Application of Analog Inverter on Machine Tool

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Abstract—The paper introduces a method that make use of made in our country analog inverter & spindle motor replace imports Digital Spindle drive & spindle motor. Taking the DASEN16i CNC for example, dispose our country analog inverter & spindle motor ,increase spindle position control software ,using CNC spindle Analog interface connection to the inverter, design circuit of electric connection, design ladder diagram of spindle speed , spindle gear change, orientation, rigid tapping etc. Final in Machining center complete use of made in our country analog inverter & spindle motor replace imports Digital Spindle drive & spindle motor, and vertical machining center of Dalian Machine Tool Group Corp achieve commodity.

Keywords-component; Machining center; Spindle driver; Analog inverter; Functional parts; Spindle speed

I. INTRODUCTION

Analog AC inverter is a kind of speed control device. In the past, it is applied on low-grade CNC lathe, and rarely on high-end CNC machine tools because of the restrictions by the function. That the main reason is that the frequency converter control speed only, without position control function, lack of the function of spindle-directing and rigid Tapping which is required by ATC machining centers. After years of low-end development, China's CNC machine tool industry is now an urgent need to enhance the competitiveness of industry products and take the high road of development. For this purpose, after a certain design, the parameters of inverter and numerical control system has a servo spindle drive functions of high-end CNC machine tools and especially the machining centers, to achieve high-end CNC machine tools feature package. It provides machining center with a new configuration which has the functions of spindle speed control, automatic tool change spindle orientation and rigidity required for tapping through localization A1000 universal AC drive writing ladder program of variable program controller after reasonable parameter settings and domestic CNC system connection. It led to the development of the market of domestic CNC machine tools、CNC systems and related features and provide a good condition for domestic machine tool market expansion. It has strategic significance of the times to achieve the goals of China's high profile main features of CNC machine tools based on domestic by 2020、high profile CNC machine tools which is needed for marine, automotive and power generation equipment manufacturers and basic manufacturing equipment to achieve 80% localization and complete system of domestic NC .

II. MACHINING CENTER AC ANALOG CONVERTER CONFIGURATION

First, domestic production currently Yaskawa A1000, Delta VFD-VE series AC analog converter are needed to focus on, and transmit signals between that and CNC systems is by correspond to specific endpoints and analog voltage mode, and can support connections with the current home and abroad with the simulation, two kinds of digital output spindle CNC system; Such as Japan FANUC, MITSUBISHI, Germany SIEMENS, domestic Omori, wide number, Huazhong CNC system with spindle analog output interface, there would be no obstacle to the control signal connection between such systems and numerical simulation of the inverter [1-4].

Secondly, the inverter is merely a simulation speed controlling device with no position control function. When machining center tool change, spindle orientation is required; when rigid tapping, spindle (rotation axis) and Z-axis (linear axis) position interpolated motion is required, those are related to the spindle position control function. Therefore, it needs to adjust and set the control parameters of the spindle in the numerical control system and analog converter, Install the encoder on the spindle and constitute spindle position, speed and current closed loop with analog converter, the CNC spindle feedback interface CNSP [5,6].

The block diagram of machining center spindle control device configured by analog converter is shown in Fig .1. This device is composed by CNC system DASEN16i (4-axis), analog inverter A1000 (11/15 kW), spindle motor (7.5/11 kW) and position encoder (1024P). Owning to spindle control function is just about z-axis, other axis are not marked in diagram.

Parameters in diagram:

S×××××: spindle rotation speed command.

M3-5:spindle natural rotation/inversion/stop command.

M19/18: spindle directional/ remove command.

M843/844/845: spindle rigid tapping natural rotation/ inversion/ remove command.

PLC: Programmable Logic Controller.

Ps: spindle position instruction.

Pz: z-axis position instruction.

ps: spindle position command.

Fs: spindle position feedback.

Pz: z-axis position instruction.

pz: z-axis position command.

Fz: z-axis position feedback.

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CNSC: spindle output analog interface.
CNSP: spindle input feedback interface.
CNSV3: z-axis output digital interface.
CNFB3: z-axis input feedback interface.

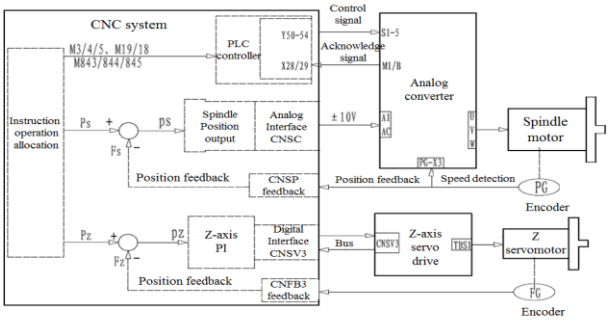


Figure 1. The block diagram of machining center spindle control device configured by analog converter

III. CONNECTION CIRCUIT IS DIVIDED INTO THE FOLLOWING FOUR GROUPS MAJOR LOOP

A. *Control loop of inverter mode*

Connect the terminal (1, 2, 3, 4, 5) of CNC system programmable controller output interface CN11 with analog inverter input interface (S1, S2, S3, S4, S5) one to one correspondingly. Transport spindle control signal spindle enabling (Y50), gain switch (Y51), emergency stop (Y52), alarm reset (Y53), accelerate and slow down switch (Y54) to the input interface of analog inverter, and control the mode of analog inverter and spindle motor [7].

B. *Answer loop of analog inverter mode*

Connect the inverter output terminal MB, M1 with the terminal (1,2) of PLC input interface CN6 correspondingly. Transport the spindle alarm and the state answer of spindle operation to PLC.

C. *Spindle analog input/ output interface*

Connect the spindle analog input/ output interface CNSC terminal (2, 1, 9, 10) of CNC system with the input/ output terminal (A1, AC, FM, AC) of analog inverter correspondingly. Transport the ±10V voltage output by spindle analog interface, the practical rotation speed of spindle motor and load 0~10 V voltage to analog inverter and CNC system respectively to control the natural/ inversion rotation, rotation angle, rotation speed, torque of analog inverter and the practical rotation speed and load factor of CNC system feedback spindle motor [8,9].

D. *Control loop of inverter mode*

Connect the terminal (3, 4, 5, 6, 7, 8, 1, 2) of spindle position encoder PG with analog inverter TB1 and the TB2 terminal (A+, A-, B+, B-, Z+, Z-, IP, IG) respectively, and then connect the terminal (SG, AO, IG, BO, IG, ZO, IG) of TB2 to the terminal (1, 11, 12, 13, 14, 9, 10)of CNC system spindle position feedback interface CNSP. Transport the pulse generated by spindle encoder to analog inverter and then to CNC system to achieve the closed-loop control of position, velocity and electricity [10].

IV. MACHINING CENTER SPINDLE CONTROL PROCESSES AND LADDER

A. *Spindle speed shift and control processes*

Spindle speed shift and control processes are shown in Fig .2.

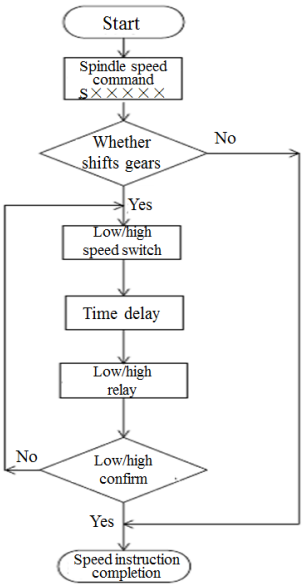


Figure 2. Spindle speed shift and control processes

B. *Tool change spindle orientation control flow*

Tool change spindle orientation control flow is shown in Fig .3.

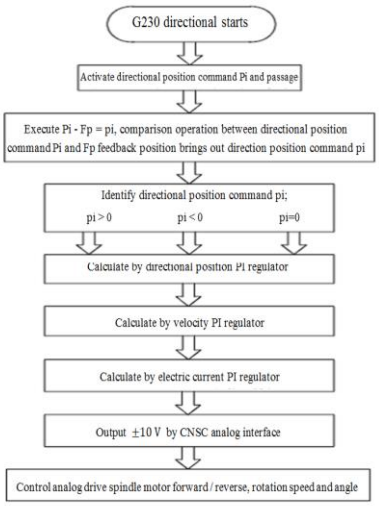


Figure 3. Tool change spindle orientation control flow

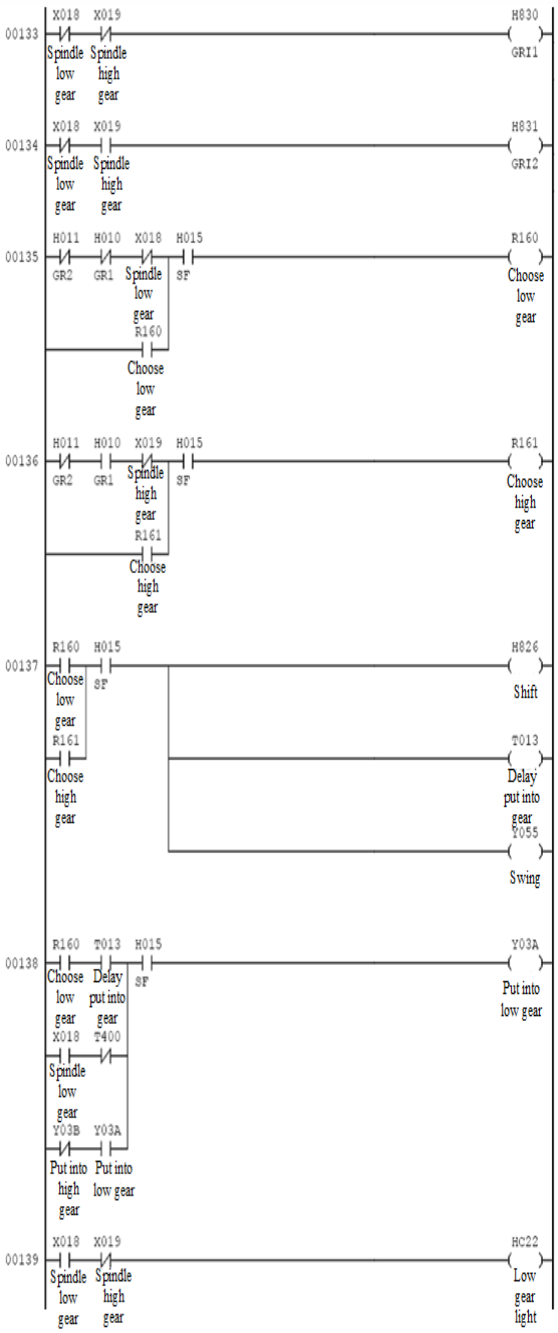
C. *The ladder of spindle machining center features configured by analog inverter*

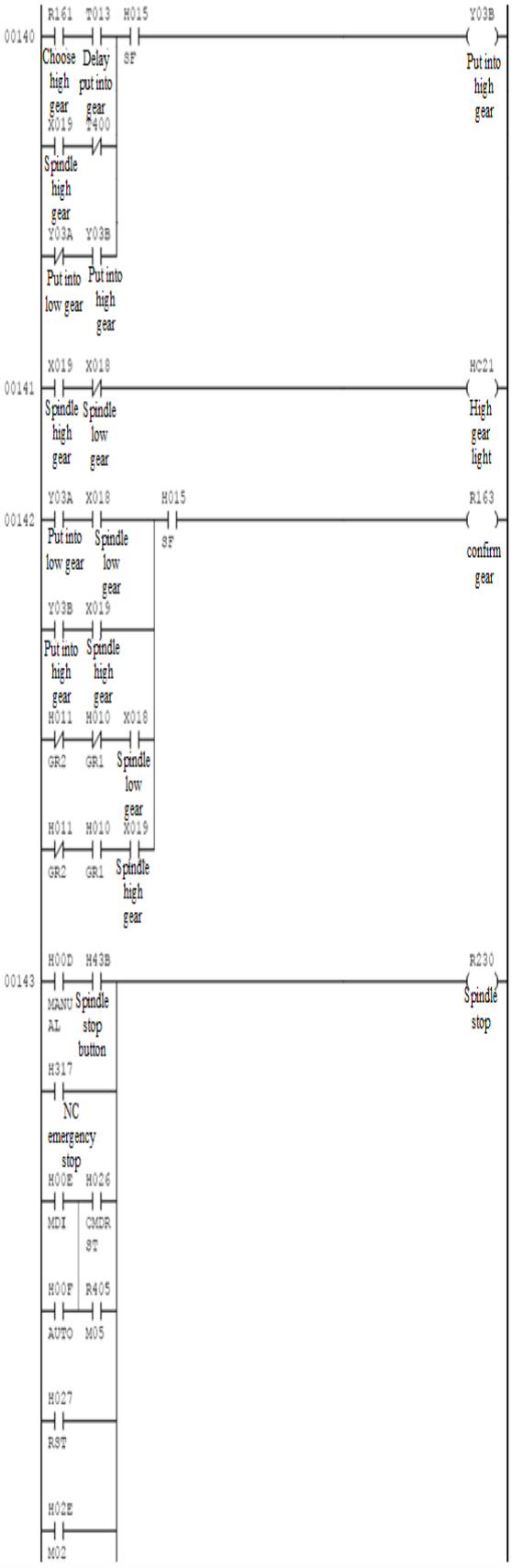
The ladder of spindle machining center features configured by analog inverter is shown in Fig .4.

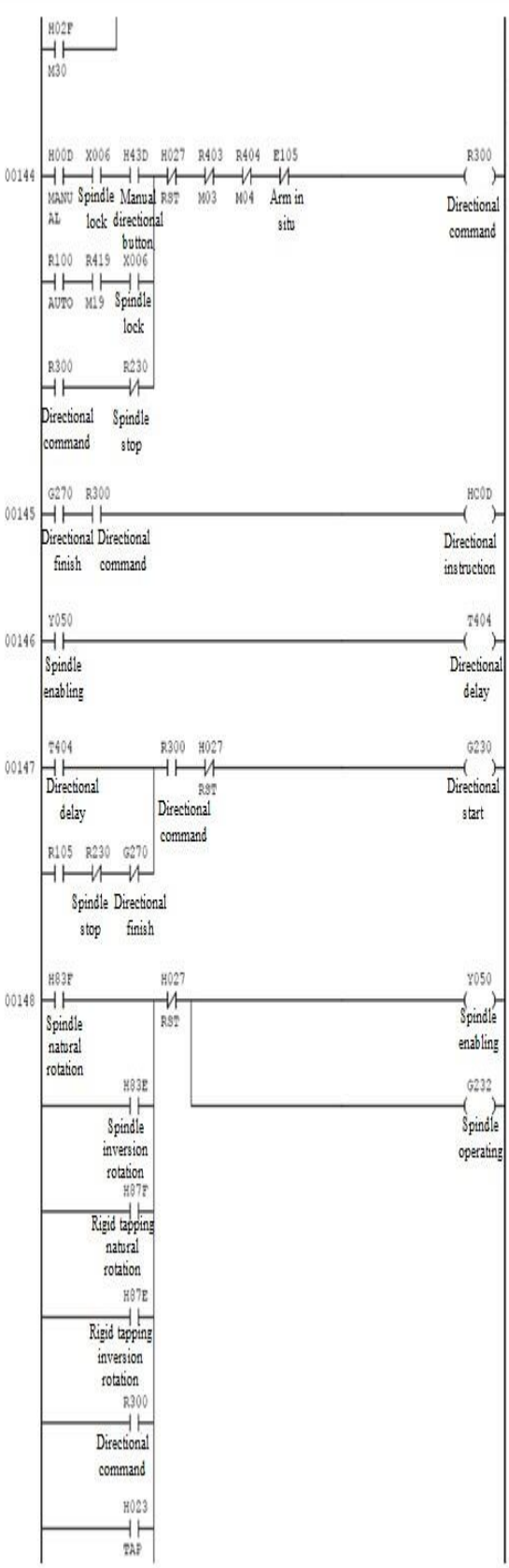
V. CONCLUSION

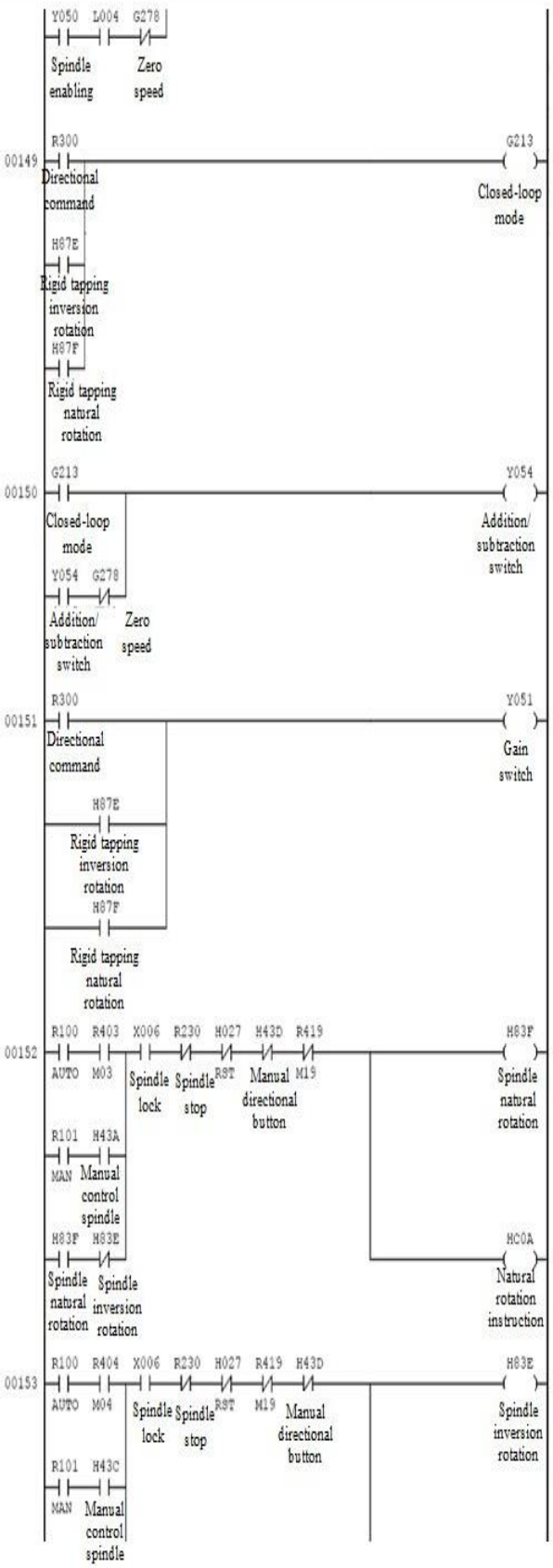
By adopting the above design of circuits and ladder, Yaskawa A1000 analog drive is configured in the high-grade machining centers (Delta VFD-VE, part domestic

inverter can be applied), it not only reduces the manufacturing cost of machining centers, more important extends spindle machining center features a supporting channels, high-end CNC machine tools and gradually reduces dependence on foreign key features by that only speed control function analog、the spindle motor and the inverter system with CNC are all used in high-grade machining centers. Currently carried out experiments with machines assessment in the Dalian Machine Tool Group VDF-850D vertical machining center, performance indicators have reached the factory acceptance criteria, and has taken a solid step forward to achieve the 2020 high-end CNC machine tools localization strategic objectives [1,5,10].






H02F
M30
00144
H00D
MANUAL
X006
Spindle lock
H43D
Manual directional button
H027
R8T
R403
M03
R404
M04
E105
Arm in situ
R300
Directional command
R100
AUTO
R419
M19
X006
Spindle lock
R300
Directional command
R230
Spindle stop
00145
G270
Directional finish
R300
Directional command
HC0D
Directional instruction
00146
Y050
Spindle enabling
T404
Directional delay
00147
T404
Directional delay
R300
Directional command
H027
R8T
G230
Directional start
R105
Spindle stop
R230
G270
Directional finish
00148
H83F
Spindle natural rotation
H027
R8T
Y050
Spindle enabling
H83E
Spindle inversion rotation
G232
Spindle operating
H87F
Rigid tapping natural rotation
H87E
Rigid tapping inversion rotation
R300
Directional command
H023
TAP


Y050
Spindle enabling
L004
G278
Zero speed
00149
R300
Directional command
G213
Closed-loop mode
H87E
Rigid tapping inversion rotation
H87F
Rigid tapping natural rotation
00150
G213
Closed-loop mode
Y054
Addition/ subtraction switch
Y054
Addition/ subtraction switch
G278
Zero speed
00151
R300
Directional command
Y051
Gain switch
H87E
Rigid tapping inversion rotation
H87F
Rigid tapping natural rotation
00152
R100
AUTO
R403
M03
X006
Spindle lock
R230
Spindle stop
H027
R8T
H43D
Manual directional button
R419
M19
H83F
Spindle natural rotation
R101
MAN
H43A
Manual control spindle
H83F
Spindle natural rotation
H83E
Spindle inversion rotation
HC0A
Natural rotation instruction
00153
R100
AUTO
R404
M04
X006
Spindle lock
R230
Spindle stop
H027
R8T
R419
M19
H43D
Manual directional button
H83E
Spindle inversion rotation
R101
MAN
H43C
Manual control spindle

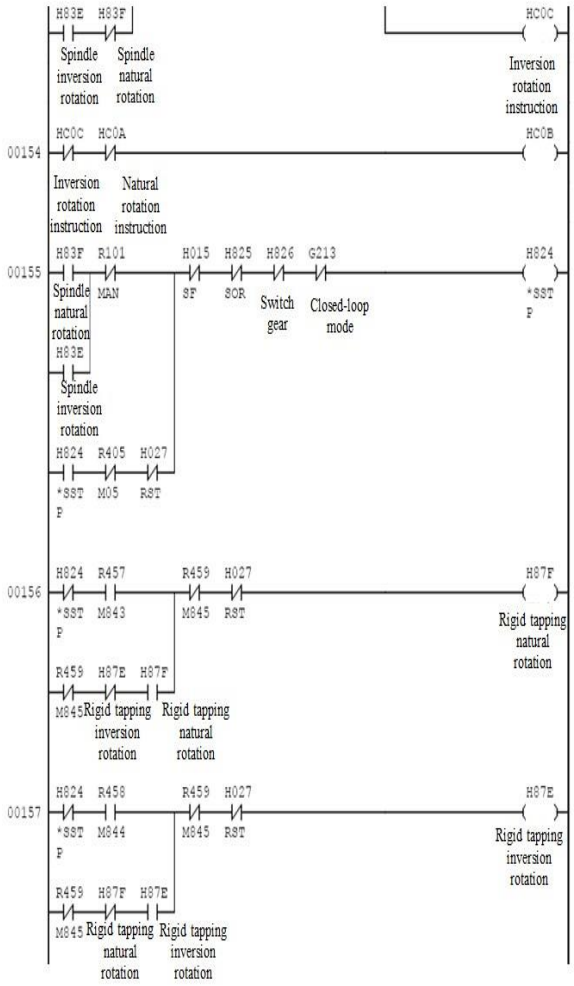


Figure 4. Rigid tapping control flow

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