An impeller assembly, comprising a generally planar disc oriented in a first plane and having a circular outer edge; and a plurality of blades mounted to the disc and extending beyond the edge of the disc, with the blades in cross-section having a shape that is substantially symmetrical along a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to the first plane in which the disc lies. In another variation, the blades are mounted so the center line of each blade is offset from the plane in which the disc lies.
PARABOLIC RADIAL FLOW IMPELLER WITH TILTED OR OFFSET BLADES

FIELD OF THE INVENTION

[0001] The present invention pertains generally to the field of mixers and mixing devices and methods. In particular, the invention relates to radial flow impellers used in such mixing systems and methods.

BACKGROUND OF THE INVENTION

[0002] Mixing devices and mixing methods are in wide use in industry. For example, in some mixing systems, a vessel is provided which has a rotating shaft extending therein that is driven by a drive system typically external to the vessel. The vessel forms a containment chamber for material that is to be mixed, agitated or otherwise to have energy imparted into it.

[0003] Impellers or impeller assemblies are mounted to rotate with the rotating driven shaft. The impellers typically extend radially outwardly from the shaft for some distance towards the outside walls of the vessel. The impellers in some cases may be paddle type elements or blade elements that may extend directly outwardly from a hub on the shaft, or may extend outwardly from a disc mounted to the shaft or may be a single disc having features disposed around the circumference of the disc.

[0004] In some mixers, the material to be mixed or otherwise treated is simply loaded into the vessel and then the impellers are activated. In some other mixers, it is known to aerate the material to be mixed by adding bubbles to the mixture via a gas sparger disposed somewhere in the vessel located near rear the bottom of the vessel or at least below a set of the impellers. In some of these mixers, the gas sparger is generally central so that the bubbles rise up and interact with the moving impellers.

[0005] Two general types of impellers are known for many mixer systems. One type of impeller is a so-called axial flow impeller. These axial flow impellers, which often take the shape of simply angled plates, or in other cases take the shape of a propeller, or winged shaped blade, move the material in a generally axial direction either upwards or downwards in the vessel parallel to the direction of the shaft elongation.

[0006] Another type of impeller is a so-called radial flow impeller. Radial flow impellers often take the shape of a flat plate or some other geometric shape, and typically push the material outwardly away from the impeller region using centrifugal force, thus creating a radial flow vector, generally outward, in the region outside of the impeller location.

[0007] One type of radial flow impeller utilizes a central disc having a number of circumferentially spaced blades or paddle portions extending out from the disc so that they partially overlap the disc and partially extend outward from the disc. When looked at from a side cross section, one commonly used type of blade has a generally parabolic cross section with two leading edges spanning back towards a single trailing vortex. In the past, these blades have generally been mounted with the center line of the parabola being located co-planar with the plane in which the disc lives. In such an arrangement, the combination of the disc and the blades is symmetrical with respect to the plane in which the disc lies. That is, the location of the blades from the disc is a mirror image of the portion of the blade below the disc.

[0008] In a variation of the above described arrangement, it has been known to provide one leg of the parabola (either the upper leg or the lower leg) to be longer than the other. However, such arrangements have still been symmetrical insofar as the shorter leg and the longer leg are symmetrical, with the only difference being that the longer leg extends further forward.

[0009] The above described arrangements are generally suitable in many applications. However, it is always desirable to improve the performance of parabolic radial flow impellers. Accordingly, there is a need for an improved parabolic radial flow impeller, impeller blade, and mixing methods.

SUMMARY OF THE INVENTION

[0010] In one aspect, an impeller assembly has a generally planar disc oriented in a first plane and having a circular outer edge; a plurality of blades mounted to the disc and extending beyond the edge of the disc, with the blades in cross-section having a shape that is substantially symmetrical along a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to the first plane in which the disc lies.

[0011] In another aspect, an impeller assembly for use with a shaft has a generally planar central mounting means for mounting to the shaft; and a plurality of blades mounted to the mounting means and extending radially outward beyond the mounting means with the blades in cross-section having a shape that is substantially symmetrical about a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the mounting means lies.

[0012] In another aspect, a mounting method includes rotating a shaft to drive an impeller assembly that comprises a generally planar disc; and a plurality of blades mounted to the disc and extending beyond the disc, with the blades in cross-section having a shape that has a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the disc lies.

[0013] In another aspect, an impeller assembly has a generally planar disc oriented in a first plane and having a circular outer edge; and a plurality of blades mounted to the disc and extending beyond the edge of the disc, with the blades in cross-section having a shape that is substantially symmetrical along a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is parallel to the first plane in which the disc lies, and the center line of each blade is offset from the first plane in which the disc lies.

[0014] In another aspect, an impeller assembly for use with a shaft has a generally planar central mounting means for mounting to the shaft; and a plurality of blades mounted to the mounting means and extending radially outward beyond the mounting means with the blades in cross-section having a shape that is substantially symmetrical about a center line and
having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is parallel to a plane in which the mounting means lies, and the center line is offset from the first plane in which the disc lies.

In another aspect, a mounting method includes rotating a shaft to drive an impeller assembly that comprises: a generally planar disc; and a plurality of blades mounted to the disc and extending beyond the disc, with the blades in cross-section having a shape that has a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the disc lies.

There has thus been outlined, rather broadly, certain embodiments of the invention in order that the detailed description thereof herein may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional embodiments of the invention that will be described below and which will form the subject matter of the claims appended hereto.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of embodiments in addition to those described and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein, as well as the abstract, are for the purpose of description and should not be regarded as limiting.

As such, those skilled in the art will appreciate that the conception upon which this disclosure is based may readily be utilized as a basis for the designing of other structures, methods and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an impeller assembly according to a first embodiment.
FIG. 2 is an end cutaway view of a portion of the impeller assembly of FIG. 1.
FIG. 3 is a perspective view of an impeller assembly according to a second embodiment.
FIG. 4 is an end cutaway view of a portion of the impeller of FIG. 3.

DETAILED DESCRIPTION

A first preferred embodiment of a radial flow impeller assembly mounted or a shaft is shown in FIGS. 1 and 2. In particular, the impeller assembly 10 includes a radially extending disc 12 having an outer peripheral region 14. A plurality of individual blades 16 are provided which each have an upper segment 18 and a lower segment 20. The upper segment 18 has a leading edge 22 and the lower segment 20 has a leading edge 23. The segments converge at a rear vertex 24. A hub 26 mounts the impeller assembly 10 to a shaft 28.

Turning to FIG. 2, it will be appreciated that in this embodiment the upper segment 18 and lower segment 20 are symmetrical with respect to each other about an imaginary center line CL, which is indicated by dotted lines. The blade 16 is mounted to overlap with the outer portion of the disc 12 so that its imaginary center line CL is at an angle (alpha) a with respect to the plane in which the disc 12 lies.

This angled orientation of the center line CL of the parabolic blades 16 with respect to the plane of the disc 12 as described in FIG. 2, provides several advantages in some applications. For example, where gas is being sparged from beneath the impeller assembly 10, because of the increased volumetric area inside the parabola lower segment 20 (compared to if the angle alpha was zero), greater gas handling can be achieved by the angled orientation. That is, greater gas handling is achieved prior to reaching the impeller gas handling flood condition in some situations. This is due at least in part to the larger enclosed region between the lower impeller segment 20 and the bottom of the disc 12, so that more gas can be entrained.

Further, for the portion of the blade 16 that extends radially outward past the disc 12, it will be appreciated that the tilting of the blade 16 causes the upper region 22 to reach forward (that is the entire blade faces downward to some extent), and so the blade is better entrained under the lower surface of the upper segment 18, which may increase one or both of the residence time or the total volume of gas that is temporarily contained by the impeller 16.

Turning to FIGS. 3 and 4, a second embodiment is depicted. In this embodiment the blade 16 is mounted to the disc 12 so that its center line CL, is at least substantially parallel, or completely parallel, with the plane in which disc 12 lies, but the center line CL, is also located offset a distance from the plane of the disc 12. In this example, the center line CL is offset below the plane of the disc 12 by an offset distance D.

It will be appreciated that this offset also provides a greater volumetric region in the area bounded by the underside of the disc 12 and the upper inside of the lower segment 20, as well as a portion 22, which is a region of the upper segment of the parabola that is disposed below the plane of the disc 12. This arrangement also has a portion 22 of the upper segment of the parabola that is disposed above the disc 12. In this way, this embodiment also can provide benefits in terms of larger gas handling compared to a prior system where the parabolic blade is mounted with its center line co-linear with the plane of the disc 12.

Two exemplary embodiments are described and illustrated in FIGS. 2 and 4, respectively. In the embodiment of FIG. 2, the vertex of the parabola is located on a center line and the vertex of the parabola in the center line intersect with the plane of the disc. In FIG. 4, the center line of the parabola is parallel with the plane of the disc, but is offset by a distance D. Other embodiments are also possible. For example, the embodiment of FIG. 4 could also have the parabola tilted downwardly somewhat similar to FIG. 2, so that the center line intersects with the plane of the disc but not at the point of the vertex.

Other variations are also possible. For example, instead of being tilted downwardly in FIG. 2, the parabola could be tilted upwards. Also, in the embodiment of FIG. 4, rather than being spaced downwardly the center line could be
5. An impeller assembly for use with a shaft, comprising:
   a generally planar central mounting means for mounting to the shaft; and
   a plurality of blades having a parabolic cross-section mounted to the disc and extending radially outward beyond the mounting means with the blades in cross-section having a shape that is substantially symmetrical about a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the mounting means lies, wherein said blades are bisected by said planar central mounting means and wherein said blades are a single, unitary blade segment.

6. (canceled)

7. The assembly according to claim 5, wherein the parabola has a central vertex located on the center line of the parabola, and wherein the blade is mounted so that the vertex extends through the plane of the disc.

8. The assembly according to claim 5, wherein the blades are equally circumferentially spaced around the disc edge.

9. A mounting method comprising:
   rotating a shaft to drive an impeller assembly that comprises:
   a generally planar disc; and
   a plurality of blades having a parabolic cross-section mounted to the disc and extending beyond the disc, with the blades in cross-section having a shape that has a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the disc lies, wherein said blades are bisected by said planar disc and wherein said blades are a single, unitary blade segment.

10. The assembly according to claim 9, wherein the parabola has a central vertex located on the center line of the parabola, and wherein the blade is mounted so that the vertex extends at the plane of the disc.

11. An impeller assembly, comprising:
   a generally planar disc oriented in a first plane and having a circular outer edge; and
   a plurality of blades having a parabolic cross-section mounted to the disc and extending beyond the edge of the disc, with the blades in cross-section having a shape that is substantially symmetrical along a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to the first plane in which the disc lies, wherein said blades are bisected by said planar disc and wherein said blades are a single, unitary blade segment.

12. (canceled)

13. The assembly according to claim 11, wherein the parabola has a central vertex at which the first and second segments meet with the vertex located on the center line of the parabola, and wherein each blade is mounted so that the vertex extends through the first plane in which the disc lies.
14. The assembly according to claim 11, wherein the blades are equally circumferentially spaced around the disc edge.

15. An impeller assembly for use with a shaft, comprising:
(a) a generally planar central mounting means for mounting to the shaft; and
(b) a plurality of blades having a parabolic cross-section mounted to the mounting means and extending radially outward beyond the mounting means with the blades in cross-section having a shape that is substantially symmetrical about a center line and having a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is parallel to a plane in which the mounting means lies, and the center line is offset from the first plane in which the disc lies, wherein said blades are bisected by said planar disc and wherein said blades are a single, unitary blade segment.

16. (canceled)

17. The assembly according to claim 15, wherein the parabola has a central vertex at which the first and second segments meet, with the vertex located on the center line of the parabola, and wherein the blade is mounted so that the vertex is offset from the first plane in which the disc lies.

18. The assembly according to claim 15, wherein the blades are equally circumferentially spaced around the disc edge.

19. A mounting method comprising:
(a) rotating a shaft to drive an impeller assembly that comprises:
(b) a generally planar disc; and
(c) a plurality of blades having a parabolic cross-section mounted to the disc and extending beyond the disc, with the blades in cross-section having a shape that has a first segment and a second segment disposed on opposite sides of the center line, with one segment being symmetrical with at least a portion of the other segment, and with the blades mounted so that the respective center line of each blade is at an angle relative to a plane in which the disc lies, wherein said blades are bisected by said planar disc and wherein said blades are a single, unitary blade segment.

20. The assembly according to claim 19, wherein the parabola has a central vertex located on the center line of the parabola, and wherein the blade is mounted so that the vertex extends through the plane of the disc.

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