lowest Rushton impeller on the impeller shaft.

It is known that microbial cells have protective cell walls, and tend to clump together when grown in a bioreactor. Microbial cell cultures thus require high speed, shearing impellers to break apart the clumps of cells; and require large amounts of air. Microbial cultures grow and multiply approximately twenty to forty (20-40) times faster than do mammalian cell cultures. Hence, the rates of oxygen consumption in a microbial cell fermentation culture are about 20 to 40 times greater than are those rates in a mammalian culture process.

In order to sustain growth in a microbial culture, a bioreactor for use in microbial systems must be capable of supplying oxygen to the culture faster than a bioreactor used for mammalian cells, and must be capable of breaking up clumps of cells.

The art has also seen perfusion devices which are located within the bioreactor for drawing fluid out from the bioreactor cavity.

The art lacks a shaft-mounted fluid transfer device which can act to provide either sparge gas or a feed fluid below the shaft-mounted impeller blades but above the bottom surface of a flexible or disposable bioreactor container. There is also a need for a fluid transfer device for a bioreactor which may be utilized along the length of the impeller shaft, below each impeller hub mounted on the shaft. Additionally, the art lacks a shaft-mounted fluid transfer device which can alternatively function as a perfusion device for a bioreactor.

Summary

The present disclosure provides a shaft-mounted fluid transfer assembly for use with a bioreactor. Additionally, the present disclosure provides a fluid transfer housing which may be

rotatably-mounted to a shaft in a bioreactor. The present disclosure also provides an impeller assembly for a bioreactor which incorporates a fluid transfer housing or a fluid transfer assembly as shown and described. Alternatively still, the present disclosure provides a bioreactor incorporating a fluid transfer housing rotatably mounted to an impeller shaft, such that the impeller shaft extends through the impeller shaft passageway of the housing body. The bioreactors incorporating the present disclosure are desirably single-use or disposable in design.

The present disclosure further contemplates providing multiple fluid transfer housings of the present disclosure rotatably mounted on an impeller shaft, such as a second fluid transfer housing mounted opposite an impeller hub from a first fluid transfer housing, each fluid transfer housings are desirably provided as part of two distinct fluid transfer assemblies of the present disclosure. Alternatively again, the present disclosure provides an impeller shaft having two distinct impeller hubs each supporting impeller blades with a fluid transfer housing of the present disclosure provided under each of the impeller hubs. Bioreactors incorporating the fluid transfer housings of the present disclosure include an elongate conduit extending between an input port of the fluid transfer housing and a port affixed to a wall of the bioreactor so as to allow fluids to pass between the outside of the bioreactor and the container cavity by passing through the fluid transfer housing of the present disclosure.

In an aspect, there is provided a fluid transfer assembly for a disposable bioreactor comprising:

a fluid transfer housing having a housing body defining an input port, at least one outlet port and an elongate housing passageway extending in fluid communication therebetween;

said housing body further defining an open shaft passageway extending therethrough; and

a rolling element bearing, such as a roller bearing or a ball bearing, affixed within said shaft passageway, said rolling element bearing comprising concentric inner and outer bearing races and a plurality of rolling elements, such as rollers or balls, positioned between the inner and outer bearing races, the outer bearing race being affixed to the housing body and the inner bearing race including an inner surface defining a shaft aperture such that the inner race is affixable to an impeller shaft so that the shaft may rotate independently of said housing body.

In another aspect, there is provided an impeller assembly for a disposable bioreactor, said impeller assembly comprising:

an elongate impeller shaft having opposed first and second ends and an elongate shaft body extending therebetween;

at least one impeller hub comprising a plurality of impeller blades, said hub mounted to said impeller shaft;

the fluid transfer assembly as defined above, the fluid transfer housing of said fluid transfer assembly being rotatably mounted to said impeller shaft, such that said impeller shaft extends through said shaft passageway of said housing body.

In another aspect, there is provided a disposable bioreactor comprising:

a flexible bioreactor container having a flexible container wall defining a bioreactor cavity;

the impeller assembly as defined above provided in said bioreactor cavity;

a fluid port mounted to said container wall, said fluid port defining an open aperture through said container wall;

an elongate fluid conduit extending from said fluid port of said bioreactor wall to said input port of said fluid transfer housing, said fluid conduit having opposed first and second ends

and an elongate tubular conduit body extending therebetween, said first end of said fluid conduit defining a first conduit aperture, said second end of said fluid conduit defining a second conduit aperture, and said conduit body defining an elongate conduit passageway extending in open fluid communication therebetween, said fluid conduit placing said outlet port of said fluid transfer housing in open fluid communication with said fluid port of said container wall, such that fluid may be provided between said fluid port of said container wall and said bioreactor cavity through said fluid transfer housing.

Brief Description of the Drawings

Figure 1 depicts a disposable bioreactor incorporating a shaft-mounted fluid transfer assembly of the present invention.

Figure 2 depicts a cross-sectional view of a shaft-mounted fluid transfer assembly of the present invention.

What Is Claimed Is:

1. A fluid transfer assembly for a disposable bioreactor comprising:

a fluid transfer housing having a housing body defining an input port, at least one outlet port and an elongate housing passageway extending in fluid communication therebetween;

said housing body further defining an open shaft passageway extending therethrough; and

a rolling element bearing, such as a roller bearing or a ball bearing, affixed within said shaft passageway, said rolling element bearing comprising concentric inner and outer bearing races and a plurality of rolling elements, such as rollers or balls, positioned between the inner and outer bearing races, the outer bearing race being affixed to the housing body and the inner bearing race including an inner surface defining a shaft aperture such that the inner race is affixable to an impeller shaft so that the shaft may rotate independently of said housing body.

2. The fluid transfer assembly of claim 1, further comprising a plurality of outlet ports in fluid communication with said housing passageway.

3. The fluid transfer assembly of claim 1 or 2, wherein said housing body includes opposed first and second planar major surfaces and a perimetrical side wall extending between said first and second major surfaces.

4. The fluid transfer assembly of claim 3, wherein said input port is defined by said perimetrical side wall of said housing.

5. The fluid transfer assembly of claim 3 or 4, wherein said first major surface of said housing body defines said at least one outlet port.

6. The fluid transfer assembly of claim 5, wherein said first major surface defines a plurality of outlet ports in fluid communication with said housing passageway.

7. The fluid transfer assembly of any one of claims 3-6, wherein said housing passageway is defined to extend along the perimetrical side wall about said shaft aperture.

8. The fluid transfer assembly of claim 7, wherein said first major surface of said housing body defines a plurality of outlet ports in fluid communication with said housing passageway, wherein said plurality of outlet ports are arrayed about said shaft aperture.

9. The fluid transfer assembly of any one of claims 3-8, further comprising a porous member spanning said outlet aperture.

10. The fluid transfer assembly of claim 9, wherein the pore size of the porous member is from about 2 micrometers to about 10 millimeters.

11. The fluid transfer assembly of claim 9, wherein the pore size of the porous member is from about 2 micrometers to about 3 millimeters.

12. The fluid transfer assembly of claim 9, wherein the pore size of the porous member is from about 5 micrometers to about 3 millimeters.

13. The fluid transfer assembly of any one of claims 9-12, wherein the porous member associated with the outlet port is also adapted for use as a particulate separation device.

14. The fluid transfer assembly of any one of claims 1-13, wherein said inlet port is further defined by an elongate port stem projecting from said housing body, said port stem defining an open elongate port passageway in open fluid communication with said housing passageway.

15. The fluid transfer assembly of any one of claims 1-14, wherein said housing body further defines at least one open reactor passageway through said housing body, said reactor passageway positioned adjacent to said shaft passageway.

16. The fluid transfer assembly of any one of claims 1-15, wherein said housing body has a general shape selected from ring-shaped, square-shaped, and polygonal-shaped.

17. The fluid transfer assembly of any one of claims 3-13, wherein said perimetrical side wall has a shape selected from rounded cylindrical and polygonal cylindrical.

18. The fluid transfer assembly of any one of claims 1-17, further comprising an elongate fluid conduit extending from said input port of said fluid transfer housing, said fluid conduit having opposed first and second ends and an elongate tubular conduit body extending therebetween, said first end of said fluid conduit defining a first conduit aperture, said second end of said fluid conduit defining a second conduit aperture, and said conduit body defining an elongate conduit passageway extending in open fluid communication therebetween, said fluid conduit for placing said outlet port of said fluid transfer housing in open fluid communication with a fluid port of a container wall, such

that fluid may be provided between the fluid port of the container wall and a bioreactor cavity defined by the container through said fluid transfer housing.

19. An impeller assembly for a disposable bioreactor, said impeller assembly comprising:

an elongate impeller shaft having opposed first and second ends and an elongate shaft body extending therebetween;

at least one impeller hub comprising a plurality of impeller blades, said hub mounted to said impeller shaft;

the fluid transfer assembly of any one of claims 1-18, the fluid transfer housing of said fluid transfer assembly being rotatably mounted to said impeller shaft, such that said impeller shaft extends through said shaft passageway of said housing body.

20. The impeller assembly of claim 19, wherein the inner race of said bearing is affixed to said impeller shaft.

21. The impeller assembly of claim 19 or 20, comprising a second fluid transfer assembly of any one of claims 1-18, the fluid transfer housing of said second fluid transfer assembly being rotatably mounted to said impeller shaft, such that said impeller shaft extends through said shaft passageway of said housing body, said second fluid transfer assembly mounted opposite said at least one impeller hub from said first fluid transfer assembly.

22. The impeller assembly of any one of claims 19-21, further comprising a second impeller hub comprising a plurality of impeller blades, said second impeller hub mounted to said impeller shaft at a location opposite said second fluid transfer housing from said at least one impeller hub.

23. A disposable bioreactor comprising:

a flexible bioreactor container having a flexible container wall defining a bioreactor cavity;

the impeller assembly of any one of claims 19-22 provided in said bioreactor cavity;

a fluid port mounted to said container wall, said fluid port defining an open aperture through said container wall;

an elongate fluid conduit extending from said fluid port of said bioreactor wall to said input port of said fluid transfer housing, said fluid conduit having opposed first and second ends and an elongate tubular conduit body extending therebetween, said first end of said fluid conduit defining a first conduit aperture, said second end of said fluid conduit defining a second conduit aperture, and said conduit body defining an elongate conduit passageway extending in open fluid communication therebetween, said fluid conduit placing said outlet port of said fluid transfer housing in open fluid communication with said fluid port of said container wall, such that fluid may be provided between said fluid port of said container wall and said bioreactor cavity through said fluid transfer housing.