RENISHAW
apply innovation™

Parametric programming

Problem

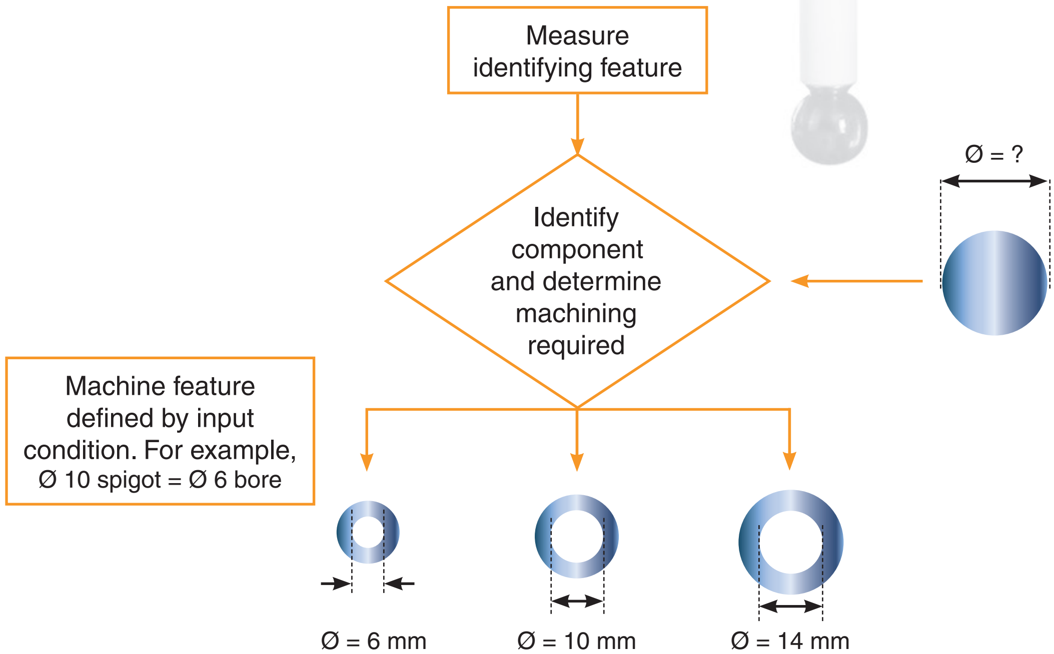
When creating machining programs for a family of many similar parts, it can take considerable time to generate, document, manage, and maintain a large number programs. If even a small revision is required to a large number of programs a lot of time may be needed to implement updates throughout an organisation.

On machines where NC program capacity is limited, the need to store many similar programs may not allow sufficient space on the control for all required programs. This problem may necessitate costly control upgrade or DNC options, or a manual program-loading procedure which could introduce delays or errors into the manufacturing process.

Solution

Identify similarities between parts in order to determine part families for which 'intelligent' programs can be generated. Use a spindle probe to measure features which vary between parts within a given family and allocate macro variables for those feature measurements. Different parts can be produced by a family-specific rather than a part-specific program by controlling features that vary between parts using logic based on probe measurement results.

Spindle probe measurements can be saved to macro variables in a machine control. The use of these variables is limited only by the programmer's imagination. The metal cutting program for a family of parts can query probing results saved in macro variables and set the size of part-specific features based on the value of one or many macro variables stored by a probing routine.



To summarise the solution:

- It can be possible to identify similarities between parts in order to determine part families
- Finished dimensions of part-specific features can be controlled using logic applied to macro variable values stored on the machine control
- The dimensions of machined part-specific features can either be continuously variable or chosen from a finite number of options
- Metal cutting programs can use probe measurement to control finished dimensions of features and one program can be used to produce a wide range of different outcomes

Benefits

Probe technology enables variable-based programming to be used to generate reactive metal cutting programs where data from probing is used to govern the shape or size of features produced during machining. This gives:

- Faster programming for ranges of similar parts
- A requirement for fewer programs
    - Less complexity
    - Less maintenance
    - Less risk of error during program loading and administration
- The option to generate simpler programs that are less dependent on operator input

Advanced application

This application is different to the one introduced in AP210 (Adaptive machining). The two applications vary in complexity and methodology:

- Adaptive machining, where the finished part shape is governed by the shape at the start of the machining process, involves creating a metal cutting program based on inspection results of the initial part shape. As such, the program is typically 're-posted' using CAM software each time a new part is inspected and needs to be machined
- Machine variable-based programming maintains a single posted program which incorporates decision-making logic to allow it to vary machining output based on the results of probing

Machine variable-based programming can be combined with many other uses of probing and most machine controls have sufficient functionality to implement the method (measurement and decision reporting can be included to give enhanced shop floor management and traceability).

RENISHAW
apply innovation™

Example 1: probe to determine the size of a feature to be machined from three possible options

Sample Productivity+™ probe software program

Inspection Cycle: Cycle1 Measured Circle: MeasureSpigotDia	Measure the reference feature: spigot diameter.
If: MeasureSpigotDia.Diameter LT 8 Then: G-Code Block: ErrorMessage_RejectPart_TooSmall	If the diameter is less than minimum expected size (8) an error message is displayed to reject/remove the part as it is incorrect.
If: MeasureSpigotDia.Diameter LT 10 Then: G-Code Block: Machine6mmBore G-Code Block: EngravePartNumber_A321 Goto: EndOfProgram	A diameter of less than 10 identifies this as component A321; a 6 mm bore feature is machined and the part number is engraved on the component. Jump to program end.
If: MeasureSpigotDia.Diameter LT 14 Then: G-Code Block: Machine10mmBore G-Code Block: EngravePartNumber_A322 Goto: EndOfProgram	A diameter of less than 14 identifies this as component A322; a 10 mm bore feature is machined and the part number is engraved on the component. Jump to program end.
If: MeasureSpigotDia.Diameter LT 18 Then: G-Code Block: Machine14mmBore G-Code Block: EngravePartNumber_A323 Goto: EndOfProgram	A diameter of less than 18 identifies this as component A323; a 14 mm bore feature is machined and the part number is engraved on the component. Jump to program end.
G-Code Block: ErrorMessage_RejectPart_TooLarge Label: EndOfProgram	

Sample Inspection Plus software program

N10	
T1 M6	
G54 X0. Y0.	
G43 H1. Z100	
G65 P9810 Z-8. F1500	
G65 P9814 D8. Z-5. Q20.	Measuring cycle
IF[#138LT8.]GOTO100	Alarm as the spigot is less than the minimum diameter go to alarm
IF[#138LT10.]GOTO20	
IF[#138LT14.]GOTO30	
IF[#138LT18.]GOTO40	
GOTO100	Spigot is tto large
N20	
G65 P1000	Sub-program to machine a 6 mm bore and engrave part number A321
GOTO999	
N30	
G65 P2000	Sub-program to machine a 10 mm bore and engrave part number A322
GOTO999	
N40	
G65 P3000	Sub-program to machine a 12 mm bore and engrave part number A323
GOTO999	
N100	
#3000=90(REJECT PART)	
N999	

SAMPLE PRODUCTIVITY+™ PROGRAMS ASSUME THE USE OF ACTIVE EDITOR PRO 1.70.20
SAMPLE INSPECTION PLUS PROGRAMS ASSUME USE WITH FANUC TYPE CONTROLS

Example 2: use variable-based programming to machine one feature to fit with another

Sample Productivity+™ probe software program

Inspection Cycle: Cycle1 Measured Circle: MeasureSpigotDia Machine Update: StoreSpigotDia_Variable900	Measure the reference feature - spigot diameter - and store to variable (e.g. #900). Acceptable diameter 12 ± 0.1
If: StoreSpigotDia_Variable900.Value GE 11.9 Then: If: StoreSpigotDia_Variable900.Value LE 12.1 Then: Goto: SpigotInTolerance	If data saved to #900 indicates the feature is within tolerance (greater than or equal to 11.9 and less than or equal to 12.1) the program jumps to the SpigotInTolerance label.
Else: G-Code Block: Alarm_SpigotOutOfTolerance1 Goto: EndOfProgram Else: G-Code Block: Alarm_SpigotOutOfTolerance2 Goto: EndOfProgram	If data saved to #900 indicates the feature is out of tolerance, a machine alarm is displayed to alert the operator before moving to the end of the program.
Label: SpigotInTolerance G-Code Block: MachineMatingBoreUsingSpigotDia_Variable900	Part is in tolerance, machine the mating bore. Bore size is defined as #900+δ (where δ is clearance value for the bore).
Label: EndOfProgram	

Sample Inspection Plus software program

N10	
T1 M6	
G54 X0. Y0.	
G43 H1. Z100	
G65 P9810 Z-8. F1500	
G65 P9814 D12. Z-5.	
IF[#138LT11.9]GOTO100	If the spigot is less than 11.9 go to alarm
IF[#138GT12.1]GOTO100	If the spigot is greater than 12.1 go to alarm
N20	
	Machine mating bore using size in #138 + a clearance value
GOTO999	
N100	
#3000=90(REJECT PART OUT OF SIZE)	
N999	

This page is intentionally left blank

Renishaw plc

New Mills, Wotton-under-Edge,
Gloucestershire GL12 8JR
United Kingdom

T +44 (0) 1453 524524
F +44 (0) 1453 524901
E uk@renishaw.com

www.renishaw.com

RENISHAW
apply innovation™

About Renishaw

Renishaw is an established world leader in engineering technologies, with a strong history of innovation in product development and manufacturing. Since its formation in 1973, the company has supplied leading-edge products that increase process productivity, improve product quality and deliver cost-effective automation solutions.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Products include:

- **Dental CAD/CAM scanning and milling systems.**
- **Encoder systems for high accuracy linear, angle and rotary position feedback.**
- **Laser and ballbar systems for performance measurement and calibration of machines.**
- **Medical devices for neurosurgical applications.**
- **Probe systems and software for job set-up, tool setting and inspection on CNC machine tools.**
- **Raman spectroscopy systems for non-destructive material analysis.**
- **Sensor systems and software for measurement on CMMs (co-ordinate measuring machines).**
- **Styli for CMM and machine tool probe applications.**

Renishaw worldwide

Australia
T +61 3 9521 0922
E australia@renishaw.com

Austria
T +43 2236 379790
E austria@renishaw.com

Brazil
T +55 11 4195 2866
E brazil@renishaw.com

Canada
T +1 905 828 0104
E canada@renishaw.com

The People's Republic of China
T +86 21 6180 6416
E china@renishaw.com

Czech Republic
T +420 548 216 553
E czech@renishaw.com

France
T +33 1 64 61 84 84
E france@renishaw.com

Germany
T +49 7127 9810
E germany@renishaw.com

Hong Kong
T +852 2753 0638
E hongkong@renishaw.com

Hungary
T +36 23 502 183
E hungary@renishaw.com

India
T +91 80 6623 6000
E india@renishaw.com

Indonesia
T +62 21 2550 2467
E indonesia@renishaw.com

Israel
T +972 4 953 6595
E israel@renishaw.com

Italy
T +39 011 966 10 52
E italy@renishaw.com

Japan
T +81 3 5366 5316
E japan@renishaw.com

Malaysia
T +60 3 5631 4420
E malaysia@renishaw.com

The Netherlands
T +31 76 543 11 00
E benelux@renishaw.com

Poland
T +48 22 577 11 80
E poland@renishaw.com

Russia
T +7 495 231 16 77
E russia@renishaw.com

Singapore
T +65 6897 5466
E singapore@renishaw.com

Slovenia
T +386 1 527 2100
E mail@rls.si

South Korea
T +82 2 2108 2830
E southkorea@renishaw.com

Spain
T +34 93 663 34 20
E spain@renishaw.com

Sweden
T +46 8 584 90 880
E sweden@renishaw.com

Switzerland
T +41 55 415 50 60
E switzerland@renishaw.com

Taiwan
T +886 4 2473 3177
E taiwan@renishaw.com

Thailand
T +66 2 746 9811
E thailand@renishaw.com

Turkey
T +90 216 380 92 40
E turkiye@renishaw.com

UK (Head Office)
T +44 1453 524524
E uk@renishaw.com

USA
T +1 847 286 9953
E usa@renishaw.com

For all other countries
T +44 1453 524524
E international@renishaw.com

H-5650-4012-02

Issued 0712 Part no. H-5650-4012-02-A