Fluid Flow Meter

This invention relates to fluid flow meters, such as axial flow mechanical fluid flow meters. By "mechanical" we mean a flow meter which has a moving part, the movement of which is utilised as a measure of the flow. The moving part may be a rotor, the rotation of which is proportional to the fluid flow rate through the meter. The invention has particular relevance to precision measuring devices utilising inductive sensing of the rotor movement. The invention also relates to the characteristics of the rotor, such as the buoyancy characteristics.

Flow conditioning ring

Disclosed herein is a fluid flow meter, comprising: means for defining a fluid flow path; a rotor, with at least one blade, positioned in said fluid flow path; and a ring positioned upstream from, and adjacent to, said rotor; wherein the ring is adapted to condition the fluid flow at the leading edge of the rotor blade over a range of operating conditions. By providing a ring the accuracy and flow measuring range may be improved as compared to the accuracy and flow measuring range of an equivalent meter without a ring.

Preferably, said range of operating conditions is a range of flow rate. Preferably, said range of flow rate is less than the rated range of flow rate of the fluid flow meter, but preferably, more than 25% or 33% or 50% or 75% of said rated range.

Preferably, the flow conditions at the leading edge of the rotor blade are improved as compared to not having a ring.

Preferably, under said range of operating conditions, the flow conditions are improved in comparison with not providing a ring upstream of the rotor blade.

Preferably, under said range of operating conditions, the ring is adapted to smooth flow, for example by breaking down larger scale vortices (e.g. in comparison to smaller scale vorticity related to turbulent flow) shed upstream of the ring.

Preferably, under at least part of said range of operating conditions, the ring is adapted to induce substantially turbulent flow at the leading edge of the rotor blade,

Preferably, the radius of the ring is optimised in order to maximise the improvement in flow conditions at the leading edge of the rotor blade.

Preferably, the radius of the ring is greater than the radius of the rotor hub. More preferably, the radius of said ring is greater than the radius of the rotor hub by between 40% and 60% of the distance from the hub of the rotor to the tip of the blades, preferably between 45% and 55%, more preferably 53%.

Preferably, the radius of the ring is greater than the radius of the rotor hub by between 35% and 55% of the distance from the hub of the rotor to the means defining the flow path, preferably between 40% and 50%, more preferably 45%.

Preferably, the means defining the flow path is substantially cylindrical in shape. More preferably, the radius of the ring is between 65% and 85% of the radius of the cylindrical means defining the flow path, preferably between 70% and 80%, more preferably 75%.

Preferably, the ring is positioned centrally within said fluid flow path.

Preferably, the axial distance of the ring from the rotor hub is optimised to maximise the improvement in flow conditions at the leading edge of the rotor blade.

Preferably, the axial distance of the ring from the rotor hub is between 10% and 30% of the chord length of the ring, more preferably between 15% and 25%, yet more preferably 20%.

Preferably, the axial distance of said ring from said rotor hub is between 1.0 mm and 3.0 mm, more preferably between 1.5 mm and 2.5 mm, yet more preferably 2.0 mm.

Preferably, the leading edge of the ring is thinner than the trailing edge of the ring.

Preferably, the leading edge of the ring is tapered. More preferably, the leading edge of the ring is sharp.

Preferably the trailing edge of the ring is blunt. More preferably, the trailing edge of the ring is square.

Preferably, the shape of the ring is mouldable.

Preferably, the ring is further adapted to throttle the fluid flow at the rotor blade.

Preferably, the ring is further adapted to induce turbulent flow downstream of the rotor. More preferably, turbulent flow is induced at the exit of the flow meter. By inducing turbulent flow the pressure and head losses across the flow meter may be reduced.

Preferably, the ring is further adapted to at least partially relieve the thrust loading on said rotor.

Disclosed herein is a method of substantially optimising the accuracy and flow range of a fluid flow meter, comprising: positioning a ring upstream from, and adjacent to, a rotor within a fluid flow path; and adjusting the characteristics and position of said ring to substantially optimise the accuracy and flow range.

Preferably, the characteristics comprise at least one of: the ring radius, the ring thickness, the ring chord length; and the ring's cross-sectional shape.

Preferably, the position comprises at least the axial distance from the rotor.

Sensor assembly

According to an aspect of the present invention, there is provided a fluid flow meter, comprising: means for defining a fluid flow path; a rotor mounted on a rotor shaft and positioned in said fluid flow path including at least one target on said rotor shaft, wherein the target is inductive; and a sensor assembly positioned in said fluid flow path including at least one sensor, wherein the sensor is inductive; wherein said sensor assembly is located around said rotor shaft such that said at least one sensor is positioned adjacent said at least one target and wherein the shaft is balanced so that the at least one target does not create an imbalance in the rotor.

Preferably, the flow meter comprises at least 2, preferably 3 inductive sensors. More preferably, said sensors are positioned equiangularly from each other about said shaft.

Preferably, the rotor is arranged so that the target does not cause any imbalance, and either that can be achieved by having a plurality of targets equiangularly and/or equidistantly disposed, or it is achieved by counter-weighting the target.

Preferably, the targets are positioned on the shaft end-face.

Buoyancy balanced rotor (including method of manufacturing same)

Disclosed herein is a rotor for a fluid flow meter that is neutrally buoyant and/or balanced about the axis of the rotor shaft.

Preferably, the rotor is buoyancy balanced. As used herein, balanced buoyancy preferably connotes a state whereby when an object is placed in a fluid it remains static in any orientation. By providing a buoyancy balanced rotor the accuracy of the flow meter at low rates can be improved. In a particularly preferred embodiment the rotor is balanced such that it remains in any orientation when placed in the fluid. The rotor may have balanced buoyancy in all 6 degrees of freedom associated with said rotor.

Preferably, the rotor is statically balanced. Preferably, the rotor is dynamically balanced (preferably when in the fluid).

Embodiments of the invention extend to a fluid flow meter incorporating the rotor as aforesaid.

Disclosed herein is a method for manufacturing a balanced buoyancy rotor for a fluid flow meter, comprising: rotating the rotor, preferably in the fluid; determining the correct position to either add mass or to remove mass; and either adding or removing said mass accordingly.

Preferably, the rotor is dynamically balanced.

Embodiments of the invention extend to a fluid flow meter incorporating a rotor manufactured as aforesaid.

Inductive target wheel with multiple inductive targets

Disclosed herein is a sensor assembly for a fluid flow meter, comprising: an inductive target wheel with a plurality of inductive targets, the rotation of which is adapted to provide a measure of fluid flow.

Preferably, the sensor assembly further comprises a plurality of inductive sensors, arranged such that the plurality of inductive targets induce a signal in the sensors.

Preferably, the number of inductive targets of the target wheel is not a multiple of the number of inductive sensors.

Preferably, the number of inductive targets on the target wheel is 4, 8, 12 or more.

Preferably, the number of inductive sensors is 3.

Embodiments of the invention extend to a fluid flow meter incorporating the sensor assembly as aforesaid.

Apparatus and method features may be interchanged as appropriate, and may be provided independently one of another. Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination. In particular, method aspects may be applied to apparatus aspects, and vice versa.

The invention will be described, merely by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is a section through a perspective view of a flow meter;
Figure 2 is plan view of a flow meter, and indicates a number of cross sections detailed in Figures 3, 4 and 5
Figure 3 is a section through a flow meter, at position A-A;
Figure 4 is a section through a flow meter, at position B-B;
Figure 5 is a section through a flow meter, at position C-C;
Figure 6 is a detailed view of a register connection at point E as shown in Figure 4;
Figure 7 is a detailed view of a part of the sensor assembly at point D as shown in Figure 4;
Figures 8 are detailed views of the sensor assembly;

CLAIMS

1. A fluid flow meter, comprising:

means for defining a fluid flow path;

a rotor mounted on a rotor shaft and positioned in said fluid flow path including at least one target on said rotor shaft, wherein the target is inductive; and

a sensor assembly positioned in said fluid flow path including at least one sensor, wherein the sensor is inductive;

wherein said sensor assembly is located around said rotor shaft such that said at least one sensor is positioned adjacent said at least one target and wherein the shaft is balanced so that the at least one target does not create an imbalance in the rotor.

2. A fluid flow meter according to claim 1, further comprising at least two sensors.

3. A fluid flow meter according to claim 2, wherein said at least two sensors are positioned equiangularly from each other about said shaft.

4. A fluid flow meter according to claim 3, wherein said at least one target is disposed in an end-face of the shaft.

5. A fluid flow meter according to claim 1, comprising a plurality of said at least one target, wherein said plurality of at least one target are disposed equiangularly about the shaft.

6. A fluid flow meter according to claim 1, comprising a plurality of said at least one target, wherein said plurality of at least one target are disposed equidistantly about the shaft.

7. A fluid flow meter according to claim 6, further comprising counter weights adapted to counter balance the plurality of said at least one target.

8. A fluid flow meter according to claim 1, further comprising counter weights adapted to counter balance the at least one target.

9. A fluid flow meter according to claim 1, wherein said at least one target is disposed in an end-face of the shaft.

10. A fluid flow meter according to claim 1, wherein the rotor is neutrally buoyant and/or balanced about the axis of the rotor shaft.

11. A fluid flow meter according to claim 10 wherein the rotor is balanced such that it remains in any orientation when placed in the fluid.

12. A fluid flow meter according to claim 10, wherein the rotor is statically balanced.

13. A fluid flow meter according to claim 10, wherein the rotor is dynamically balanced, when in the fluid.

14. A fluid flow meter according to claim 10, wherein the rotor is buoyancy balanced.

15. A fluid flow meter according to claim 14 wherein the rotor is balanced such that it remains in any orientation when placed in the fluid.

16. A fluid flow meter according to claim 15, wherein the rotor is statically balanced.

17. A fluid flow meter according to claim 16, wherein the rotor is dynamically balanced, when in the fluid.

18. A fluid flow meter according to claim 1, wherein the number of at least one target is not a multiple of the number of the at least one sensor.

19. A fluid flow meter according to claim 18, wherein the number of the at least one target on a target wheel is 4, 8, 12 or more.

20. A fluid flow meter according to claim 19, wherein the number of the at least one sensor is three.

21. A fluid flow meter according to claim 1 in which the rotor has at least one blade, and comprising:

a ring positioned upstream from, and adjacent to, said rotor,

wherein the ring is adapted to condition the fluid flow at a leading edge of the at least one blade over a range of operating conditions.

22. A fluid flow meter according to claim 21, in which the rotor is neutrally buoyant and/or balanced about the axis of the rotor shaft.