ROTARY PUMP OR MOTOR

FIELD

[0001] This disclosure relates to positive displacement pumps or motors and, more particularly, to rotary actuated pumps and motors.

BACKGROUND

[0002] Pumps and engines in their various forms are the most prolific mechanical devices in the world other than electric motors and are a key enabling technology to modern and emerging civilizations.

[0003] Rotary pumps and motors having rotary piston members are known in the art, as are motors and pump devices wherein a rotor having cam surfaces is involved in the displacement of fluid. However, in each of these prior art embodiments, multiple rotating elements are utilized, often with complex camming arrangements. These complex devices result in multiple wearing surfaces which increase the cost of maintenance. They also require complex mechanical interaction which require complicated timing arrangements and other related complications. The cost of original construction is also high for such complex devices. Moreover, in most of these devices, the camming rotor is not utilized for the purpose of directly forming fluid displacement chambers.

[0004] U.S. 4,854,837 and U.S. 4,605,361 both to Robert K. Cordray present rotary pumps and motors which are simpler in design and construction, capable of small size construction and yet large in flow rate or displacement relative to their size. However, while these pumps are an advancement in the art; there is still a need for improvement on the those designs to further improved the construction and operation.

SUMMARY OF THE INVENTION

[0005] The methods and systems provide for an improved rotary device where in variable chambers are produced between a rotor and stator(s). The size and shape of the variable chambers are varied by rotating the rotor on a shaft and by sliding the rotor axially along the shaft wherein the rotating and sliding are controlled by a bearing interacting with the rotor and shaft such that the bearing transmits rotation of the shaft to the rotor to thus rotate the rotor and axial movement of the bearing within a defined slot on the shaft results in the rotor axially sliding. The rotating and sliding of the rotor results in changing the size and shape of the variable chambers. For example, introduction of a fluid into a variable chamber occurs when the chamber moves from the closed position to the open position, and expelling the fluid occurs as the variable chamber moves from the open position to the closed position. Additional improvements are disclosed such as using ball bearings to facilitate rotation of the shaft within the device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a schematic perspective view of a rotary device in accordance with some embodiments of this disclosure.

[0007] FIG. 2 is a schematic illustration of the components of the rotary device of FIG. 1 in an expanded view.

[0008] FIG. 3A is a cross-sectional illustration of the rotary device of FIG. 1.

[0009] FIG. 3B is a schematic illustration of the rotor and stators in the same position as that illustrated in cross-sectional illustration FIG. 3A.

[0010] FIG. 4A is an expanded view of a first orientation of the stators and rotor.

[0011] FIG. 4B is an expanded view of a second orientation of the stators and rotor.

[0012] FIG. 5 is a perspective view of the interior of the rotary device with the baffle.

[0013] FIG. 6 is a perspective view of the interior of the rotary device without the baffle.

DESCRIPTION

[0014] The present disclosure may be understood more readily by reference to the following description. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, those of ordinary skill in the art will understand that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the related relevant feature being described. Additionally, the description is not to be considered as limiting the scope of the embodiments described herein.

[0015] Referring now to the drawings, wherein like reference numbers are used herein to designate like elements throughout the various views, various embodiments are illustrated and described. The figures are not necessarily drawn to scale, and in some instances the drawings have been exaggerated and/or simplified in places for illustrative purposes only. Where components of relatively well-known designs are employed, their structure and operation will not be described in detail. One of ordinary skill in the art will appreciate the many possible applications and variations of the present invention based on the following description.

[0016] Referring initially to FIGS. 1, 2 and 3A, a rotary pump or motor system 10 is disclosed. The system 10 can be used as a positive displacement pump and will be illustrated and discussed in detail in this capacity. However, it should be noted that the design of the present invention may, with modifications, function as a motor or as a compressor or as a 4-cylcle engine.

[0017] As illustrated in FIGS. 1, 2 and 3A, pump 10 has a central axis 11 and includes an outer housing 12 in the form a ported sleeve; thus, outer housing 12 defines one or more ports 13, which provide fluid flow contact between the interior and exterior of outer housing 12. As illustrated, ports 13 are configured in four pairs spaced circumferentially about outer housing 12 to provide for flow of fluid into and out of pump 10 as further described herein. Outer housing 12 also defines an interior cavity 14.

[0018] Pump 10 includes a cylindrical inner sleeve 16 spaced slightly radially inwardly within the outer housing 12. When inner sleeve 16 is in housing 12, it divides cavity 14 into annular cavity 20 and central cavity 21. Thus, the inner sleeve 16 has a wall 23 with an outer surface 18, which together with outer housing 12 defines annular cavity 20, which is a cylindrical cavity and is generally indicated in FIG. 5; inner sleeve 16 has and inner surface 22 which defines central cavity 21. The annular cavity 20 between the inner sleeve 16 and outer housings is utilized in conjunction with the ports 13 of the pump 10 as discussed in greater detail below.

[0019] A pair of coaxial stators, first and second stators 24 and 26 (respectively) are at each end of the inner sleeve 16 to enclose cavity 21. Outer housing 12 and inner sleeve 16 are positioned between the flange 25 of first stator 24 and flange 27 of second stator 26. At least a portion of the outer surface of the stators is generally cylindrical so as to securely and non-rotatably firmly fit against the interior annular surface 22 of the inner sleeve 16. Additionally, the stators 24 and 26 can be mechanically linked to the inner sleeve 16 or can be integrally formed therewith, so that stators 24 and 26 do not rotate, or in any other manner move, with respect to inner sleeve 16.

[0020] The typical designs and orientations of stators 24 and 26 and of a rotor 34 can better seen from FIGS. 4A and 4B. Referring first to FIG. 4A, first stator 24 includes a circular cam surface 28 preferably defined by a pair of surface peaks 30 spaced diametrically opposite each

other, and a pair of surface valleys 32 likewise spaced diametrically opposite each other. Surface valleys 32 are positioned circumferentially equidistantly between the surface peaks 30, and likewise, the surface peaks 30 are positioned circumferentially equidistantly between the surface valleys 32. In embodiments, the cam surface 28 is defined by a plurality of flat, normalized surfaces aligned obliquely to each other and extending between the surface peaks 30 and the surface valleys 32. The flat surfaces of cam 28 are thus defined by planes extending through peripheral helical lines 29 which interconnect alternating surface peaks and valleys. The sharp peak ends and sharp valley junctures are preferred so that the rotor may break away sharply and distinctly from one function to the next as described below.

[0021] The second stator 26 in FIG. 4A is formed in mirror image to the stator 20 so that it too includes a cam surface 28' having sharp surface peaks 30' and sharp obliquely angled surface valleys 32'. As will be noted, stators 24 and 26 each have an inner surface which defines a bore 33, 33' configured to receive a shaft 60. As seen in FIGS. 3A and 3B, the cam surfaces 28, 28' of the stators are spaced apart and opposed to one another and at least partially positioned in cavity 21. As will be noted, FIG. 3A is a cross-sectional illustration of pump 10 and FIG. 3B illustrates the rotors and stators in the same position as they appear in FIG. 3A.

[0022] As best seen from FIG. 2 and 3A, rotor 34 is disposed within the cavity 21 and positioned between the stators 24, 26. The rotor 34 has in inner surface 36 (typically cylindrical) which defines a bore 38 configured to receive shaft 60, which typically will be a cylindrical shaft as described below. Further, inner surface 36 defines a rotor slot 40 configured to receive a bearing, as described further below.

[0023] Further, rotor 34 can comprise a first rotor element 42 and a second rotor element 48, which are both cylindrical. The first rotor element 42 and the second rotor element 48 each include a portion of the rotor slot 40 defined by the inner surface 36.

[0024] As best seen from FIGS. 3A and 4A, first rotor element 42 has a first cam face 44 and a first opposing face 46, which is opposed to first cam face 44, and second rotor 48 has a second cam face 50 and a second opposing face 52, which is opposed to second cam face 50. First opposing face 46 and second opposing face 52 are mating surfaces so that first rotor 42 and second rotor 48 can be mated or joined to form rotor 34 with rotor slot 40 typically extending across the two rotor elements.

[0025] First cam face 44 of rotor 34 is adjacent to cam surface 28 of first stator 24, and second cam face 50 of rotor 34 is adjacent to cam surface 28' of second stator 26. Similar to the stators, first cam face 44 has sharp surface peaks 54 and sharp surface valleys 56, and second cam face 50 has sharp surface peaks 54' and sharp surface valleys 56'. In some orientations of rotor 34, first cam face 44 will mate with cam surface 28 of first stator 24 with peak meeting valley. Similarly, in some orientations of rotor 34, second cam face 50 will mate with cam surface 28' of second stator 26 with peak meeting valley.

[0026] In the embodiment illustrated in FIG. 4A, the peaks of the stators are aligned to be opposing each other, and subsequently the valleys of the stators are also aligned to be opposing each other. In this arrangement, the rotor has peaks 54 aligned with valleys 56', and valleys 56 aligned with peaks 54'. Accordingly, the length dimension of the rotor 34 is substantially uniform throughout the entire rotor 40. In operation, distance between the stators 24, 26 and the length dimension of the rotor 40 are such that when the first cam face 44 of the rotor 34 is matingly engaged against the cam surface 28 of the first stator 24 with peaks 54 of rotor 40 engaging valleys

32 of first stator 24 and with valleys 56 being engaged by peaks 30 of first stator 24, the surface peaks 54' of the second cam face 50 of rotor 40 abut the surface peaks 30' of the second stator 26 so as to create a pair of chambers 58 defined on either side of the abutting surface peaks 30' and 26' of the rotor 34 and the stator 26. Similarly, a pair chamber 58 will form on first cam face 42 side when second cam face 50 mates with second stator 26.

[0027] Accordingly, chambers 58 are variable chambers in that they move from a closed position with little or no volume when a cam face of the rotor is matingly engaged against the cam surface of stator to a fully open, or maximum volume when the cam face of the rotor is turned to have its peaks abutting the peaks of the associated cam surface of a stator. Accordingly, the first stator 24 and rotor 34 define a first variable chamber (typically a pair of first variable chambers spaced circumferentially apart; however, the design could readily be altered to produce additional first variable chambers), and the second stator 26 and rotor 34 define a second variable chamber (typically a pair of second variable chambers spaced circumferentially apart; however, the design could be altered to produced additional second variable chambers). The second variable chamber has a size and shape that changes simultaneously with but in opposition to with the changing of the size and shape of the first variable chamber such that when the first variable chamber is moving to the open position, the second variable chamber is moving to the closed position, and when the first variable chamber is moving to the closed position, the second variable chamber is moving to the open position. This allows introducing a fluid into the first variable chamber while expelling a fluid from the second variable chamber, and subsequently introducing a fluid into the second variable chamber while expelling a fluid from the first variable chamber.

[0028] Of course, the orientation of the stators and rotors determine the pattern of the inflow and outflow of fluid, that is which ports are used for inflow and which for outflow of fluid.

Thus, other orientations or more or less variable chambers may be desired depending on the operation of pump. For example, in an alternative embodiment illustrated in FIG. 4B, peaks 30 of first stator 24 are aligned to be opposing valleys 32' of second stator 26; subsequently, valleys 32 of first stator 24 are aligned to be opposing peaks 30' of second stator 26. In this arrangement, the rotor has peaks 54 aligned with peaks 54', and valleys 56 aligned with valleys 56'. Accordingly, the length dimension of the rotor 40 is larger at the peaks than at the valleys; however, the distance between the stators 24, 26 and the length dimension of the rotor 34 are still such that, when the first cam face 44 of the rotor 34 is matingly engaged against the cam surface 28, a pair of chambers forms on the second cam face 50 side. Likewise, when the second cam face 50 mates with second stator 26, a pair of chambers 58 forms on the first cam face 42 side. The difference between the embodiments of FIG. 4A and 4B is a change in where the chambers are formed; hence affecting the ports where fluid enters and exits pump 10.

[0029] In any relative orientation of the stators and the rotor, the rotor has a length and diameter determined to be disposed for rotation within cavity 21 between the stators so as to form variable chambers on each side of the rotor.

[0030] As best seen from FIG. 5 and 6, inner sleeve 16 includes a plurality of inlet and outlet ports 17 in the circumferential outer surface 16 thereof which are designed and located to interface with chambers 58 formed within the central cavity 21 by the rotating and reciprocating action of the rotor 34 and its interaction with stators 24, 26. Typically, ports 17 will be in the form of eight helical slots which are defined by the circumferential wall of the inner housing 16. Generally, ports 17 are arranged in axially-aligned pairs of ports. As illustrated in FIGS. 5 and 6, a first set of ports 17a are circumferentially-spaced slots axially positioned at the interface of the rotor 34 stator 24, and a second set of ports 17b are circumferentially-spaced slots axially

positioned at the interface of rotor 34 and stator 26. Thus, an axially-aligned pair includes a port 17a and 17b. The slots of each pair are helically shaped so as to obliquely angle toward each other at one end and away from each other at the opposite ends, thus being of opposite hand. Further, the pairs are alternated around the circumference of inner sleeve 16 so that adjacent pairs of slots are aligned in the exact opposite manner. This pattern thereby creates four ports 17a associated with the chambers 58 formed between the rotor 34 and the stator 24, and four ports 17b associated with the lower chambers 58 formed between the rotor 34 and the stator 26. Each port 17 is associated with either discharge of fluid from or input of fluid into a lower chamber 58.

[0031] Further, ports or slots 17 are also associated with ports 13 in outer housing 12 so that a port 13 is in fluid flow communication with an associated chamber 58 by means of an associated slot 17. As best seen in FIGS. 2, 3A and 5, the pump 10 includes a divider 82, which isolates each slot 17 so that a slot 17 is only associated with one port 12; thus, preventing cross-flow of fluid in annular cavity 20. In this manner, fluid is introduced into pump 10 through a first port 13 and then into an associated chamber 58 through a first slot 17, which is associated with the first port. As the pump rotates the chamber 58 comes into fluid flow communication with the next circumrenal spaced slot 17 (second slot 17), which is associated with a different port 13 (second port 13); thus, the fluid now is pushed out of chamber 58 through the associated second slot 17 and then out the associated second port 13. Further understanding of the flow of fluid between slots 17 and chambers 58 can be gained by examining U.S. 4,854,837 to Robert K. Cordray, which while pumps and motors of this disclosure differ in certain key features from U.S. 4,854,837, the currently disclosed pumps and motors have a similar operation and fluid flow with respect to slots 17 and chambers 58 as U.S. 4,854,837.

[0032] As illustrated, baffle 82 is a central cylindrical ring 84 with arms 86 extending axially out on both sides of ring 84. Baffle 82 is configured to fit into annular cavity so as to have a sealing engagement with outer housing 12 and outer surface 18 of inner sleeve 16. While illustrated as separate piece, baffle 82 can also be integrally formed on the outer surface 18 of inner sleeve 16 so as to be a raised wall thereon.

[0033] In the illustrated forms, shaft 60 extends axially along central axis 11 through bore 33 stator 24, bore 38 of rotor 34 and bore 33' of stator 26. At a first end 62, shaft 60 is configured to be attached to a secondary shaft (not shown) so that shaft 60 and the secondary shaft rotate together. However, shaft 60 can extend out so as to integrally form the secondary shaft, which generally is operationally attached to a motor or other similar equipment. Shaft 60 extends through first end housing 70, ball bearing element 72, first stator 24, rotor 34, second stator 26, and ball bearing element 74, and shaft 60 has a second end 64 received by second end housing 76. Second end housing 76 typically forms a closed end of pump 10. Included in the assembly can be various sealing rings 78.

[0034] When used as a pump, the rotor 34 may be rotated by a drive shaft 60. The drive shaft is freely rotatable within stationary stators 24 and 26, which is facilitated by ball bearing elements 72, 74. However, the drive shaft 60 includes a mechanism for securing the rotor 34 for rotation therewith. Thus, as the shaft 60 is caused to rotate, the rotor 34 rotates with it; and in a similar manner, when rotor 34 is caused to rotate the shaft 60 rotates with it. However, the rotor 34 is secured to the drive shaft 60, in such a manner as to allow the rotor 34 to move axially relative to the drive shaft 60 as it rotates so that it may reciprocate between mating engagement of the first cam face 44 and the cam surface 28 of the first stator 24, as discussed above, and mating engagement between the second cam surface 50 and the cam surface 28' of the second stator 26.

[0035] As most easily seen in FIG. 3A, the mechanism for securing the rotor 34 to the drive shaft 60 while permitting the reciprocating movement along its length can be a bearing 80 which rest partly (first portion 88) in a shaft slot 66 defined by the surface 68 of shaft 60. Shaft slot 66 is located in axial portion 65 of shaft 60 between the pair of stators 24, 26. Additionally bearing 80 rest partially (second portion 90) in rotor slot 40. Thus, as illustrated second portion 90 of bearing 80 is mated into rotor slot 40 so that the portion is sandwiched between first rotor element 42 and second rotor element 48. Shaft slot 66 is longer than first portion 88 of bearing 80; thus, bearing 80 is free to slide longitudinally (axially) along shaft 60 within shaft slot 66 between a first position and a second position which allows rotor 34 to slide longitudinally. However, the engagement of bearing 80 with shaft 60 and rotor 34 is such that rotation of shaft 60 results in rotation of the rotor 34, and likewise rotation of rotor 34 results in rotation of shaft 60. Accordingly, the rotor 34 rotates with the shaft 60 while allowing the rotor 34 to move axially along the central portion of shaft 60.

[0036] In the illustrated form, the assembled elements of pump 10 are held together by connecting first end housing 70 to second end housing 76, such as by bolts 92. Shaft 60 is held in axial alignment and allowed to rotate by ball bearing elements 72, 74 and can be maintained within the pump by securing rings that prevent axial movement of shaft 60. Stators 24, 26 and rotor 34 are held in position and operational contact by being mounted on shaft 60 and by the connection of first end housing 70 to second end housing 76.

[0037] In one embodiment, the operation of rotary 10 is generally carried out by a method such as the following. A fluid is introduced into a first variable chamber 58 of the rotary device through a first slot defined by inner sleeve 16. The introduction is controlled by the first slot and by a size and shape of the first variable chamber.

[0038] As rotor 34 turns, the fluid is subsequently expelled from the variable chamber through a second slot defined by the sleeve 16. The expelling is controlled by the second slot and the size and shape of the first variable chamber.

[0039] During the rotation of rotor 34, the size and shape of the first variable chamber is varied by rotating the rotor on shaft 60 and by sliding rotor 34 axially along shaft 60. The rotating and sliding are controlled by bearing 80 interacting with rotor 34 and shaft 60 such that bearing 80 transmits rotation of shaft 60 to rotor 34 to thus rotate the rotor and axial movement of bearing 80 within defined slot 66 on shaft 60 results in the rotor axially sliding, and wherein the rotating and sliding of rotor 34 results in changing the size and shape of the first variable chamber such that the size and shape of the first variable chamber results in a maximum volume in an open position and a minimum volume in a closed position, and the first variable chamber moves between the open position and closed position so that the introducing the fluid occurs as the variable chamber moves from the closed position to the open position, and the expelling the fluid occurs as the first variable chamber moves from the open position to the closed position.

[0040] The method typically includes using at least a second variable chamber, and more typically a pair of first variable chambers and a pair of second variable chambers; though it is possible to design the pump with additional first and second variable chambers. The first variable chamber(s) will generally be defined between the first stator and the rotor and the second variable chamber(s) will typically be defined between the second stator and the rotor. If multiple first variable chambers are used they will move in sync between open and closed position. The second variable chamber(s) have a size and shape that changes simultaneously with but in opposition to with the changing of the size and shape of the first variable chamber(s) such that when the first variable chamber is moving to the open position, the second variable chamber is moving to the

closed position, and when the first variable chamber is moving to the closed position, the second variable chamber is moving to the open position. The process will further include steps of introducing and expelling fluid from the second variable chamber(s) similar to the steps described above for the first variable chamber(s).

[0041] The above description can be further understood from the following numbered embodiments, which are meant to provide example of embodiments and not limit the embodiments.

[0042] Embodiment 1: A rotary device comprising a housing, and inner sleeve, a pair of coaxial stators, a shaft, a bearing and a rotor. The inner sleeve comprised of a wall defining a substantially cylindrical cavity having central axis, and defining a plurality of paired sets of sleeve slots disposed in the wall so as to allow fluid flow from the cylindrical cavity to outside of the inner sleeve, wherein the inner sleeve is enclosed by the housing.

[0043] The pair of coaxial stators disposed at each end of the inner housing to enclose the cavity, each the stator having a cam surface with the cam surfaces of the stators being spaced apart and opposed to one another and at least partially positioned in the cavity.

[0044] The shaft has an axial portion extending axially between the pair of coaxial stators and configured for rotation within the cavity, wherein the shaft has a shaft slot extending axially in the axial portion.

[0045] The bearing has a shaft portion and a rotor portion, and the shaft portion is disposed within the shaft slot and configured to axially slide within the shaft slot between a first position and a second position.

[0046] The rotor has a length and diameter dimensions disposed for rotation within the cavity between the stators. The rotor includes first cam face and a second cam face configured for

mating engagement with oppositely disposed stator cam surfaces. Wherein the rotor has an inner cylindrical surface configured to receive the shaft with the rotor portion of the bearing in a rotor slot defined by the inner cylindrical surface.

[0047] Wherein when the bearing is positioned in the rotor slot and shaft slot, sliding of the bearing slides within the shaft slot results in the rotor sliding axially along the shaft portion, and such that rotational movement of the shaft results in rotational movement of the rotor, and wherein the rotor is spaced between the stators to reciprocate along the shaft means between alternating mating engagement with each of the stator cam surfaces during rotation of the rotor to define a plurality of chambers between the rotor and each stator.

[0048] Embodiment 2: The rotary device of Embodiment 1, wherein the housing defines a plurality of ports, and wherein the sleeve slots control the intake and discharge of fluid between the plurality of chambers and the ports, wherein the sleeve slots are sized and shaped so that, as the rotor rotates and reciprocates within the cavity, the rotor functions as a rotary valve that opens and closes the sleeve slots, and with each the chamber being interconnected with a pair of the set of sleeve slots based circumferentially adjacent each other and wherein in each of the set of sleeve slots corresponds to one of the ports such that one of the pair of the set of sleeve slots is interconnected with a first port of the plurality of ports and the other of the pair of the set of sleeve slots is interconnected with a second port of the plurality of ports.

[0049] Embodiment 3: The rotary device of either Embodiment 1 or Embodiment 2, wherein the inner sleeve is enclosed in the housing so as to define an annulus between the inner sleeve and the housing, and wherein the rotary device further comprises a baffle located within the annulus so that fluid from one of the sets of sleeve slots is isolated so as to be in fluid flow communication with only the port corresponding to the sleeve slot.

[0050] Embodiment 4: The rotary device of any of Embodiments 1 to 3, wherein the rotor comprises a first rotor element and a second rotor element, wherein the first rotor element has the first cam face and a first opposing face opposing the first cam face, and the second rotor element has the second cam face and a second opposing face opposing the second cam face, wherein the first opposing face and second opposing face mate so that the first rotor element and the second rotor element each include a portion of the rotor slot defined by the inner cylindrical surface.

[0051] Embodiment 5: The rotary device of any of Embodiments 1 to 4, further comprising a ball bearing arrangement associated with one of the stators so as to provide for free axial rotation of the shaft.

[0052] Embodiment 6: A rotary device comprising a sleeve, a first and second stator, a cylindrical two-piece rotor, a shaft, a bearing, and a plurality of helical slots. The sleeve defines a substantially cylindrical central cavity having a central axis and first and second ends.

[0053] The first stator is secured at the first end and the second stator is secured at the second end of the central cylindrical cavity defined by the sleeve. The first stator having a first cam surface and the second stator having a second cam surface with each such cam surface including at least a pair of surface peaks circumferentially alternated with at least a pair of surface valleys. The first cam surface and the second cam surface are opposed to one another and spaced apart on opposite sides of the central cavity defined within the sleeve.

[0054] The cylindrical two-piece rotor has a first cylindrical piece mated with a second cylindrical piece. The rotor located within the central cylindrical cavity defined by the sleeve and adjacent to and in contact with the first and second stators. The rotor having a length dimension, a central axis, an opening extending along the central axis, and a diameter such that it may be both

rotated around and reciprocated along its the central axis within the central cylindrical cavity defined by the sleeve between the first stator and the second stator. The rotor including a first cam face associated with the first cylindrical piece and a second cam face associated with the second cylindrical piece. The first cam surface and the second cam surface each being a cam surface including at least a pair of surface peaks circumferentially alternated with at least a pair of surface valleys and configured, when in a first position, for simultaneous substantial peak-to-valley mating engagement between the first cam face and the adjacent first cam surface of the stator so that no chamber is defined there-in-between, and substantial peak-to-peak mating engagement between the second face and the adjacent second cam surface of the second stator so that a chamber is defined there-in-between, and when in a second position, simultaneous substantial peak-to-valley mating engagement between the second cam face and the adjacent second cam surface so that no chamber is defined there-in-between, and substantial peak-to-peak mating engagement between the first cam face and the adjacent first cam surface so that a chamber is defined there-in-between, and when in neither the first position or the second position, defining variable chamber positions wherein variable chambers are formed between the first cam face and first cam surface and between the second cam face surface and the second cam surface.

[0055] The shaft has a length dimension and located within the opening extending along the central axis of the rotor, wherein the shaft has a shaft slot extending axially along the shaft.

[0056] The bearing has a shaft portion and a rotor portion. The shaft portion disposed within the shaft slot and configured to axially slide within the shaft slot between a first position and a second position, and the rotor portion disposed within a rotor slot in the opening extending along the central axis of the rotor. Wherein the bearing is held fixedly within the rotor slot, thus the shaft is connected to the rotor for rotation of the rotor by the shaft while at the same time

permitting reciprocating axial movement of the rotor along the shaft within the central cavity defined by the sleeve; whereby, during rotation the rotor can reciprocate along the shaft means between alternate the first position, the second position and variable chamber positions.

[0057] The plurality of helical slots disposed in the sleeve for controlling intake and discharge of fluid from the variable chambers defined between each the first end-surface and the second end-surface and the adjacent respective first-stator cam surface and second-stator cam surface on each side of the rotor. Wherein, the helical slots are so sized and shaped that when the rotor is rotated within the central cavity, the first cam face and second cam face vary their contact with and spacing from the adjacent respective first cam surface and second cam surface, and the rotor reciprocates thereby functioning as a rotary valve that opens and closes the helical slot ports, each the chamber being interconnected with a pair of helical slot spaced circumferentially adjacent each other and being of opposite hand with respect to each other for controlled intake and discharge of fluid through the plurality of helical slots.

[0058] Embodiment 7: The rotary device of Embodiment 6, further comprising a housing enclosing the inner sleeve. The housing defines a plurality of ports, and the helical slots control the intake and discharge of fluid between the variable chambers and the ports such that each helical slot has a corresponding port so as to controls fluid flow between one of the variable chambers and the corresponding port.

[0059] Embodiment 8: The rotary device of Embodiment 7, wherein the inner sleeve is enclosed in the housing so as to define an annulus between the inner sleeve and the housing, and wherein the rotary device further comprises a baffle located within the annulus so that fluid from one of the helical slots is isolated so as to be in fluid flow communication with only the corresponding port of that helical slot.

[0060] Embodiment 9: The rotary device of any of embodiments 6 to 8, further comprising a first ball bearing arrangement associated with the first stator and a second ball bearing arrangement associated with the second stator so as to provide for free axial rotation of the shaft.

[0061] Embodiment 10: A method comprising:

introducing a fluid into a first variable chamber of a rotary device through a first slot defined by a sleeve, wherein the introduction is controlled by the first slot and by a size and shape of the first variable chamber;

expelling the fluid from the variable chamber through a second slot defined by the sleeve wherein expelling is controlled by the second slot and the size and shape of the first variable chamber; and

varying the size and shape of the first variable chamber by rotating the rotor on a shaft and by sliding the rotor axially along the shaft wherein the rotating and sliding are controlled by a bearing interacting with the rotor and shaft such that the bearing transmits rotation of the shaft to the rotor to thus rotate the rotor and axial movement of the bearing within a defined slot on the shaft results in the rotor axially sliding, and wherein the rotating and sliding of the rotor results in changing the size and shape of the first variable chamber such that the size and shape of the first variable chamber results in a maximum volume in an open position and a minimum volume in a closed position, and the first variable chamber moves between the open position and closed position so that the introducing the fluid occurs as the variable chamber moves from the closed position to the open position, and the expelling the fluid occurs as the first variable chamber moves from the open position to the closed position.

[0062] Embodiment 11: The method of Embodiment 10, wherein the rotary device includes a pair of stators, and the rotor and pair of stators defining the first variable chamber and

a second variable chamber, wherein the second variable chamber has a size and shape that changes simultaneously with but in opposition to with the changing of the size and shape of the first variable chamber such that when the first variable chamber is moving to the open position, the second variable chamber is moving to the closed position, and when the first variable chamber is moving to the closed position, the second variable chamber is moving to the open position, and wherein the process further includes:

introducing the fluid into the second variable chamber through a third slot defined by the sleeve, wherein the introduction into the second variable chamber is controlled by the third slot and by a size and shape of the second variable chamber; and

expelling the fluid from the variable chamber through a fourth slot defined by the sleeve, wherein the expelling from the variable chamber is controlled by the fourth slot and the size and shape of the first variable chamber.

[0063] Embodiment 12: The method of Embodiment 11, further comprising isolating each of the first slot, second slot, third slot and fourth slot that there is only fluid flow between the first slot and the second slot through the first variable chamber, and only fluid flow between the third slot and the fourth slot through the second variable chamber, and no fluid flow between the first slot and the third slot or fourth slot, and not fluid flow between the second slot and the third slot or fourth slot.

[0064] Embodiment 13: The method of any of Embodiment 10 to 12, wherein the rotary device further comprise a ball bearing arrangement associated with the pair of stators as to provide for free axial rotation of the shaft in relation to the stators.

[0065] Embodiment 14: The method of either Embodiment 12 or 13, wherein the rotary device further comprises a housing enclosing the sleeve, wherein the housing defines at

least a first port, second port, third port and fourth port, and wherein the first slot controls introduction of the fluid from the first port to the first variable chamber, the second slot controls expelling of the fluid from the first variable chamber to the second port, the third slot controls introduction of the fluid from the third port to the second variable chamber, and the fourth slot controls expelling of the fluid form the second variable chamber to the fourth port.

[0066] The design described herein can handle both gaseous and liquid phase fluids and can handle multiple fluids simultaneously such as in a resin dispensing pump that meters two chemicals at different ratios. Further, the design could be used, for example, as an air compressor, refrigeration compressor, or as a hydraulic or pneumatic motor.

[0067] For example, most prior art air compressors are quite noisy and produce a great deal of vibration. This is one of the greatest drawbacks for air compressors is that they are so obnoxious that they are not typically located close to the work they are to perform. In industrial applications the compressors are located as far from the workers as possible and even are housed in separate buildings. In very large compressor installations there is a considerable amount of heat given off by these units causing certain worker environmental concerns. Typically, the larger the compressor's air capacity the more noise, vibration, and heat rejection is a problem. One of the principle advantages of the currently described rotary pump design is that it is extremely quiet and produces virtually no vibration; thus, allowing the implementation of air compressors in different ways and places than could be conceived before. Another advantage is that the currently disclosed design is much more efficient than compressors of the prior art, that is it delivers more high-pressure air volume per horsepower of work put in.

[0068] While systems and methods are described in terms of "comprising," "containing," or "including" various components or steps, the systems and methods also can "consist essentially

of" or "consist of" the various components and steps. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range are specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Additionally, where the term "about" is used in relation to a range it generally means plus or minus half the last significant figure of the range value, unless context indicates another definition of "about" applies.

[0069] Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the elements that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent(s) or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

What is claimed is:

1. A rotary device comprising:

a housing;

an inner sleeve comprised of a wall defining a substantially cylindrical cavity having central axis, and defining a plurality of paired sets of sleeve slots disposed in the wall so as to allow fluid flow from the cylindrical cavity to outside of the inner sleeve, wherein the inner sleeve is enclosed by the housing;

a pair of coaxial stators disposed at each end of the inner housing to enclose the cavity, each the stator having a cam surface with the cam surfaces of the stators being spaced apart and opposed to one another and at least partially positioned in the cavity;

a shaft having an axial portion extending axially between the pair of coaxial stators and configured for rotation within the cavity, wherein the shaft has a shaft slot extending axially in the axial portion;

a bearing having a shaft portion and a rotor portion, and the shaft portion is disposed within the shaft slot and configured to axially slide within the shaft slot between a first position and a second position; and

a rotor having a length and diameter dimensions disposed for rotation within the cavity between the stators, the rotor including first cam face and a second cam face configured for mating engagement with oppositely disposed stator cam surfaces, wherein the rotor has an inner cylindrical surface configured to receive the shaft with the rotor portion of the bearing in a rotor slot defined by the inner cylindrical surface,

wherein when the bearing is positioned in the rotor slot and shaft slot, sliding of the bearing slides within the shaft slot results in the rotor sliding axially along the shaft portion, and such that rotational movement of the shaft results in rotational movement of the rotor, and

wherein the rotor is spaced between the stators to reciprocate along the shaft means between alternating mating engagement with each of the stator cam surfaces during rotation of the rotor to define a plurality of chambers between the rotor and each stator.

2. The rotary device of claim 1, wherein the housing defines a plurality of ports, and wherein the sleeve slots control the intake and discharge of fluid between the plurality of chambers and the ports, wherein the sleeve slots being sized and shaped so that, as the rotor rotates and reciprocates within the cavity, the rotor functions as a rotary valve that opens and closes the sleeve slots, and with each the chamber being interconnected with a pair of the set of sleeve slots based circumferentially adjacent each other and wherein in each of the set of sleeve slots corresponds to one of the ports such that one of the pair of the set of sleeve slots is interconnected with a first port of the plurality of ports and the other of the pair of the set of sleeve slots is interconnected with a second port of the plurality of ports.

3. The rotary device of claim 2, wherein the inner sleeve is enclosed in the housing so as to define an annulus between the inner sleeve and the housing, and wherein the rotary device further comprises a baffle located within the annulus so that fluid from one of the sets of sleeve slots is isolated so as to be in fluid flow communication with only the port corresponding to the sleeve slot.

4. The rotary device of claim 1, wherein the rotor comprises a first rotor element and a second rotor element, wherein the first rotor element has the first cam face and a first opposing

face opposing the first cam face, and the second rotor element has the second cam face and a second opposing face opposing the second cam face, wherein the first opposing face and second opposing face mate so that the first rotor element and the second rotor element each include a portion of the rotor slot defined by the inner cylindrical surface.

5. The rotary device of claim 1, further comprising a ball bearing arrangement associated with one of the stators so as to provide for free axial rotation of the shaft.

6. A rotary device comprising:

sleeve defining a substantially cylindrical central cavity having a central axis and first and second ends;

a first stator and a second stator, the first stator secured at the first end and the second stator secured at the second end of the central cylindrical cavity defined by the sleeve, the first stator having a first cam surface and the second stator having a second cam surface, the first cam surface and second cam surface each including at least a pair of surface peaks circumferentially alternated with at least a pair of surface valleys, the first cam surface and second cam surface being opposed to one another and spaced apart on opposite sides of the central cavity defined within the sleeve;

a cylindrical two-piece rotor having a first cylindrical piece mated with a second cylindrical piece, the rotor located within the central cylindrical cavity defined by the sleeve and adjacent to and in contact with the first and second stators, the rotor having a length dimension, a central axis, an opening extending along the central axis, and a diameter such that it may be both rotated around and reciprocated along its the central axis within the central cylindrical cavity defined by the sleeve between the first stator and the second stator, the rotor including a first cam face associated with the first cylindrical piece and a second cam face associated with the second cylindrical piece, the first cam face and the second cam face each being a cam surface including at least a pair of surface peaks circumferentially alternated with at least a pair of surface valleys and configured, when in a first position, for simultaneous substantial peak-to-valley mating engagement between the firs cam face and the adjacent first cam surface of the first stator so that no chamber is defined there-in-between, and substantial peak-to-peak mating engagement between the second cam face and the adjacent second cam surface of the second stator so that a chamber is

defined there-in-between, and when in a second position, simultaneous substantial peak-to-valley mating engagement between the second cam face and the adjacent second cam surface so that no chamber is defined there-in-between, and substantial peak-to-peak mating engagement between the first cam face and the adjacent first cam surface so that a chamber is defined there-in-between, and when in neither the first position or the second position, defining variable chamber positions wherein variable chambers are formed between the first cam face and the first cam surface and between the second cam face and the second cam surface;

a shaft, the shaft having a length dimension and located within the opening extending along the central axis of the rotor, wherein the shaft has a shaft slot extending axially along the shaft;

a bearing having a shaft portion and a rotor portion, the shaft portion disposed within the shaft slot and configured to axially slide within the shaft slot between a first position and a second position, and the rotor portion disposed within a rotor slot in the opening extending along the central axis of the rotor, wherein the bearing is held fixedly within the rotor slot, thus the shaft is connected to the rotor for rotation of the rotor by the shaft while at the same time permitting reciprocating axial movement of the rotor along the shaft within the central cavity defined by the sleeve; whereby, during rotation the rotor can reciprocate along the shaft means between alternate the first position, the second position and variable chamber positions; and

a plurality of helical slots disposed in the sleeve for controlling intake and discharge of fluid from the variable chambers defined between each the first end-surface and the second end-surface and the adjacent respective first-stator cam surface and second-stator cam surface on each side of the rotor; wherein, the helical slots are so sized and shaped that when the rotor is rotated within the central cavity, the first cam face and second cam face vary their contact with and spacing

from the adjacent respective first cam surface and second cam surface, and the rotor reciprocates thereby functioning as a rotary valve that opens and closes the helical slot ports, each the chamber being interconnected with a pair of helical slot spaced circumferentially adjacent each other and being of opposite hand with respect to each other for controlled intake and discharge of fluid through the plurality of helical slots.

7. The rotary device of claim 6, further comprising a housing enclosing the inner sleeve, wherein the housing defines a plurality of ports, and wherein the helical slots control the intake and discharge of fluid between the variable chambers and the ports such that each helical slot has a corresponding port so as to controls fluid flow between one of the variable chambers and the corresponding port.

8. The rotary device of claim 7, wherein the inner sleeve is enclosed in the housing so as to define an annulus between the inner sleeve and the housing, and wherein the rotary device further comprises a baffle located within the annulus so that fluid from one of the helical slots is isolated so as to be in fluid flow communication with only the corresponding port of that helical slot.

9. The rotary device of claim 8, further comprising a first ball bearing arrangement associated with the first stator and a second ball bearing arrangement associated with the second stator so as to provide for free axial rotation of the shaft.

10. A method comprising:

introducing a fluid into a first variable chamber of a rotary device through a first slot defined by a sleeve, wherein the introduction is controlled by the first slot and by a size and shape of the first variable chamber;

expelling the fluid from the variable chamber through a second slot defined by the sleeve wherein expelling is controlled by the second slot and the size and shape of the first variable chamber; and

varying the size and shape of the first variable chamber by rotating the rotor on a shaft and by sliding the rotor axially along the shaft wherein the rotating and sliding are controlled by a bearing interacting with the rotor and shaft such that the bearing transmits rotation of the shaft to the rotor to thus rotate the rotor and axial movement of the bearing within a defined slot on the shaft results in the rotor axially sliding, and wherein the rotating and sliding of the rotor results in changing the size and shape of the first variable chamber such that the size and shape of the first variable chamber results in a maximum volume in an open position and a minimum volume in a closed position, and the first variable chamber moves between the open position and closed position so that the introducing the fluid occurs as the variable chamber moves from the closed position to the open position, and the expelling the fluid occurs as the first variable chamber moves from the open position to the closed position.

11. The method of claim 10, wherein the rotary device includes a pair of stators, and the rotor and pair of stators defining the first variable chamber and a second variable chamber, wherein the second variable chamber has a size and shape that changes simultaneously with but in opposition to with the changing of the size and shape of the first variable chamber such that when the first variable chamber is moving to the open position, the second variable chamber is moving

to the closed position, and when the first variable chamber is moving to the closed position, the second variable chamber is moving to the open position, and wherein the process further includes:

introducing the fluid into the second variable chamber through a third slot defined by the sleeve, wherein the introduction into the second variable chamber is controlled by the third slot and by a size and shape of the second variable chamber; and

expelling the fluid from the variable chamber through a fourth slot defined by the sleeve, wherein the expelling from the variable chamber is controlled by the fourth slot and the size and shape of the first variable chamber.

12. The method of claim 11, further comprising isolating each of the first slot, second slot, third slot and fourth slot that there is only fluid flow between the first slot and the second slot through the first variable chamber, and only fluid flow between the third slot and the fourth slot through the second variable chamber, and no fluid flow between the first slot and the third slot or fourth slot, and not fluid flow between the second slot and the third slot or fourth slot.

13. The method of claim 12, wherein the rotary device further comprise a ball bearing arrangement associated with the pair of stators as to provide for free axial rotation of the shaft in relation to the stators.

14. The method of claim 12, wherein the rotary device further comprises a housing enclosing the sleeve, wherein the housing defines at least a first port, second port, third port and fourth port, and wherein the first slot controls introduction of the fluid from the first port to the first variable chamber, the second slot controls expelling of the fluid from the first variable chamber to the second port, the third slot controls introduction of the fluid from the third port to

the second variable chamber, and the fourth slot controls expelling of the fluid form the second variable chamber to the fourth port.