at an open end of bellmouth component **104**. Variable thickness coating **102** may be applied to measurement annulus region **130** of substantially uneven internal surface **120** of bellmouth component **104** to create a more even internal surface **132**. As noted herein, the applying may include any appropriate method for the material used, e.g., spraying, infusion, injection, deposition, etc. Where a correction factor is employed that is initially based on substantially uneven internal surface **120** to determine a static pressure (and/or a mass flow rate) of airflow **114** through bellmouth component **104**, the correction factor can be revised for determining a static pressure based on more even surface **132**. In the above-described fashion, variable thickness coating **102** can be applied to previously installed and used bellmouth components without replacement and, in most cases, without removal of the component.

[0022] While FIG. 1 shows one form of bellmouth component **104**, as observed in FIGS. 4-5, it is understood that various other shapes and arrangements are possible. For

example, a bellmouth component may be more or less rounded overall, longer or shorter, or have straighter or curvier sides, etc. In FIG. 4, a bellmouth component 204 with measurement annulus region 230 is generally longer and has more curved sides than bellmouth component 104 in FIG. 1, and in FIG. 5, a bellmouth component 304 with measurement annulus region 330 has substantially aligned or parallel sides. In addition, a measurement annulus region need not be substantially cylindrical as in FIG. 1. For example, as shown in FIG. 5, a measurement annulus region 330 may have opposing slanted sides 334, and FIG. 4 shows measurement annulus region 230 with a throat region 234 that has a slightly smaller diameter than adjacent regions. Furthermore, FIG. 6 shows an end view of one embodiment of bellmouth component 204, as in FIG. 4, including coating 102 on one or more struts 150 thereof. As shown in FIG. 4 and FIG. 6, the annulus or measurement annulus region 230 includes at least one strut 150 at least partially covered with variable thickness coating 102.

[0023] While the use of variable thickness coating 102 has been described herein as making bellmouth component 104 dimensionally consistent for the purposes of measuring static pressure, it is understood that coating 102 may act to improve other measurements, thus allowing more accurate control of any industrial component that relies on the particular measurement.

[0024] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0025] The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The embodiment was chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. An airflow inlet, comprising:

a bellmouth component having a substantially uneven internal surface; and

a variable thickness coating in a measurement annulus region of the substantially uneven internal surface, the variable thickness coating configured to present a more even internal surface than the substantially uneven internal surface,

wherein the measurement annulus region includes only an annulus about the internal surface of the bellmouth component.

2. The airflow inlet of claim 1, wherein the coating includes an epoxy.

3. The airflow inlet of claim 1, wherein the coating includes a plastic.

4. The airflow inlet of claim 1, wherein the coating includes a fiberglass.

5. The airflow inlet of claim 1, further comprising a static pressure sensor system configured to determine a static pressure of an airflow through the bellmouth component using an annulus area based on the more even internal surface.

6. The airflow inlet of claim 1, wherein the bellmouth component includes a cast bellmouth component having the substantially uneven internal surface.

7. The airflow inlet of claim 1, wherein the substantially uneven internal surface varies up to 1.3 centimeters.

8. The airflow inlet of claim 1, wherein the measurement annulus region includes opposing slanted sides.

9. The airflow inlet of claim 1, wherein the annulus includes at least one strut at least partially covered with the variable thickness coating.

10. A bellmouth component for an airflow inlet, the bellmouth component comprising:

a static pressure measurement annulus region configured for measuring a static pressure by at least one sensor system, the measurement annulus region including a variable thickness coating on a substantially uneven internal surface of the bellmouth component in only the measurement annulus region, the variable thickness coating configured to present a more even surface variation than the substantially uneven internal surface within the measurement annulus region.

11. The bellmouth component of claim 10, wherein the variable thickness coating is selected from the group consisting of: an epoxy, a plastic and a fiberglass.

12. The bellmouth component of claim 10, further comprising the at least one sensor system at the measurement annulus region configured to measure the static pressure of an airflow through the bellmouth component.

13. The bellmouth component of claim 10, wherein the substantially uneven internal surface varies up to 1.3 centimeters.

14. The bellmouth component of claim 10, wherein the bellmouth component includes a cast bellmouth component.

15. The bellmouth component of claim 10, wherein the measurement annulus region includes opposing slanted sides.

16. The bellmouth component of claim 10, wherein the annulus includes at least one strut at least partially covered with the variable thickness coating.

17. A method comprising:

accessing a bellmouth component of an airflow inlet, the bellmouth component including a substantially uneven internal surface; and

applying a variable thickness coating to a measurement annulus region of the substantially uneven internal surface of the bellmouth component to create a more even internal surface, wherein the measurement annulus region includes only an annulus about the internal surface of the bellmouth component.

18. The method of claim **17**, wherein the measurement annulus region includes an annulus area at which a static pressure of an airflow through the bellmouth component is measured.

19. The method of claim **17**, further comprising revising a correction factor used for determining a static pressure of an airflow through the bellmouth component, wherein the correction factor is initially based on the substantially uneven internal surface.

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