Design of Tool Information Error Prevention Based on FIDIA

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Abstract. It often takes place in the field of CNC machining that quality accident of parts due to the tool information entry incorrect. In this paper, an error check program based on FIDIA CNC system is designed. The tool information in FIDIA CNC system is read by AUCOL program and compared with the theoretical tool length value to judge whether the tool information is correct, so as to reduce the tool information error in CNC system caused by human error.

Keywords: FIDIA, the Information of Tools, the AUCOL Program

1. Introduction
With the maturity of digital technology, more and more companies have begun to develop digital workshops to expand production capacity. Building digital workshop for the whole manufacturing process can lay a solid foundation for mass production and digital manufacturing. The tool management system of CNC machine tool is the basic condition and core framework of NC machining production. The content of early tool management is relatively simple, mainly logistics management. Nowadays, with the continuous development and improvement of tool management, the rational use of tool management system can effectively improve the efficiency of parts processing. For a long time, due to the wide variety, large quantity, expensive price, various parameters, complex components, frequent borrowing and lending, the enterprise workshop lacks effective management of cutting tools, and the application of cutting tools has also caused many problems. In order to verify the correctness of cutting tools, various machine tool manufacturers and enterprises have designed different methods [1-2].

At present, FIDIA CNC system is widely used in CNC machining equipment, including C2 series, C20 series and C40 series and so on. Caused by the imperfection of some tool management conditions or application conditions, operators may make various mistakes due to negligence during the tool replacement work, which causes the tool information to be inconsistent with the actual tool information, resulting in parts failure occurs from time to time. In order to prevent such phenomena and reduce the failure rate of parts, we can optimize the control system and improve the control program of the props [3].

This article intends to use the AUCOL program to verify the error of tool information. The programmable logic controller used by the FIDIA CNC system is I/O LUX modules group, which communicates between NC and axis servo modules through the FFB bus used by the FIDIA system like other PLCs. I/O LUX modules group includes digital input and output modules [4], analog input and output modules, output modules with relays, and some special function modules [5]. Each group
of I/O LUX modules is connected to the CNC system with a CC10 bus interface module, and a TRM10 bus termination module is used as the end of the group. The infrared communication mode is used to transmit data between the modules in the I/O LUX modules group. The AUCOL language is a logic programming language similar to assembly language designed for I/O LUX. And the program written in AUCOL language is called AUCOL program. Equipment debugging engineer can control the normal operation of I/O lux through the AUCOL program to realize a series of work on the equipment, including hydraulic pressure, refrigeration, spindle rotation, tool exchange, etc.

2. Calibration Design

Before the design of the calibration program, it is necessary to understand the general process of automatic tool measurement. Most tool measuring instruments complete the measurement of the spindle tool after tool switching. The tool calibration control designed in this paper compares the actual tool length with the set theoretical tool length before the spindle works. If the measurement result is within the tolerance range, processing can continue normally. Otherwise, The tool information is judged to be wrong, causing the system alarm.

2.1. Overall Scheme Design

FIDIA CNC system is equipped with tool management system, which contains tools 0-100, among which tool 0 is the current using tool on spindle, and the tool information includes tool length, radius, number of edges, wear, etc. This paper sets the value of an infrequently used tool (such as No. 99 tool) as the theoretical value. For the equipment without tool measurement or with problems in tool measurement application, the relevant theoretical information of the tool which is going to be used next is transmitted to No. 99 tool’s value at the beginning of the program. Before the program is processed, the theoretical information stored in No.99 tool is compared with the actual information. If the verification information is within the tolerance range, the program can be continued. Otherwise, the device will prompt that the tool exceeds the tolerance range and stop in an emergency.
2.2. Design of Theoretical Information Input
Since the theoretical value of the tool is designed by the process department, it needs to be added in the beginning of program when the program is completed. That is, the input of theoretical information is realized by the way of NC code. According to the overall plan design, this paper sets No. 99 tool as the theoretical tool length information. The NC program to set NO. 99 tool length information is:

T.99 L150

After executing the program, the tool length value of No. 99 tool is set to 150.000mm, which is the theoretical data for comparison with the actual tool length value.

2.3. Design of Tool Length Information Verification
Since the comparison between the actual tool information and the theoretical information is made before machining, the command to start the comparison needs to be designed in the beginning of the NC program. This paper adopts M code to realize the verification process by calling M instruction in NC program.

As shown in Figure 3, the first step is reading the theoretical tool information and the actual tool information entered by the operator. Then compare the theoretical tool with the actual tool information. If the error is less than 0.01mm, the tool length is considered to be within the error range, and the tool length is correct. So the program will continue to execute. Otherwise, the machine tool will stop in an emergency, and a prompt message will be issued: Tool length error.

Figure 2. Overall scheme design
Figure 3. Tool length information verification design

3. Installation

3.1. Program Parameters and Instruction Definition
FIDIA's AUCOL language program is usually stored in the "C:\FIDIA_custon" folder of the machine tool operating system. The folder contains about 200 files. Among them, the files that need to be applied in the debugging of the AUCOL program of FIDIA system mainly include the following categories.

As shown in Table 1, the main program of FIDIA's AUCOL language is mainly in the file with the suffix of PLC. There usually are 10 PLC files in a system, arranged in sequence numbers 1-10, representing 10 PLC main programs. These 10 PLC files have different functions, including coordinate start, basic system functions, spindle control, tool management control, door lock control, five-axis lock.release control, etc. The file with the same file name and the suffix DEF is a matching definition file. Before writing the program, the parameters are needed to define in the DBP file.
Table 1. Main files of AUCOL program

| File type               | File function                                           |
|------------------------|---------------------------------------------------------|
| PLC file(PL****.PLC)   | Standard PLC program                                    |
| SET file(PLCBLK.SET)   | Definition and setting of common parameters in PLC      |
| DEF file(PL****.DEF)   | Definition of I/O bit and local variable processed by CNC|
| GBL file(PL****.GBL)   | Definition of the global memory bit and option definition file |
| DBG file(PL****.DBG)   | File for system debugging                              |
| ERR file(PLC.ERR)      | Error list file                                         |
| AUC file(PL****.AUC)   | Definition of I/O bit processed by AUCOL                |

According to the logic of tool length comparison, the new parameters that need to be created in the tool comparison include the actual tool length, the theoretical setting length and the comparison error data. The corresponding parameters are shown in the following table 2:

Table 2. Custom variables

| Parameter meaning         | Parameter name |
|---------------------------|----------------|
| The actual tool length    | Toolrel        |
| The theoretical setting length | Toolset    |
| The comparison error data | Tooltol        |

In this paper, the protected M. instruction is written in the 6th PLC in the FIDIA machine tool when testing. So the corresponding parameters are added in the 6th definition file. Find the file to be written, and then use WordPad to open the corresponding definition file, and add the register definition program.

```
.RECISTER TOOLREL
.RECISTER TOOLSET
.REGISTER TOOLTOL
```

As shown above, the definition of the three parameters is completed, and then the corresponding M command can be written in the main program of the PLC.

3.2. Cycle Programming

The main program of the PLC file starts with some basic definitions, including "AUCOL DEFINITIONS", which mainly contains the following contents:

```
.AUCNUM         1, USED          ;Declare the current program number, whether it is used
.INCLUDE      "PL1239.GBL"        ;Declare the global memory bit and option definition file in the current program
.INCLUDE      "PL1239.AUC"        ;Declare the I/O bit file which is handled by CNC contained in the current program
.INCLUDE      "PL1239.DEF"        ;Declare the I/O bit file contained in the current program
.INCLUDE      "SYSTEM.CND"
```

Next, define the process file called in the PLC file. In the AUCOL program, the running of the program depends on the process. And each process is relatively independent, similar to an independent subroutine. According to the AUCOL program, P0 and P1 are special processes. P0 process includes system emergency stop, startup, and other process calls; while P1 process usually contains the writing of M instruction. In addition, processes starting from P2 are called in process P0.

When a process is normally called, it is called from the entry label. For example, as for the timer setting process TM1M, the following code will be included in process P1.

```
LOAD    TM1M, TM1M.INI            ; Set the TM1M entry address in TM1M. INI
START   TM1M                     ; Start TM1M process
```

By calling and executing the above program, the TM1M process will start execution from TM1M.INI.
This paper uses M code to perform tool length information verification. Therefore, it is necessary to set up a new M code application in the P1 program.

Through the inquiry of all programs, it is determined that M666 is an unused M code, and then it is defined in the main program. Open the sixth PLC file and find an independent "M AUCOL DEFINITION" program to define the M666 instruction. The program is:

```
.DEFM M666, INITIAL ; TOOL CHECK
```

Then write the M command main loop according to the design logic in Figure 3.

The main loop of the program is M666, and its main contents to be completed include:
1. Read the current tool length and the theoretical tool length from the tool information;
2. Calculate the error between the theoretical value and the actual value;
3. Judge whether the comparison error is less than 0.01mm. If it is less, the program ends. Otherwise, the system will alarm.

The main program is as follows:

```
;M666 – TOOL CHECK
M666:
READP "TLENGTH[00],TOOLREL ;Read the current tool length and transmit the result to TOOLREL
READP "TLENGTH[99],TOOLSET ; Read the theoretical tool length and transmit the result to TOOLSET
SUB TOOLSET,TOOLREL,TOOLTOL ; Calculate the error between the theoretical value and the actual value, and transmit the error result to TOOLTOL
CMP TOOLTOL,100L             ; Compare error result with 100L
IFGT JUMP M666_100            ; If bigger, jump to M666_100
IFLT JUMP M666_100            ; If smaller, jump to M666_100
JUMP M666_50                  ; if normal, continue execution

M666_50:
DMSG 436                      ; Prompt that the tool is correct
JUMP P1.EX

M666_100:
DMSG 437                      ; System alarm
BSET MGOMAN                   ; Emergency stop
JUMP P1.EX
```

After completing the above program, the design of the entire ACCOL program has been completed. Finally, it is needed to write the alarm statement. The alarm text of the FIDIA CNC system is usually written in "FIDIA\WS\ENGLPLC.ING". After opening the text, all the alarms designed by the system can be seen. Find the empty alarm or the irrelevant alarm and modify it. According to the design of the program, if the error result is within tolerance, the information is message 436, saying "TOOLCHECK OK". Otherwise the information is message 437, saying "TOOL CHECK ERROR".

### 3.3. Application Verification

After the design is completed, the verification is carried out on a five axis vertical machining center. Due to the defect of the machining center’s tool magazine, the tool may jam during the tool change process. When the operator continues to process after the fault repair, the tool is prone to appear In the case of information confusion. There were 2 parts quality problems caused by the tool information confusion error in the past. After the design content of this paper is realized on the equipment, try to call a tool with a length of 153.78mm. Before calling, set the theoretical tool length to 153.78mm, then execute M666 after tool change. The machine tool panel displays PL6436 "TOOL CHECK OK", and continues to execute the program. Then change to another tool with a tool length of 137.235mm and
execute M666. The machine panel will display PL6437 "TOOL CHECK ERROR", and the system will stop in an emergency. Which means the verification function is working well. 50 times of correct tool length information and 50 times of incorrect tool length information have been tested on this machining center. When the tool length information is correct, the machine tool can process normally. When the tool length information is wrong, the system can enter the emergency stop state. The accuracy rate is 100%.

4. Application Summary
This paper implements a tool information verification design based on FIDIA CNC system, and verifies it on field equipment. It can be seen from the results that the design achieves the expected function. At the same time, there are many data that can be used in tool calibration, including tool type, tool radius, etc. Combining these data with a dedicated tool measuring instrument can achieve a better verification effect.

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