

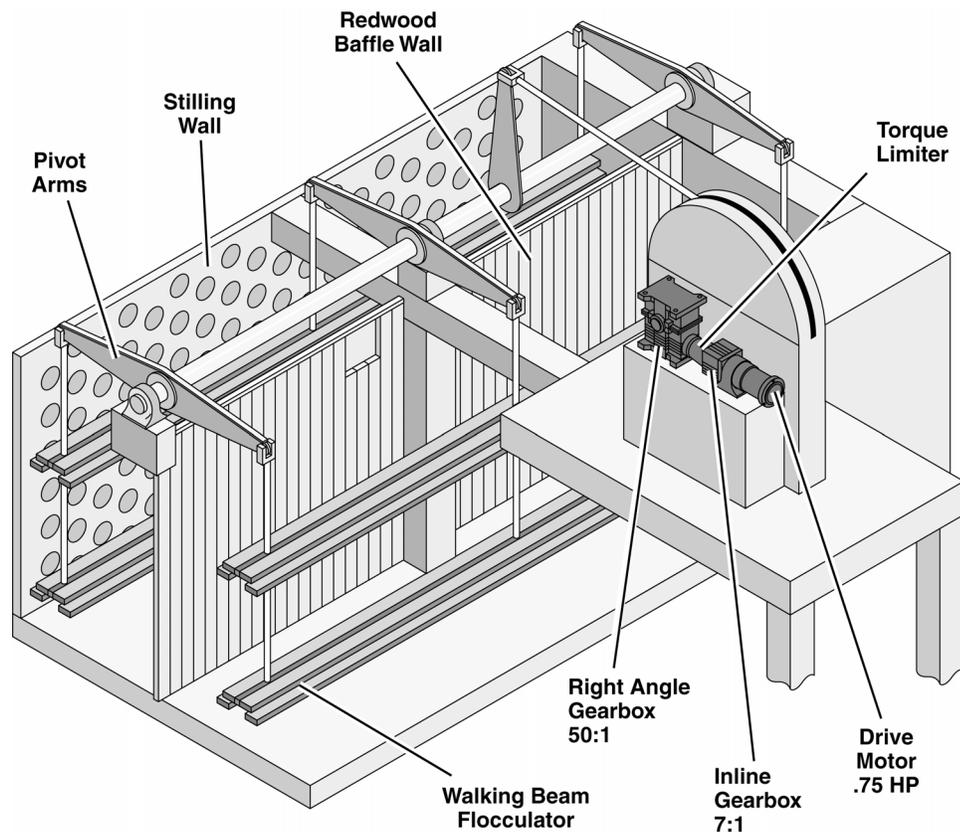
Technical Note

Application: Torque Limiting - Wastewater

Application

Description:

This is a Walking Beam Flocculator used in a wastewater treatment plant. A right angle gear reducer with a slip clutch prevents the reducer from damage in the event of a jam. The slip clutch is very similar to SEW's LR adapter. During a jam, it allows the motor to rotate, but not the reducer.



Requirements:

- Customer wants to use electronics instead of the slip clutch, if possible.
- Torque to be limited to 4400 lb-in
- Alarm to signal when torque reaches 85% of overload torque.
- Variable speed

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Discussion:

This application involves torque limit, not torque control. Knowing the difference between the two is important.

Torque Limit – allows the drive to operate to a certain torque. As long as the predetermined torque is not reached, the drive operates normally. When the predetermined torque is reached, the motor slows or stops.

Torque Control – requires the motor to produce a predetermined torque at all times, regardless of speed. If the load torque is less than the predetermined torque, the motor rotates faster and faster – a very undesirable situation.

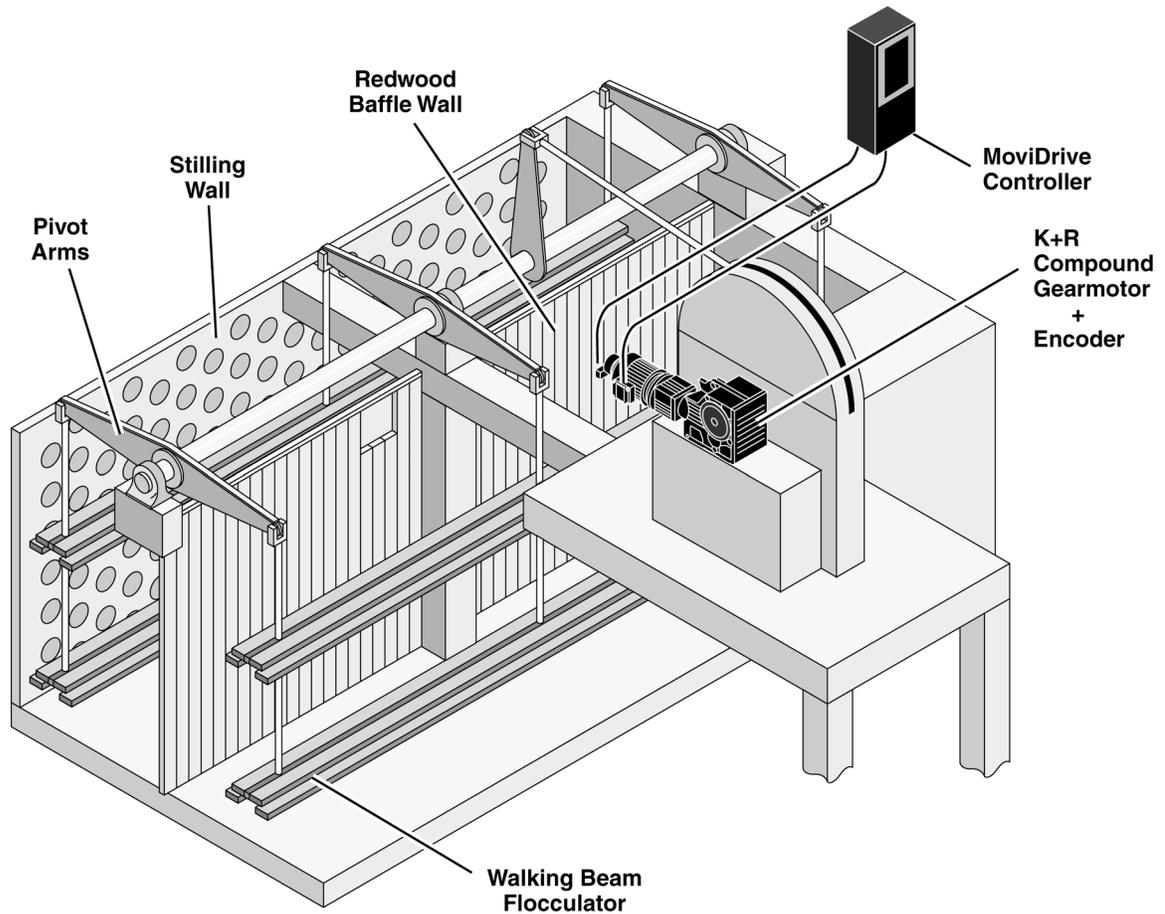
In any motor, only part of its total current produces torque. The other part produces the magnetizing current in the stator or else produces heat. In CFC mode, the Movidrive® controls the power factor of each current phase independently by placing the magnetic flux in the stator at a specific position. Therefore, it knows exactly how much of the amp draw (total current) is used for torque (active current). Limiting the active current effectively limits the motor torque. The MC-31C cannot be used in this application, since it does not have the necessary characteristics (i.e.: CFC mode) to decipher the active current.

The following parameters should be considered during setup:

P700	Operating Mode
P304	Torque Limit
P500	Speed Monitoring
P501	Delay Time
P620	Binary Output
P430	Current Reference
P433	Signal Condition
P005	Active Current Display

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Solution:



Features/Product:

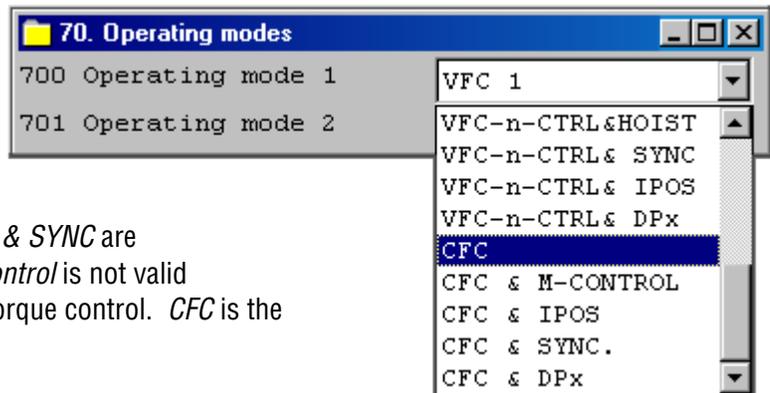
- K57R37DT80K4, 362:1, 4.7 rpm
- ES1S Incremental encoder on motor
- Movidrive® (MDV) Controller Size 1

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Details:

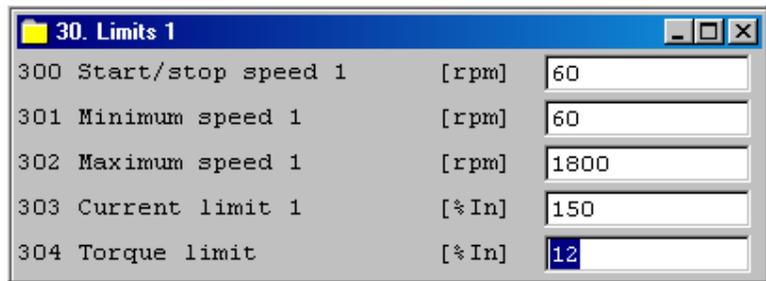
P700 – Operating Mode

Parameter 700 must be set to some type of *CFC* mode, since we are using an SEW motor. Neither Synchronization nor IPOS are required; therefore, *CFC & IPOS* and *CFC & SYNC* are inappropriate choices. Also, *CFC & M-Control* is not valid because torque limiting is required, not torque control. *CFC* is the correct choice.



P304 – Torque Limit

Parameter 304 represents the upper limit of torque. It is shown as a percentage of the total amps (I_n) that the Movidrive® can produce. P304 must be a whole number (integer) greater than or equal to 1. The formula below calculates the value of P304.



$$P304 = \frac{\text{Max Load Torque}_{lb-in}}{\text{Ratio}_{Gearbox} \times \text{Eff}_{Gearbox} \times K_{T_{Motor}} \times I_{N_{Inverter}}} \times 100$$

where, K_T is found on page 182 of the Movidrive® System Manual (08/2001)
 I_N is the total amps that the inverter can produce and may be found on pages 22 through 38 of the Movidrive® System Manual (08/2001)

Example:

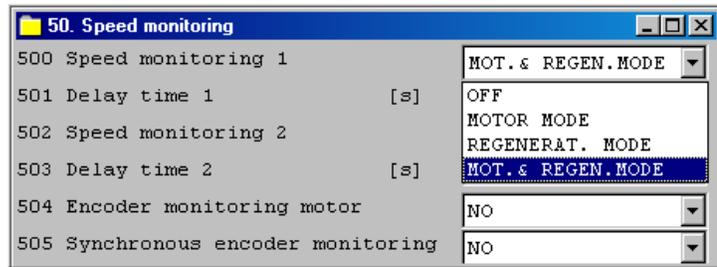
Customer is using a K57R37DT80K4, 362:1 ratio, 4.7 rpm with a Movidrive® Size 1, 460V (MDV60A-0015-5A3) and wishes to limit his torque to 4400 lb-in.

$$P304 = \frac{4400}{362 \times .925 \times 27.3 \times 4.0} \times 100 = 12$$

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P500 – Speed Monitoring

Parameter 500 determines what happens when the specified torque (active current) in P304 has been reached. If P500="OFF", the Movidrive® produces the amount of current specified in P304, but no more. As the load torque continues to increase, no more current is available, so the motor tries to produce more torque by slowing down. If it is unsuccessful, it stalls. Obviously, the motor can overheat if it remains in a stalled position too long.

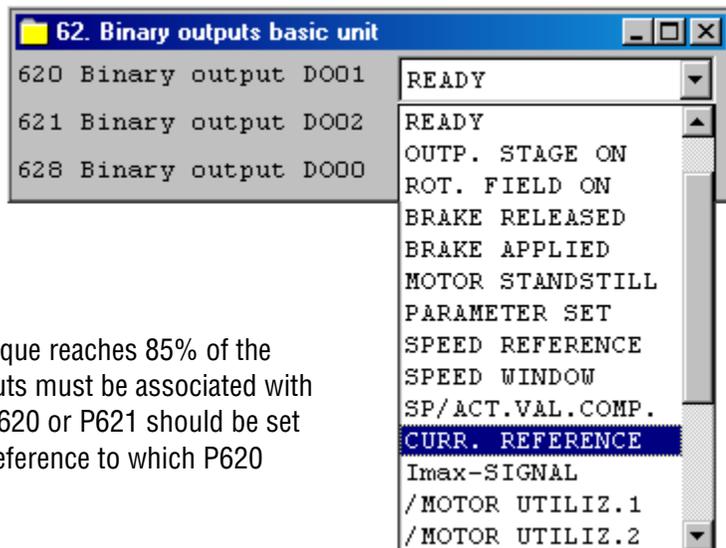


If P500="MOT. & REGEN.MODE", the drive begins a countdown once the maximum current (as specified in P304) has been reached. The number of seconds in the countdown is determined by P501. If the load torque decreases within this time period, the drive functions normally without faulting. However, if the load torque stays the same or increases, the drive continues to produce the maximum current in P304, but then faults with an F-08 Speed monitoring error after the countdown ends.

If torque limiting is the main topic of this application, the reader may wonder why P500 involves *speed* monitoring. In fact, the Movidrive® actually does monitor speed in this application! As stated above, if the load increases while the current is held to a limited amount by P304, the motor slows down in an attempt to produce more torque. The Movidrive® detects this speed reduction and faults after the time specified in P501.

P501 – Delay Time

Parameter 501 determines how long the drive waits (in seconds) once the drive reaches the maximum torque specified in P304 before it faults with an F-08 error.



P620 – Binary Output

In order to signal an alarm when the torque reaches 85% of the overload torque, one of the binary outputs must be associated with a reference current. Therefore, either P620 or P621 should be set to "CURR. REFERENCE". The current reference to which P620 refers is shown in P430.

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P430 – Current Reference

P430 is the reference value that may be used to signal a binary output. It is shown as a percentage of the total current available in the Movidrive® and must be an integer. Unlike P304 that measures just active current, P430 measures total current, which includes active current and magnetizing current.

43. Current reference signal	
430 Current reference value [%In]	27
431 Hysteresis [%In]	0
432 Delay time [s]	0
433 Signal = '1' if:	I > I ref

The following formula calculates the value of P430.

$$P430 = \frac{\sqrt{\left\{ \frac{\text{Desired Load Torque}_{lb-in}}{\text{Ratio}_{Gearbox} \times \text{Eff}_{Gearbox} \times K_{T_{Motor}}} \right\}^2 + \{I_{d,N}\}^2}}{I_{N_{Inverter}}} \times 100$$

where, K_T is found on page 182 of the Movidrive® System Manual (08/2001)
 I_N is the total amps that the inverter can produce and may be found on pages 22 through 38 of the Movidrive® System Manual (08/2001)
 $I_{d,N}$ is the magnetizing current shown on page 182 of the Movidrive® System Manual.

Since the customer desires an alarm to signal when the torque reaches 85% of the overload torque,

$$P430 = \frac{\sqrt{\left\{ \frac{4400 \times .85}{362 \times .925 \times 27.3} \right\}^2 + \{0.98\}^2}}{4.0} \times 100 = 27$$

P433 – Signal Condition

The conditional statement selected in P433 determines when the drive sends 24V to a binary output in order to set the terminal high (“1”). “I ref” refers to the current reference value in P430. Thus, if the customer wanted to signal an alarm when the load current is greater than the value shown in P430, then P433 should read, “I > I ref.”

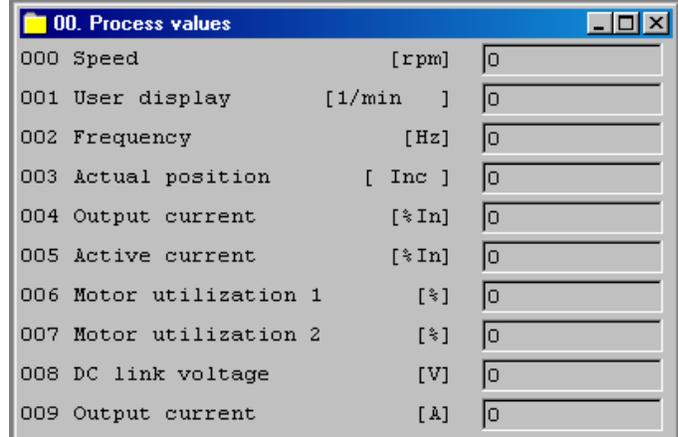
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P005 – Active Current Display

This parameter displays the active current of the drive. It will never go above the value as defined by P304. Users may view this parameter to see the actual load torque.

Comment:

It is advisable to add TH thermostats or TF thermistors to the motor as a precaution. The Movidrive® has TH/TF evaluation as a standard feature.



Parameter ID	Parameter Name	Unit	Value
000	Speed	[rpm]	0
001	User display	[1/min]	0
002	Frequency	[Hz]	0
003	Actual position	[Inc]	0
004	Output current	[%In]	0
005	Active current	[%In]	0
006	Motor utilization 1	[%]	0
007	Motor utilization 2	[%]	0
008	DC link voltage	[V]	0
009	Output current	[A]	0

Benefits:

History shows that equipment used in wastewater is often large and expensive. Also, motors are often grossly oversized. Since the reaction time of typical electronic overload protection is slow, serious equipment damage occurs before the overload protection trips - making typical electronic overload protection unreliable and undesirable in wastewater. Thus, most wastewater applications still utilize mechanical overload devices.

The Movidrive® is beneficial because it knows the precise motor speed and the actual load current at all times. Therefore, it detects an overload immediately. In fact, on slow speed applications, the Movidrive® actually reacts faster than a mechanical overload device, as the example below illustrates.

Example: K57R37DT71D4, 4.7 rpm, 362:1 ratio
Overload detection time elapse = 100ms
Stopping time after overload detection = 100ms

From the moment the overload occurs to the time the Movidrive® detects it and stops the motor is $(100 + 100) = 200\text{ms}$. Within 200ms, an 1800-rpm motor moves 6 revolutions. Therefore, the reducer output shaft rotates $6/362 = .016$ revolutions, or 1 arc minute. A typical mechanical overload device requires the output shaft to rotate more than 1 arc minute of shaft movement in order to detect the overload.

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Questions:

1. How can you set up the system to avoid a nuisance trip?

By setting P501 to some time value (e.g. 5 seconds), you control how long the inverter continues to power the motor until it faults. If the jam or overload is removed before the time delay has expired, the motor continues to operate after the overload is removed – without faulting.

2. Could an MC07 be used instead of the Movidrive®?

No. CFC mode is critical for this application. Not only does the MC07 not offer CFC mode, it does not have an encoder input. The only alternate choice is the Movidrive® Compact since it offers both options.

3. Can IPOS^{plus} be used if the customer desires to do other functions?

Absolutely! In fact, IPOS^{plus} can be used instead of P430 and P433 to turn on or off binary outputs. The advantage of IPOS^{plus} is that it can read the active current instead of the total current and perform various tasks depending upon what the customer desires.

Note: As long as the IPOS^{plus} program does not contain “GO REL” or “GO ABS” commands, the drive should still be commissioned in CFC mode, not CFC & IPOS.

Important Concepts:

- The standard Movidrive® in CFC mode with an SEW motor precisely measures the active current that produces torque. Therefore, it can limit torque and replace SEW's LR Adapter, AR adapter, or TS Mechanical Overload.
- Load torque can be monitored and limited no matter how oversized the motor is for the application.
- Torque Limiting can actually be done quicker electronically than mechanically, especially with high gearbox ratios.
- Torque Limit should not be confused with Torque Control.