A driving device for a rotary chemical machine such as a centrifugal separator having a reduction gear mechanism contained in a rotary casing, a torque control mechanism for imparting a desired torque to the output shaft thereof and including a braking element responsive to control means for measuring the load demand in the motor by the centrifugal separator. Thus, the device provides variable torque responsive to the load at the output shaft.
FIG. 1.
1. DRIVING DEVICE FOR ROTARY CHEMICAL MACHINE

This invention relates to a driving device for a rotary chemical machine, and more particularly to an improved driving device for a rotary chemical machine such as a centrifugal separator which will automatically operate under predetermined operating conditions.

A rotary chemical machine, such as a centrifugal separator, particularly a centrifugal separator of the type having a discharger for discharging off the muddy material out of a separating basket thereof, ordinarily needs to be rotated at two different rotating speeds at least, such as, at high speed in low torque for separating liquid from solid material and at low speed in high torque for discharging solid material out of the separating basket. The conventional centrifugal separator having a scraping edge has two driving devices. One of these is a driving device having two prime motors—a high-speed prime motor for driving in high speed range and a low-speed prime motor for driving in low speed range. The other is the type of driving device which has only one prime motor such as variable speed prime motor such as D.C. electric motor, multi-pole induction motor or hydraulic motor.

The conventional driving device is suited for driving the centrifugal separator only in so far as its ability to drive the separating basket at two different rotating speeds as concerned, but in designing the conventional driving device, no due consideration is given to the below-mentioned operating conditions peculiar to the centrifugal separator and therefore, the design fails to give adequate performance.

That is, the centrifugal separator needs to be operated in various torque and at various rotating speeds responsive to the moisture, viscosity of the fluid materials to be treated and quantity to be treated; but the conventional centrifugal separator does not satisfy such operating conditions. This is because the conventional driving device for the centrifugal separator is equipped with a prime motor which is ordinarily an induction electric motor having constant rotating speed, D.C. electric motor having variable speed characteristics, or multi-pole induction motor having step speed characteristics, but even if these prime motor could vary its speed, its output torque cannot be freely varied, and accordingly, the conventional driving device, which transmits the rotation of the prime motor directly to the basket, can not be well adapted for the above-mentioned unique operating conditions of the centrifugal separator. Therefore, such conventional driving device of the centrifugal separator drives the basket with excessive torque in some cases, and with less excessive torque in other cases. This applies excessive load to the prime motor and its transmitting mechanism, and it is also difficult to operate the device as desired.

It is, therefore, an object of the present invention to provide an improved driving device for a rotary chemical machine, which may be freely preset to the operating conditions of the machine.

It is another object of the present invention to provide a driving device for a rotary chemical machine such as a rotary centrifugal separator which is automatically operated under preset operating conditions.

It is another object of the present invention to provide a driving device for a rotary chemical machine such as a rotary centrifugal separator which is automatically operated under preset operating conditions.

It is a further object of the present invention to provide a driving device for a rotary chemical machine which generates variable torque responsive to the load at the output shaft of the driving device.

It is still another object of the present invention to provide a driving device for a rotary chemical machine such as a centrifugal separator which may provide a low torque high speed operation for separating liquid from slurry and a high torque low speed operation for discharging solid material out of the basket with one prime motor.

These and other objects of this invention, as hereinafter will readily become apparent, are provided by a driving device for a rotary chemical machine having a rotary basket, normally and reversely rotatable, and a rotary shaft affixed to the rotary basket, which comprises a reversible prime motor having a cylindrical hollow input shaft driven thereby, an output shaft secured to said rotary shaft, a rotary casing rotatably mounted around said output shaft, a first one-way clutch interposed between the input shaft of said prime motor and said rotary casing for coupling the input shaft of said prime motor to said rotary casing when the input shaft rotates in one direction, a second one-way clutch interposed between the input shaft of said prime motor and said output shaft for coupling the input shaft to said output shaft when the input shaft rotates in the other direction, a reduction gear mechanism contained in said rotary casing and having a first sun gear integrally formed on said output shaft, a sleeve shaft rotatably mounted on the said output shaft coaxially adjacent to the sun gear and having a second sun gear integrally formed thereon adjacent to the said first sun gear and projecting externally of said rotary casing, a stub shaft mounted around said output shaft, so as to be rotatable about its own axis and also around said output shaft within said rotary casing, first and second planetary idle gears rotatably mounted on said stub shaft and engaged with said first sun gear and said second sun gear respectively, and driven separately from said rotary casing only when said input shaft of said prime motor is rotated in one direction, a torque control mechanism having a non-restricting element fixedly secured to the projected end of said sleeve shaft at least one pair of braking elements movable relative to each other toward or away from both surfaces of said non-restricting element so as to engage the same braking element drive control means including a dual-operated air cylinder for actuating said braking elements, control means including a solenoid valve for controlling the quality of air supply to said air cylinder and a control circuit for actuating said solenoid valve and having an electric motor load detector for detecting the amplitude of the load current of said prime motor, a control for urging said braking elements into engagement said non-restricting element at a desired force, and a control calculator for comparing the detected value detected by said load detector with a preset value preset by said control for producing the output responsive thereto for controlling the drive of said braking elements so as to
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3 impart a desired torque to said output shaft. When the sleeve shaft of the reduction gear mechanism is
restricted properly, by braking the non-restricting ele-
ment, the rotary casing is rotated so that the stub shaft is
accordingly rotated around the output shaft and rela-
tive to the second sun gear and the second planetary
gear meshed with the second sun gear with the re-
sult that the stub shaft is rotated about its own axis, and
therefore the rotation of the rotary shaft is transmitted
through the sleeve shaft, first and second planetary
gears to the first sun gear so that the output shaft is ro-
tated by the torque proportional to the force restricting
the sleeve shaft. Thus, various torques may be pro-
duced at the output of the driving device for the rotary
chemical machine.

Another aspect of the driving device for the rotary
chemical machine, is attained by the provision of
means for slidably alternating the operating position of
said braking elements of said torque control mecha-
nism. Thus, very broad range of torque may be pro-
vided by displacing the position of the braking elements
as they engage the non-restraining element at the out-
put shaft of the driving device.

According to a further aspect of the present inven-
tion, there is provided a driving device for the rotary
chemical machine which comprises an electric braking
mechanism instead of the previously described me-
chanical braking mechanism. Thus, the wear of the
braking elements is avoided, and service and main-
tenance are reduced.

According to still another aspect of the present in-
vvention, there is also provided a driving device for the
rotary chemical machine having a rotary basket nor-
ma lly and reversely rotatable and a rotary shaft affixed
to the rotary basket, which comprises a reversible
prime motor having an input shaft driven thereby, an
output shaft secured to said rotary shaft and having a
first arm radially projected therefrom, a rotary casing
rotatably mounted around said output shaft, a driving
timing wheel driven by the reversible prime motor and
coupled through a belt with a driven timing wheel
mounted on the output shaft, a reduction gear mecha-
nism contained in said rotary casing and having a first
sun gear integrally formed on said driven timing wheel
to the driven by the belt, a sleeve shaft rotatably
mounted on said output shaft coaxially adjacent to the
sun gear and having a second arm radial ly projected
therefrom and a second sun gear integrally formed
thereon, a first stub shaft mounted around said output
shaft so as to be rotatable about its own axis and also
around said output shaft within said rotary casing and
also mounted in such a manner that the second arm of
said sleeve shaft is coupled to the first stub shaft, a sec-
ond stub shaft so mounted around said output shaft as
to be rotatable about its own axis and also around said
output shaft within said rotary casing and also mounted
in such a manner that the first arm of said output shaft
is complete to the second stub shaft, one-way clutch
mounted at the projected end of said second stub shaft,
first and second ring gears formed on the inner periph-
ery of said rotary casing corresponding to said first and
second sun gears respectively, first and second idler
planetary gears rotatably mounted on the first and sec-
ond stub shafts, respectively, intermeshing with the first
sun and ring gears and second sun and ring gears, re-
spectively, in such a manner that the one-way clutch
couples the second planetary gear with the second stub
shaft when the input shaft is rotated in one direction
and the one-way clutch disengages the second planeto-
gear from the second stub shaft when the input
shaft is rotated in the other direction, a torque control
mechanism having a non-restricting element formed on
the rotary casing as an extension of one wall thereof for
rotation therewith of at least one pair of braking ele-
ments movable relative to each other toward or away
from both surfaces of said non-restricting element.

According to still another embodiment of the present
invention, there is provided a driving device for the ro-
tary chemical machine having a rotary basket and a ro-
tary shaft secured thereto which comprises a reversible
prime motor having a first high speed input shaft driven
thereby and second low speed input shaft driven
thereby, an output shaft secured to said rotary shaft
which is connected to the same reduction gear mecha-
nism as described in the immediately preceding para-
graph, i.e., the rotary casing containing the embodiment
where the two arms support the two idler planetary
gears and planetary gears are formed on the rotary cas-
ing, but in this embodiment there are three one-way
clutch mechanisms, the first sun gear integrally is
formed on said first driven timing wheel driven through
the first belt and the first one-way clutch is mounted
between the first high speed driven timing wheel and
the output shaft for coupling only when the first driven
timing wheel is rotated in one direction, the second
one-way clutch is mounted between the planetary gear
mechanism and the output shaft for disengaging the
coupling of the gear mechanism to the output shaft
only when the first high speed driven timing wheel is
coupled with the output shaft by the first one-way
clutch, the third one-way clutch being mounted be-
tween the second low speed driven timing wheel and
the planetary gear mechanism for coupling the second
low speed driven timing wheel with the planetary gear
mechanism only when the second driven timing wheel
is rotated in one direction, a torque control mechanism
having a non-restricting element formed on the rotary
casing as an extension of one wall thereof for rotation
thereforth, and at least one pair of braking elements
movable relative to each other toward or away from
both surfaces of said non-restricting element.

These and other objects, features and advantages of
the present invention will become more fully apparent
from the following description given in conjunction
with the accompanying drawings, in which

FIG. 1 is a schematic view of one embodiment of a
driving device for a rotary chemical machine according
to the present invention;

FIGS. 2 to 4 are enlarged sectional views of the driv-
ing device for the rotary chemical machine constructed
in detail of the device in FIG. 1;

FIG. 5 is a schematic view of another embodiment of
the driving device for the rotary chemical machine con-
structed according to the present invention;

FIG. 6 is a partial sectional view of the driving device
constructed in detail of the device in FIG. 5; and

FIG. 7 is a schematic view of still another embodi-
ment of the driving device for the rotary chemical ma-
chine of the present invention;

Reference is now made to the drawings, and particu-
larly to FIG. 1, which schematically shows the entire
structure of one embodiment of a centrifugal separator
with a basket having a driving device constructed ac-
cording to the present invention.
This separator has a basket 2 fixed to the lower end of a vertically extended rotary shaft 1 and rotatable together as generally well known. The upper end of the rotary shaft 1 is rotatably supported by bearings 5 within a bearing box 4 fixed to a frame 3, and is connected to the lower end of an output shaft 7 through a coupling 6 so that the vibration of the basket 2 may not be transmitted thereto. A driving device, generally designated by numeral 8, comprises a reduction gear mechanism, generally designated by numeral 9, and a torque control mechanism 10, and is connected to only one reversible prime motor M such as, for example, an ordinary electric induction motor through a pair of clutches 11 and 12 and a starter compensating mechanism 13.

The driving device 8 comprises a rotary casing 14 which contains the reduction gear mechanism 9 such as a planetary gear mechanism and which is rotatably mounted around the output shaft 7 having the shaft coupling 6 at one end thereof.

The torque control mechanism 10 is for the purpose of imparting a desired torque to the output shaft 7 and comprises a control mechanism including a non-restricting element for restricting part of the driving device 8 such as, for example, a brake disc 15.

The starter compensating mechanism 13 is for the purpose of preventing an overload from being applied to the electric motor M when starting the motor M, and may be, for example, a centrifugal clutch or any well known fluid clutch.

Referring now to FIGS. 2 and 3, in the driving device constructed according to the first embodiment of the present invention numeral 16 denotes a cylindrical hollow input shaft driven through the starter compensating mechanism (not shown for clarity in depicting the invention in these figures) by the reversible motor M and connected through a pair of one-way clutches 11 and 12 to a rotary casing 14 and the output shaft 7. The one-way clutch 11 interposed between the input shaft 16 and the rotary casing 14 couples the input shaft 16 to the rotary casing 14 when the input shaft 16 rotates in one direction, while the one-way clutch 12 disposed between the input shaft 16 and the output shaft 7 couples the input shaft 16 to the output shaft 7 when the input shaft 16 rotates in the other direction. The output shaft 7 is formed integrally with a sun gear 17 forming part of the gear mechanism within the rotary casing 14, and is supported by bearings 18 within the rotary casing 14 so as to be freely rotatable with respect to the rotary casing 14. A sleeve shaft 20 formed integrally with a sun gear 19 coaxially adjacent to the sun gear 17 is rotatable through needle bearings 21 on the output shaft 7, and one end of the sleeve shaft 20 projects externally from the rotary casing 14, and part of the torque control mechanism such as, for example, the brake disc 15 is affixed to the flange 22 formed at the projecting end.

There are provided planetary idle gears 23 and 24 rotatably mounted on a stub shaft 25 and engaged with the sun gear 17 and the sun gear 19 respectively, within the rotary casing 14, and both ends of the stub shaft 25 are rotatably supported at the upper and lower end portions through needle bearings 26 provided within the rotary casing 14.

It will be understood now that when the input shaft 16 is rotated in one direction so that the one-way clutch 11 now acts to drive the rotary casing 14, this casing is then rotated in the same direction as that of the input shaft 16, and therethrough the idle planetary gears 23 and 24 rotatably engaged with the stub shaft 25 tend to rotate in intermeshing engagement with the sun gears 17 and 19, respectively, formed on the output shaft 7. However, since the reaction force necessary to rotate the planetary idle gear 24 by the sun gear 19 is not available since the sleeve shaft 20 is not restricted at this time, the planetary idle gear 24 cannot rotate with the result that the stub shaft 25 may not accordingly rotate about its own axis, but will rotate around the output shaft 7 integral with the rotary casing 14 and sleeve shaft 20. That is, the output shaft 7 may not be rotated in this mechanism unless the sleeve shaft 20 is not restricted.

If the sleeve shaft 20 is, however, restricted by a proper force so as not to rotate, the rotation of the rotary casing 14 rotates the stub shaft 25 around the output shaft 7 and simultaneously relatively rotates between the sun gear 19 and the planetary idle gear 24, and thereby rotates the stub shaft 25 about its own axis. Therefore, the rotation of the rotary casing 14 is, in this case, transmitted through the sleeve shaft 20 and planetary idle gears 24 and 23 to the sun gear 17 with the result that the output shaft 7 is rotated by the torque proportional to the force restricting the sleeve shaft 20.

When the input shaft 16 is driven in reverse to the rotating direction as described above, clutch 11 is disengaged, and at the same time the other clutch 12 is actuated, and thereby the input shaft 16 drives with the output shaft 7. Accordingly, the output shaft 7 transmits, in this case, the torque of the input shaft 16 directly. It is readily understood from the foregoing description that if the sleeve shaft 20 is restricted by a predetermined restricting force, various torques may be produced at the output shaft 7.

According to the present invention, the centrifugal separator is provided with a torque control mechanism for producing various amounts of torque at the output shaft 7 by varying the restricting force imparted to the sleeve shaft 20 responsive to the operating conditions of the centrifugal separator.

As further exemplified in FIGS. 2 and 3, the torque control mechanism is arranged to engage the oppositely disposed surfaces of the control disc 15 and comprises several pairs of braking elements 27, 27 (one pair of braking elements being illustrated in FIGS. 2 and 3) which are movable relative to each other to control the rotation of disc 15. The drive control device in particular has a dual-operated air cylinder 28, and a control device 29 therefore which controls the disc 15. The control device 29 includes in the embodiment shown in FIG. 2, a solenoid valve 30 for controlling the quantity of air supplied to the air cylinder 28 and a circuit for controlling the opening of the solenoid valve 30. The circuit includes an electric motor load detector 31 for detecting the amplitude of the load current of the electric motor M which is the input shaft 16. The control 32 for operation of the braking elements 27, 27 is coordinated with a control calculator 33 which compares the value detected by the load detector 31 with a preset value established by the control to produce the output responsive thereto.

From the foregoing description of this embodiment of the invention, it will now be understood that when a muddy solid substance adheres onto the inner wall of
the basket 2 of the separator is discharged by a discharger, the following torque may be imparted to the output shaft 7 by the torque control mechanism 10.

More particularly, when the electric motor M is started after preset values predetermined by the control 32, which preset values are determined by the state of the moisture content of the substance to be treated, grain size, viscosity, desired percentage of moisture content after separation, and operating hours, the control signal responsive to the preset values is imparted to the solenoid valve 30 which is then opened with the result that the braking elements 27, 27 are urged into contact with the brake disc 15 with a predetermined pressure. Therefore, the braking torque corresponding to the preset value. Thus, if an excessive load is applied to the electric motor M during operation, by any cause, the solenoid valve 30 is controlled by the detected signal from the detector 31 with the result that the transmission of the excessive load to the electric motor M and to entire drive device is prevented.

The alternative embodiment of a control device for controlling the torque applied to the output shaft 7 is shown in FIG. 3 and is broader than the device shown in FIG. 2. The control device of FIG. 3 comprises a device for alternating the operating position of the braking element 27, 27. This device includes an electric motor control 34, a screw shaft 35 directly coupled to the electric motor 34 and a slider 37 having a nut portion 36 threaded on the screw shaft 35, for movement of slider 37 positioned to slide on a stationary base 38 radially adjacent of the brake disc 15. The electric motor control 34 is connected to the control calculator 33 of the control circuit, and is controlled by the signal therefrom.

According to the aforementioned description of this embodiment of the driving device, it can be seen that as the braking elements 27, 27 are capable of being moved radially of the brake disc 15, a very broad range of torques may be applied to the output shaft 7.

FIG. 4 shows still another embodiment of the control device for controlling the torque applied to the output shaft of this invention. The device of this embodiment comprises an eddy current mechanism instead of the mechanical braking mechanism designated in FIGS. 2 and 3 in order to avoid the wear of the braking element and to reduce the necessity of service and maintenance thereof. This braking concept comprises an eddy current mechanism generally called eddy current retarder, and includes a pair of electromagnetic poles 39, 39 which are disposed opposite sides of the brake disc 15. The poles 39, 39 are connected to the control calculator 33 of the control circuit in a manner similar to the solenoid 30 previously described and is controlled by the output signal value of the control calculator 33.

According to this embodiment of the control device an eddy current is generated on the brake disc 15 by means of a magnetic flux generated by the poles 39, 39, and accordingly, a reaction torque is applied to the brake disc 15 with the result that the disc 15 is braked. It will be readily understood that since the braking force is proportional to the amplitude of the eddy current, i.e., the strength of the magnetic flux density generated by the poles 39, 39, the strength of the torque applied to the output shaft 8 may be varied responsive to the amplitude of the control signal for energizing the poles 39, 39.

Turning now to FIG. 5 which is a schematic illustration of another embodiment of this invention for a basket type centrifugal separator, it can be seen that the driving device 8 comprises a driven timing wheel 40, which is driven by a reversible electric motor M provided on the frame 3 through a drive timing wheel 41 and a belt 42. The driving device 8 is substantially the same as those shown in FIGS. 2 to 4, but is varied as best seen in detail in FIG. 6, the description of which follows later.

The driving device 8 comprises a rotary casing 14 similar to the driving device designated in FIGS. 2 to 4, but is constructed somewhat differently. These ring gears 45 and 46 form a planetary gear mechanism 9, together with a pair of planetary gears which will be hereinafter described in greater detail.

The lower end of an output shaft 7 in the center of the rotary casing 14 is relatively rotatably supported with respect to the rotary casing 14 by a thrust bearing 47 provided at the lower end of the rotary casing 14, while the other end projects outwardly of the upper end of the casing 14 and is connected to the main shaft 1 of the basket by means of the shaft coupling 6 shown in FIG. 5.

Beneath the coupling 6, there is provided on the output shaft 7, an input sleeve shaft 16 supported by bearings 48 and a reduction gear sleeve shaft 50 supported by bearings 49 with each sleeve being capable of rotation separately and independently of each other. The sleeve shaft 16 is rotatably supported relative to the casing 14 by bearings 51 so as to be driven by the reversible electric motor M shown in FIG. 5 by means of the driven time wheel 40 secured to the end of the input shaft 16. The reduction gear shaft 50 has an arm 52 extending radially from one end thereof and a sun gear (hereinafter called the second sun-gear) coaxially with the shaft 50 at the other end. Secured to the arm 56 is one end of a stub shaft 54 having an axis parallel with the input sleeve shaft 16 and output shaft 7, and at the other end of the stub shaft 54 is a first planetary gear 56 rotatably supported by bearings 55. The first planetary gear meshes with a planetary sun-gear 57 provided on the in-put sleeve shaft 16 and also with the first ring-gear 45 provided on the inner wall of the rotary casing 14. An arm 58 extends radially of the shaft 7 in the vicinity of the bearing 47 and is provided with a second short stub shaft 59 aligned on the same axis as the first stub shaft 54 and provided with a one-way clutch 60 and a second planetary gear 61 which meshes with the second planetary ring-gear 46 on rotary casing 14 and with the second sun-gear 53. This one-way clutch 60 couples the second planetary gear 61 with the second short stub shaft 59 when the input sleeve shaft 16 is rotated as designated by arrow A which rotates the second planetary gear 61 oppositely to the direction designated by the arrow A, while the one-way clutch 60 disengages the second planetary gear 61 from the second short stub shaft 59 when the input shaft 16 is rotated oppositely to the direction as illustrated by the arrow A, which, of course, rotates the second planetary gear 61 in the direction illustrated by the arrow A.

In this embodiment the braking of either of the disc 15, 15 formed as an extension on the top or bottom walls of the rotary casing 14 is accomplished in the
same manner as described earlier in connection with FIG. 1.

In the above described embodiment, assuming now that the input shaft 16 is rotated in the direction designated by an arrow A in FIG. 6, the one-way clutch 60 couples the second planetary gear 61 with the second short stub shaft 59, and neither of the brake discs 15 are restricted by the braking elements 27, 27. In this case there is no relative rotation between the second planetary gear 61 and the second short stub shaft 59 with the result that the second planetary gear 61 is restricted so as not to rotate around its own axis, i.e., about the second short stub shaft 59. Since relative rotation of the second planetary gear 61 is stopped, the second ring gear 46 and second sun gear 53 on the reduction gear shaft 50 is held in unison with the output shaft 7, and is then stopped. Therefore, at this time the first planetary gear 56 meshed with the first sun gear 57 tends to transmit rotary torque opposite to the rotation of the first sun gear 57. However, since the first ring gear 45 meshes with the first planetary gear 56 and rotary casing 14 is held in unison by the second planetary gear 61 the action of the clutch 60, at this time, the above rotary torque may not rotate the first planetary gear 56 about the first short stub shaft 54 and accordingly the rotation of the input sleeve shaft 16 is transmitted directly to the rotary casing 14 held in unison with the output shaft 7. Therefore, in this case, the output shaft 7 and rotary casing 14 are rotated directly together with the input sleeve shaft 16 in the state integration with the input shaft 16 and accordingly the output shaft 7 is rotated in the direction as designated by an arrow A. Consequently, the main shaft 1 of the basket directly coupled with the output shaft 7 is rotated in low torque at high speed for separating the solids from the liquid.

When the separation of solids from the liquid within the basket is completed, the driving device is switched to rotation in at a high torque at low speed for discharging the muddy substance out of the basket by a command from the control device (not shown). This high torque and low speed operation is executed as follows:

The electric motor M is switched to reverse drive in FIG. 5 by a drive command from the control device (not shown) and simultaneously the solenoid valve 30 for operating the braking elements, is opened in a preset degree with the result that the braking elements 27, 27 are urged onto the brake discs 15, 15 by a predetermined pressure, and thereby the rotation of the rotary casing 14 is restricted.

When the input sleeve shaft 16 is rotated in the direction designated by an arrow B, the first planetary gear 56 meshed with the first sun gear 57, tends to rotate or is rotated in an opposite direction to the rotating direction of the input sleeve shaft 16 about the first short stub shaft 54. In this case, however, since the rotary casing 14 is restricted by brakes 27, 27 as aforementioned, the first planetary gear 56 may not rotate the rotary casing 14 depending on the amount of restriction as restricting element 15, 15 but, on the contrary, the first planetary gear 56 is rotated clockwise around the output shaft 7 meshing with the first ring gear 45 fixed to the casing 14 and accordingly in the direction as illustrated by the arrow B with the result that the arm 52 of the reduction gear shaft 50 supporting the first planetary gear 56 is rotated clockwise around the output shaft 7. Therefore, the second sun gear 53 on gear shaft 30 is also rotated clockwise and rotary torque in the direction as designated by an arrow A for rotating the second planetary gear 61 about the second short stub shaft 59 is transmitted to the second planetary gear 61 meshed with the second sun gear 53. The one-way clutch 60 is disengaged by this torque, and accordingly, the second planetary gear 61 is not coupled to the second short stub shaft 59, but is freely rotated about the second short shaft 59 by the second sun gear 53. This rotation of the second planetary gear 61 is converted to the torque for rotating or tending to rotate the rotary casing 14 in the direction as designated by the arrow A through the second ring gear 46. However, since the rotary casing 14 is restricted by the braking elements 27, 27 as aforementioned, the rotary casing 14 is not rotated or is rotated slowly depending on the amount of restriction by brakes 27, 27 but, on the contrary, the second planetary gear 61 is rotated in the direction as illustrated by the arrow B around the second ring gear 46. As a result, the arm 58 supporting the second planetary gear 61 and output shaft 7 are rotated in the direction as illustrated by the arrow B.

With such a rotation of the input shaft 16 and output shaft 7 in the direction designated by the arrow B as described above, the rotational speed of output shaft 7 is greatly reduced by a large ratio, and accordingly this rotation is utilized for scratching the solid substance adhered onto the inner wall of the basket of the centrifugal separator.

The aforementioned principle of the present invention will be further performed as various alternatives and modifications as will be hereinafter described.

FIG. 7 shows still another embodiment of the driving device for the centrifugal separator of this invention having similar functions as those of the embodiments shown in FIGS. 1 to 6, in which the driving device 8 includes three one-way clutches 62, 63, and 64. This driving device 8 comprises a rotary casing 14 similar to the driving device shown in FIG. 6 and containing a planetary gear mechanism 9, the detail of which is omitted in FIG. 7, within the rotary casing 14. This planetary gear mechanism 9 is connected through the three one-way clutches 62, 63 and 64 to the output shaft 7, high speed driven timing wheel 65, and low speed input shaft 66. A low speed driven timing wheel 67 is mounted on the low speed input shaft 66, and is connected to drive timing wheels 69 and 70 on a drive shaft 68 directly coupled with the reversible electric motor M together with the high speed driven timing wheel 65 through V belts 71 and 72, respectively. The one-way clutch 62 for coupling the driven timing wheel 65 with the output shaft 7 is mounted between the high speed driven timing wheel 65 and the output shaft 7 only when the driven timing wheel 65 is rotated in one direction such as, for example, in the direction designated by the arrow A, and the one-way clutch 64 for coupling the low speed driven timing wheel 67 with the planetary gear mechanism 9 between the low speed driven timing wheel 67 and the planetary gear mechanism 9 only when the driven timing wheel 67 is rotated in one direction such as, for example, in the direction illustrated by an arrow A. In other words, another one-way clutch 63 is interposed between the planetary gear mechanism 9 and the output shaft 7, and disengages the connection of the planetary gear mechanism 9 to the output shaft 7 only when the high speed driven tim-
ing wheel 65 is coupled with the output shaft 7 by the one-way clutch 62.

The rotary casing 14 is connected to the torque control mechanism for imparting a desired torque to the output shaft 7 by restricting the braking elements 15, 15 such as brake discs mounted to the casing 14 similar to the embodiment shown in FIG. 6. Since this torque control mechanism is entirely the same as that shown in FIGS. 2 and 3, the details are omitted.

Assuming now that liquid suspension material such as mud is poured into the basket 2 in the device shown in FIG. 7, and the separator is rotated so as to separate the liquid from the material.

The drive electric motor M rotates the drive timing wheel 69 in the direction designated by the arrow A so that the rotation of the drive timing wheel 69 rotates the high-speed driven timing wheel 65 in the direction illustrated by an arrow A through the V belt 71. When the high-speed driven timing wheel 65 is so rotated the one-way clutch 62 interposed between the high-speed driven timing wheel 65 and the output shaft 7 couples the timing wheel 65 with the output shaft 7, while the one-way clutch 63 interposed between the planetary gear mechanism 9 and the output shaft 7 disengages the connection of the output shaft 7 to the planetary gear mechanism 9. In this case, the output shaft 7 is rotated at high speed from the high-speed driven timing wheel 65 directly, and the basket 2 for the separator is also rotated at high speed in the direction as designated by an arrow A. When the basket 2 is rotated for a preset period so that the fluid material within the basket 2 is removed, the drive electric motor M is reversely driven by the command from the control device (not shown), and at the same time, the braking element 15, 15 is restricted by the torque control mechanism 10 with a predetermined force by the command from the control device. The high-speed driven timing wheel 65 is oppositely driven to the direction as described above, that is opposite to the direction designated by the arrow A, and thereby the clutch 62 is disengaged so that the driven timing wheel 65 is idled about the output shaft 7. Since the low-speed driven timing wheel 67 is driven opposite to the direction as designated by the arrow A at this time, the output shaft 66 is also rotated in the same direction with the result that the input shaft 66 and the planetary gear mechanism 9 are coupled by the one-way clutch 64. The rotation transmitted through the one-way clutch 64 to the planetary gear mechanism 9 operates the one-way clutch 63 with the result that the planetary gear mechanism 9 and the output shaft 7 are coupled with each other by the one-way clutch 63. That is, although the planetary gear mechanism 9 tends to rotate the rotary casing 14, since the rotary casing 14 is restricted by the torque control mechanism 10 through the braking element 15, the rotary casing 14 is not rotated or is rotated very little depending upon the amount of restriction by the braking elements 27, 27 but the planetary gear mechanism 9 is rotated around the output shaft 7 within the rotary casing 14 similar to the case of the device shown in FIG. 6. As a result, since the one-way clutch 63 is rotated around the output shaft 7 opposite to the direction as designated by the arrow A, the one-way clutch 63 is operated so that the planetary gear mechanism 9 and the output shaft 7 are coupled together. Thus, the low-speed rotation transmitted to the input shaft 66 is further reduced through the planetary gear mechanism 9 and is transmitted to the output shaft 7 so as to rotate the output shaft 7 at low speed in high torque. In this case, as aforementioned, since the planetary gear mechanism 9 and the rotary casing 14 are constructed substantially similar to those of the device shown in FIG. 6, it is readily understood from the foregoing description that the torque proportional to the force for restricting the rotary casing 14 is applied to the output shaft 7.

From the foregoing description, it will now be apparent that the present invention provides a driving device for rotary chemical machine such as centrifugal separator, which improves the conventional machine which could not heretofore be operated at optimum operating conditions so as to enable the machine to operate at optimum levels according to the operating conditions of the machine.

Having now generally described the invention, a further understanding can be attained by reference to certain specific examples which are provided herein for purpose of illustration only and are not intended to be limiting in any manner the scope of the alternative applications of the present invention unless otherwise so specified. For example, the variable torque operation is applied only in low-speed operation of the device of the embodiment of the present invention, but this variable torque operation may also be applied to high-speed operation within the spirit of the present invention.

What is claimed is:
1. A driving device for a rotary chemical machine having a normally and reversely rotatable rotary basket and a rotary shaft affixed to the rotary basket, comprising a reversible prime motor having a cylindrical hollow input shaft driven thereby, an output shaft secured to said rotary shaft, a rotary casing rotatably mounted around said output shaft, a first unidirectional clutch interposed between the input shaft of said prime motor and said rotary casing for coupling the input shaft of said prime motor to said rotary casing when the input shaft rotates in one direction, a second unidirectional clutch interposed between the input shaft of said prime motor and said output shaft secured through the rotary shaft to said rotary basket for coupling the input shaft to said output shaft when the input shaft rotates in the other direction, a reduction gear mechanism contained in said rotary casing and having a first sun gear integrally formed on said output shaft, a sleeve shaft rotatably mounted on said output shaft coaxially adjacent to the sun gear and having a second sun gear integrally formed thereon adjacent to said first sun gear, and further having one end thereof projected externally from said rotary casing, a stub shaft so mounted around said output shaft, so as to be rotatable about its own axis and also around said output shaft within said rotary casing, first and second idle planetary gears rotatably mounted on said stub shaft and engaged with said first sun gear and second sun gear respectively and driven separately from said rotary casing only when said input
shaft of said prime motor is rotated in one direction, a torque control mechanism having a non-restricting element affixed to the projected end of said sleeve shaft, at least one pair of braking elements movable relative to each other toward or away from both surfaces of said non-restricting element, braking element drive control means including a dual-operated air cylinder for actuating said braking elements, control means including a solenoid valve for controlling the quantity of air supplied to said air cylinder and a control circuit for controlling the opening of said solenoid valve and having an electric motor load detector for detecting the amplitude of the load current of said prime motor, a control for urging said braking elements into engagement with said non-restricting element by a desired force, and a control calculator for comparing the detected value detected by said load detector with a preset value preset by said control for producing the output responsive thereto for controlling the actuation of said braking elements so as to impart a desired torque to said output shaft.

2. A driving device according to claim 1, further comprising means for alternating slidably the operating position of said braking elements of said torque control mechanism and having a control electric motor, a screw shaft directly coupled to said control electric motor and a slider having a nut portion threaded on the screw shaft and so placed as to slide on a stationary base radially of said braking elements.

3. A driving device according to claim 1, wherein said braking mechanism is an eddy current braking mechanism which comprises a pair of electromagnetic poles disposed on opposite surfaces of the brake element, and a control calculator connected to said poles for controlling the electromagnetic poles.

4. A driving device for the rotary chemical machine having a rotary basket normally and reversely rotatable and a rotary shaft affixed to the rotary basket, comprising a reversible prime motor having an input shaft driven thereby, and an output shaft secured to said rotary shaft and having a first arm radially projected therefrom, a rotary casing rotatably mounted around said output shaft, a driving timing wheel driven by the reversible prime motor through a belt with a driven timing wheel mounted on the output shaft, a reduction gear mechanism disposed in the casing and having a firstsun gear and having a second arm radially projected therefrom and a second sun gear integrally formed thereon, a first stub shaft so mounted around said output shaft as to be rotatable about its own axis and also around said output shaft within said rotary casing in such a manner that the second arm of said stub shaft is coupled to the first such shaft, a second stub shaft mounted around said output shaft so as to be rotatable about its own axis and also around said output shaft within said rotary casing in such a manner that the first arm of said output shaft is coupled to the second stub shaft, one-way clutch mounted on said second stub shaft, first and second ring gears formed on the inner periphery of said rotary casing corresponding to the first and second sun gears of said driven timing wheel and sleeve shaft, respectively, first and second idle planetary gears rotatably mounted on the first and second stub shafts, respectively, in meshing engagement with the first sun and ring gears and second sun and ring gears, respectively, in such a manner that the one-way clutch couples the second planetary gear with the second stub shaft when the input shaft is rotated in one direction and the one-way clutch disengages the second planetary gear from the second stub shaft when the input shaft is rotated in the other direction, a torque control mechanism having a non-restricting element on the rotary casing, at least one pair of braking elements movable relative to each other toward or away from both side surfaces of said non-restricting element.

5. The driving device according to claim 4, further comprising means for alternating slidably the operating position of said braking elements of said torque control mechanism and having a control electric motor, a screw shaft directly coupled to said control electric motor and a slider having a nut portion threaded on the screw shaft and so placed as to slide on a stationary base radially of said braking elements.

6. The driving device according to claim 4, wherein said braking mechanism is an eddy current braking mechanism which comprises a pair of electromagnetic poles disposed on opposite surfaces of the brake element and a control calculator connected to said poles for controlling the electromagnetic poles.

7. A driving device for the rotary chemical machine having a rotary basket normally and reversely rotatable and a rotary shaft affixed to the rotary basket, comprising a reversible prime motor having a first high speed input shaft driven thereby and second low speed input driven thereby, an output shaft secured to said rotary shaft and having a first arm radially projected therefrom, a rotary casing rotatably mounted around said output shaft, a first driving timing wheel driven by the reversible prime motor through a belt with a first high speed driven timing wheel mounted on the output shaft and a second driving timing wheel driven by the reversible prime motor through a second belt with a second low speed driven timing wheel mounted on the second low speed input shaft, a reduction gear mechanism contained in said rotary casing and having a first sun gear integrally formed on said first driven timing wheel, a sleeve shaft rotatably mounted on said output shaft coaxially adjacent to the sun gear and having a second arm radially projected therefrom and a second sun gear integrally formed thereon, a first stub shaft so mounted around said output shaft as to be rotatable about its own axis and also around said output shaft within said rotary casing in such a manner that the second arm of said sleeve shaft is coupled to the first stub shaft, a second stub shaft so mounted around said output shaft as to be rotatable about its own axis and also around said output shaft within said rotary casing in such a manner that the first arm of said output shaft is coupled to the second stub shaft, first one-way clutch mounted between the first high speed driven timing wheel and the output shaft for coupling only when the first driven timing wheel is rotated in one direction, first and second ring gears formed on the inner periphery of said rotary casing corresponding to the first and second sun gears of said first driven timing wheel and the sleeve shaft, respectively, first and second idle planetary gears rotatably mounted on the first and second stub shafts, respectively, in meshing engagement with the first sun and ring gears and second sun and ring gears, respectively, a second one-way clutch mounted between the planetary gear mechanism and the output.
shaft for disengaging the connection of the planetary gear mechanism to the output shaft only when the first high speed driven timing wheel is coupled with the output shaft by the one-way clutch, a third one-way clutch mounted between the second low speed driven timing wheel and the planetary gear mechanism for coupling the second low speed driven timing wheel with the planetary gear mechanism only when the second driven timing wheel is rotated in one direction, a torque control mechanism having a non-restricting element on the rotary casing, at least one pair of braking elements movable relative to each other toward or away from both side surfaces of said non-restricting element.

8. The driving device according to claim 7 further comprising means for alternating slidably the operating position of said braking elements of said torque control mechanism and having a control electric motor, a screw shaft directly coupled to said control electric motor and a slider having a nut portion threaded on the screw shaft and so placed as to slide on a stationary base radially of said braking elements.

9. The driving device according to claim 7 wherein said braking mechanism is an eddy current braking mechanism which comprises a pair of electromagnetic poles disposed on opposite surfaces of the brake element and a control calculator connected to said poles for controlling the electromagnetic poles.