Model Selection and Application Skills of Inverter

Equipment Introduction

Two basic requirements for frequency control:

1. Output power on the motor axis must be larger or equal to the required power of power.
2. Electromagnetic torque produced by the motor must be larger or equal to the loaded resistance torque. (Which means that the output power of inverter larger or equal to the rated power of motor, output current of inverter larger than rated current of motor)-Maximum current principle.

Note: Same motor powers but different number of pole pairs, rated torque and rated current of motor are different.

Frequency control of constant torque load

- Main features of constant torque load:

(1).The magnitude of load torque depends on the loading, and is unrelated to rotary speed.

(2).The size of load power is in direct proportion to rotary speed.

- Example of constant torque load debugging:

Example 1: belt conveyor

Motor brand: power: 30KW rotary speed; 1470r/min; current: 56.8A; motor series: 4 series; rated frequency: 50 Hz

Inverter model: EDS1000-4T0300G/0370P power-30KW current-60A

Inverter parameter setting: F0.00=2 (terminal UP/DOWN adjust setting frequency) F0.02=1 (terminal run command control)

F0.03=110 (reverse run banned) F0.08=10S (Acce time) F0.09=10S (Dece time) F0.11=20HZ (Upper limit freq.) F0.14=4.0 (Torque boost) F1.00=0 (start from starting frequency) F1.01=6HZ (Starting frequency) F1.02=2S (Duration of starting frequency) F1.05=0 (Dece stop) F2.05=5HZ (Carrier frequency) F5.00=19(X1three-wire control) F5.01=16(X2 Frequency acce UP) F5.02=17(X3 Frequency dece DOWN) F5.08=2(three-wire control mode 1) F9.04=95%(Motor overload protection coefficient)

Example 2: plastic extruder

Motor brand: power 55Kw; rotary speed: 1480r/min; current: 102.5A; motor series: 4 series; rated frequency: 50Hz

Inverter model selection: EDS1000-4T0550G/0750P power-55Kw; current-112A

Inverter parameter setting: F0.00=00 (setting keypad simulate potentiometer) F0.02=0 (operation keypad run control) F0.08=15S (Acce time) F0.09=15S (Dece time) F0.14=4.0 (Torque boost) F1.00=0 (start from starting frequency) F1.01=6HZ (Starting frequency) F1.02=2S (Duration of starting frequency) F1.05=0 (Dece stop) F9.04=92%(Motor overload protection coefficient)

Example 3: drilling hoist

Motor brand: power 37Kw; rotary speed: 1440r/min; current: 69.8A; motor series: 4 series; rated frequency: 50Hz

Inverter model selection: EDS1000-4T0370G/0450P power-37Kw; current-75A

Inverter parameter setting: F0.00=04 (VCI analog setting) F0.02=1 (terminal run command control) F0.08=10S (Acce time) F0.09=3S (Dece time) F0.14=2.0 (Torque boost) F1.05=2 (Dece + DC brake stop) F1.06=15HZ (DC brake initiative freq. when stop) F1.07=0.5S (DC brake time when stop) F1.08=8% (DC brake voltage when stop) F3.30=15 (TB-TC failure band-type signal) F5.00=11(Fault resetting) F9.04=93% (Motor overload protection coefficient)

Note: Configure brake unit and brake resistance models: brake unit: 2545-; brake current: 25A; power: less than 45kw; brake resistance: 10kw 16Ω

FAQ and troubleshooting of constant torque load debugging:

(1) Inadequate starting torque

(2) Large current or over current protection when running at low frequency

(3) Motor rotor is easily locked when load is increased under running

Troubleshooting:

(1) Increase the mechanical transmission ratio in order to reduce the resistance torque of the motor shaft;

(2) Use vector control with feedback to increase the starting torque to 180% -200% that of the motor rated torque, the low-frequency operation with load capacity is also increased;

(3) If the preset torque boost is small, increase the torque boost value appropriately, or set up automatic torque boost;

(4) Reduce the fundamental frequency of the motor to increase the working flux of motor, but the fundamental frequency should not be less than 45HZ;

(5) Preset slip frequency compensation function, to enhance the load capacity of the motor;

(6) Set the starting frequency appropriately to increase the starting torque;

(7) Appropriately reduce the carrier frequency to increase the output voltage of the inverter;

(8) For the same power, select six-level motors to increase the electromagnetic torque of the motor.

Frequency control of constant power load

- Main features of constant power load:

(1) The power of constant power load is independent of Rotary speed;

(2) The resistance torque of constant power load is in inverse proportional to Rotary speed.

- Example of constant power load debugging:

<Case 1> industrial washing machine

Motor brand: Power: 11KW; Rotary speed: 1460r/min; Current: 21.4A; Motor Series: 4

Rated frequency: 60HZ

Inverter Selection: EDS1000-4T0110G/0150P; power-11KW; current-25A

Inverter parameter settings: F0.01 = 8 F0.02 = 1 F0.08 = 40 F0.09 = 40 F0.10 = 110 F0.13 = 1 F0.14 = 2 F0.15 = 4 F1.05 = 1 F2.05 = 5 F2.18 = 80 F2.19 = 80 F2.20 = 150 F2.21 = 150 F2.22 = 170 F2.23 = 170 F2.30 = 11 F2.31 = 70 F2.32 = 90 F2.37 = 3 F2.38 = 8 F2.39 = 8 F2.40 = 30 F2.41 = 25 F2.42 = 50 F2.43 = 40 F2.44 = 80 F5.00 = 1 F5.01 = 2 F5.02 = 7 F5.03 = 8 F8.03 = 60 F9.04 = 120% F9.09 = 180%
Note: Model of configuration braking resistor: Power: 1KW; resistance: 50Ω

< Case 2 > Fabric winding machine
Motor brand: Power: 15KW; Rotary Speed: 1460r/min; Current: 30.4A; Motor Series: 4;
Rated frequency: 50HZ
Inverter Selection: EDS1000-4T0150G/0185P ; power -15KW; current -33A
Inverter parameter settings: F0.02 = 1 F0.08 = 15 F0.09 = 15 F0.10 = 85 F0.14 = 2 F1.05 = 2 F1.06 = 10 F1.07 = 0.5 F1.08 = 8 F2.05 = 5 F3.00 = 1 F3.01 = 1 F3.02 = 1 F3.05 = 20% F3.08 = 1.15 F3.09 = 1.15 F3.21 = 9.999 F9.04 = 92% F9.08 = 150% F9.09 = 180%
Note: Model of configuration braking resistor: Power: 1KW resistance: 40Ω

< Case 3 > Air compressor (pulsating torque load) - constant pressure air supply

Motor brand: Power: 30KW; Rotary Speed : 1470r/min; Current: 56.8A; Motor Series: 4;

Rated frequency: 50HZ
Inverter Selection: EDS1000-4T0370G/0450P; power -37KW; current -75A
Inverter parameter settings: F0.02 = 1 F0.08 = 30S F0.09 = 40S F0.11 = 20HZF1.05 = 0F3.00 = 1F3.01 = 0F3.02 = 0 F3.05 = 3.5V F3.21 = 9.99V F9.04 = 120%

Note: The air compressor is pulsating torque load and the motor is strong in overload capacity. Select G -type machine and increase one grade to avoid frequent over-current protection actions, which will affection production.

1. FAQ of constant power load debugging:
(1) How constant power load to configure the motor power and inverter power;
(2) What is appropriate for the maximum operating frequency of constant power load;
(3) When constant power load stops fast, the motor maybe still in the power generation state, causing the increase of inverter DC bus voltage, eventually making the inverter skip the voltage or over-current protection.

Solutions:
(1) Considering that when the motor is operating above the rated frequency, its effective torque has constant power features. Make full use of constant power zone in the process of motor speed regulation to boost constant power load, so as to make their features close. In addition, considering that the motor may meet short-term overload when the constant power load works above the rated frequency, increase one grade when selecting inverter;

(2) Consider the maximum bearing capacity, dynamic balance and vibration resistance of rotor bearings , the maximum working frequency of constant power load should not be three times more than that of the rated motor frequency;
(3) Configure braking unit and braking resistor or configure energy feedback unit and starting inverter stop DC braking function, overvoltage stall function and automatic voltage regulation function or adopt electromagnetic brake to brake. Note: When the resistance value of brake resistor is too large, there will be insufficient brake torque, the frequency skips over-voltage protection; when the resistance value of brake resistor is too small, there will be too much brake torque, the frequency skips over-current protection.

Frequency control of square torque load (quadratic load)

Main features of square torque load:
(1). torque of the square torque load is in proportional to rotary speed;
(2). Power of square torque load is in proportional to the cubic of rotary speed.

Square torque load debugging example:
<Case 1> boiler induced-draft fan, draught fan (Roots blower is a constant torque load, select G-type inverter)
Motor brand: Power: 55KW; Speed: 2980r/min; Current: 102.7A; Motor Series: 2; Rated frequency: 50HZ
Inverter Selection: EDS1000-4T0450G/0550P; power-55KW electricity-112A
Inverter parameter settings: F0.00 = 4 F0.02 = 1 F0.08 = 30 F0.09 = 30
F0.14 = 0 F0.15 = 1 F0.16 = 1 F1.00 = 1 or 2 F1.03 = 8%
F1.04 = 0.5 F1.05 = 0 F2.02 = 1 F3.30 = 15 F9.04 = 92%
F9.09 = 200%
Note: If the impeller of the fan operates in reverse direction or the inverter operates freely when a fault occurs,, the frequency must be set with functions of DC brake or speed tracking restart function , otherwise the inverter current limiter does not start or skips over-current protection.

< Case 2 > Centrifugal pump (constant pressure water supply 1 drives 1)

(Note: screw pump, mud pump, reciprocating piston pump, vacuum pump are constant torque load, select G-type inverter)

Motor brand: Power: 55KW; Speed : 2980r/min; Current: 102.7A; Motor Series: 2;

Rated frequency: 50HZ
Inverter Selection: EDS1000-4T0450G/0550P; power -55KW; Current - 112A
(the selection principle of fire patrol pump inverter is selecting one from two, in this inverter selection: EDS1000-4T0220G/0300P; power -30KW; current -60A among which must adjust V/F curve and increase the current limit level , otherwise the frequency limiting.)
Inverter parameter settings: F0.02 = 1 F0.08 = 30 F0.09 = 30 F0.14 = 0

F0.15 = 1 F0.16 = 1 F1.05 = 1 F2.02 = 1 F3.00 = 2 F3.01 = 0
F3.02 = 0 F3.03 = 0.35MP (target pressure setting value) F3.08 = 1.15
F3.09 = 1.15 F3.21 = 1MP F3.26 = 1 where F3.16-F3.19 sleep
(The awake function must be set based on customer requirement or be set as F0.11 = 35 (lower limit frequency) F0.12 = 2 (lower frequency operation mode-free stop)

Note:

1. Constant pressure water supply 1 drives two need to add the setting F5.10-F5.13 = 21 F3.25 = 0001 or 0002 or more (pump free switching interval-Pump anti-rust function).
2. when F3.00 is set to 1, the figures set value F3.03 (voltage value) will be used as the given quantity of general purpose PID closed-loop control system, F3.21 must be set to 9.99V; When F3.00 is set to 2, starts constant pressure water supply PID control function, digital input value F3.03 (pressure value) will be target pressure setting value of constant pressure water supply control system, whose upper value is F3.21, which must be set as the F3.21. F3.21 must be set as the range of remote transmission pressure gage or range of pressure transmitter; otherwise the system pressure will be instable.
3. The wiring between the inverter and the remote pressure gauge: there is a sliding rheostat inside of the remote pressure gauge, whose sliding end is connected to the pointer of pressure gage. When the pressure changes, the sliding end position of sliding rheostat also changes. The resistance value range of remote pressure gauge is 300-400 ohms. You can use the resistance grade of a multimeter to measure the resistance value of any two ends of remote pressure gauge. Compare three groups of resistance values , and you can identify high resistance end, middle end (sliding), the low resistance end, among which high resistance is connected to 10V voltage, middle end connected to VCI, low resistance end connected to GND (when connected to the remote pressure gauge, 10 V voltage of inverter is likely to be lower, use DC voltage grade of multimeter to measure the voltage between 10V and GND. If the voltage is 8.5V, set the corresponding parameter F3.07 to 85% (the corresponding feedback quantity of the maximum input quantity), otherwise, the system pressure is unstable.
4. Wiring between current output pressure transmitter (4-20mA) and inverter:
    1. Red wire of two-wire pressure transmitter connected to the inverter 24V voltage, the black wire connected to the inverter CCI. Use wire to short circuit COM and GND;
    2. 24V of four -wire pressure transmitter connected to the inverter 24V, COM connected inverter COM, CCI connected inverter CCI, GND connected to the inverter GND, the corresponding parameter F3.05 shall be set to 20% (feedback quantity of the minimum input quantity), and otherwise the system pressure is unstable.
    3. Wiring between voltage output pressure transmitter (0-10V or 0-5V) and inverter: Red wire of pressure transmitter connected to the inverter 24V voltage, the green wire connected to VCI, and black wire connected to the inverter GND.

4. PID preset principles and PID adjustment bases:

(1) PID preset principles:

1. Proportional gain Kp, for initial commissioning, preset Kp value to larger than middle.

2. Integration time I integral gain Ki, the values of I or Ki are related to the time constant of the dragging system. For the smaller time constant of dragging system, set the integration time I to shorter one (integral gain Ki is set to longer); on the contrary, for the larger time constant of dragging system, set the integration time I to longer one (integral gain Ki is set to shorter).

3. For derivative time D or differential gain Kd, the values of D or Kd are related to the time constant of dragging system, for the smaller time constant of dragging system, set the derivative time D or differential gain Kd to shorter ones; on the contrary, for the larger time constant of dragging system, set the derivative time D or differential gain Kd to longer ones.

(2) PID adjusted bases, if the PID preset is improper, the main phenomena and adjustment methods are as follows:

1. If the controlled variable vibrates in the vicinity of target value, first, increase integral time I or decrease the integral gain Ki. If there is still vibration, reduce the proportional gain Kp appropriately.
2. If the controlled variable is difficult to recover after the change, first, increase the proportional gain Kp, if the reaction is still slow, reduce the integral time I appropriately or increase the integral gain Ki. If there is differential function, increase the differential time D or increase differential gain Kd.

The parameter debugging techniques are for constant pressure water supply and for reference purposes only. <Case 3> submersible pump / deep well pump

Motor brand: Power: 25KW; speed: 2960r/min; current: 53A; motor series: 2; rated frequency: 50HZ

Inverter Selection: EDS1000-4T0300G/0370P; power-30KW; current-60A

Inverter parameter settings: F0.02 = 1 F0.08 = 15 F0.09 = 15

F0.11 = 20HZ F0.14 = 2 F0.15 = 0 F0.16 = 1 F1.00 = 0 F1.01 = 10 F1.02 = 0.5 F1.05 = 1 F2.02 = 1 F3.00 = 2 F3.01 = 0 F3.02 = 0 F3.03 = 0.35MP (target pressure setting) F3.08 = 1.15

F3.09 = 1.15 F3.21 = 1MP F3.26 = 1 F9.04 = 120% F9.09 = 200%

Note: The overload capacity of submersible pump motor is strong. When inverter starts, the starting current is very large. The inverter is easy to current-limiting protection or jumps E009 motor overload protection. So when selecting the inverter model: please note that: the distance between the inverter and the motor should exceed 50 meters. Select G model inverter according to the same power of motor; If the distance between the inverter and the motor

exceeds 100, select larger grade power of G model inverter of the same pump power, and consider heat dissipation of submersible pump/deep well, the inverter should be set with lower limit frequency. Meanwhile, output cables of inverter should be thicker, AC output reactor should be added between inverter and the motor, otherwise, the inverter cannot work normally. In addition, especially new wells or standby wells which haven't been used for a long time, before starting the inverter for the first time, use power frequency to start and run for a period of time, so as to cooperate between the pump and the motor. Otherwise, the frequent over-current protection or current-limiting protection in the starting process may occur frequently. Again, when the submersible pump goes down to the well, forward and reverse function of inverter must be used when the submersible pump goes down to each section of the well to cooperate between the inverter and motor. Otherwise, the frequent over-current protection or current-limiting protection in the starting process may occur frequently.

FAQ of square torque load debugging:

(1) start current limiting; (2) motor overload near rated frequency.

Solutions:

(1) Reduce torque boost, adjust V/F curve and increase the current limit level;

(2) Reduce output frequency of inverter or increase rated frequency of motor;

(3) If it is a submersible pump load, the power grade of inverter needs to be increase one grade, and output cable of inverter should be thicker, and AC output reactor between inverter and motor should be added.

In the following applications, capacity of the inverter must be increased (at least increase one grade or two grades):

(1) Multi-stage motor, the same power, motor series of six or eight, rated current inverter motor is less than the rated current of motor;

(2) Allows the motor overload longer than two minutes (Example: submersible pumps, deep well pumps);

(3) Low frequency start with heavy loading, acceleration and deceleration time with special requirements: a. rapid start and stop; b. frequent jog. (Example: extrusion molding machine, cement rotary kiln, ball mill) Note: increase the number of motor series or increase the reduction ratio of reduction box is especially suitable to the load of low frequency starting with heavy load.

(4) Impact load (clutch connected to load) ;

(5) imbalanced load (example: mixer, grinder, rolling mill);

(6) High inertia load. (example: punch machine, centrifuge, cement rotary kiln, rotary ceramic grinding);

(7) Four-quadrant operation load (example: lift, crane, grab machine);

(8) Pulsating torque load (example: air compressor, deep well pump/submersible pumps, vibration machine, sand pumps, hydraulic pumps, musical fountain) ;

(9) High-speed operation load (example: woodworking machinery, machine tools, textile machinery, printing machinery);

(10) Synchronous motor or wound rotor induction motor. Note: For continuous, intermittent

and short-term load, select the inverter according to the maximum current. (Example: CNC lathe, planer, etc.)

Inverter selection and application of single inverter driving multiple motors

1. Multiple motors simultaneously start and stop, the inverter selection principle: limit the starting current to a certain range, the inverter rated current greater than or equal to the rated current of all motors. The calculation expression:

$In \geq (1.05\text{-}1.1)\ \Sigma Imn$

Note: In-inverter rated current; ΣImn- running the rated current of total motors at the same time.

1. Multiple motors start and stop respectively, the inverter selection principle: because the motor starting later can only start at a output frequency, the worst situation is starting directly at the rated frequency, so when selecting inverter, make sure to consider the starting current of later starting motor starting directly at the rated frequency. The calculation expression:

$In \geq [(1.05\text{-}1.1)\ \Sigma Imn + K1\Sigma Ist] / K2$

Note: In- inverter rated current; rated ΣImn- running the rated current of total motors at the same time; ΣIst- power frequency starting total starting current of motors, in which Ist- starting current of power frequency motor (5-7 times rated current of motor); K1- safety factor

1. When the later starting motor starts from stop state: K1 = 1.2;
2. When the later starting motor starts from free brake state: K1 = (1.5-2); K2- inverter overload capacity (K2 = 1.5).
3. Example: travelling crane translation mechanism

Motor brand: Power: 15KW; speed : 960r/min; current: 31.5A

Motor series: 6; rated frequency: 50HZ
Inverter selection: EDS1000-4T0370G/0450P; power -37KW; current -75A
Inverter parameter settings: F0.02 = 1 F0.08 = 10S F0.09 = 10S F1.00 = 0 F1.01 = 6 F1.02 = 1S F1.05 = 2 F1.06 = 15HZ F1.07 = 0.5 S F1.08 = 8% F5.00 = 19 (X1- three-wire control) F5.08 = 2 F9.04 = 120%
Note 1: the motor used by travelling crane translation mechanism is six series conical motor. When the motor starts, there is some static friction between the rotor and the stator so the inverter must be set with starting frequency so as to increase starting impact torque. Otherwise, the motor is difficult to start. In addition, the inverter must be configured with braking unit and braking resistor.
Note 2: Note: braking unit and braking resistor models: Braking unit No.: 2545 - braking current: 25A; Power: 45KW or less
Braking resistor: 10KW 16Ω