TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics and Mechanics
Vol. 57, Issue I, March, 2014

TRAPEZOIDAL THREADING CYCLE FOR NUMERICAL CONTROLED LATHES

Călin BELDEAN, Ioan VUSCAN, Nicolae PANC, Marcel MARIES

Abstract: *This paper describes a mathematical methode that will generate the passes of a trapezoidal threading cycle for numerical controled lathes. The purpose of this paper is to find an equation that will generate values that are closer to the values suggested by the threading insert manufacturer.*
Key words: *trapezoidal threading, threading, threading cycle, cnc lathes.*

1. Introduction

Trapezoidal threads are one of the most used types of threads in machine building industry due to the fact that it can withstand high axial forces [1] and can be easily machined either by turning or by milling. Its unique feature is the 30° angle on both flanks of the thread.
The characteristic elements of the thread, defined by DIN103 are: profile; pitch; flank angle; outside diameter; average diameter and inner diameter.
Trapezoidal thread can be made as right thread or left thread, with one start or with multiple starts. The symbol of the thread is Tr "outside diameter" × "pitch" for a thread with one start and Tr "outside diameter" × "pitch · number of starts" for a thread with multiple starts. In case the thread is left handed at the end of the symbol will appear the symbol "LF" (ex: Tr 20×4 LF).
There are three types of threading methods [2]: radial infeed; modified flank wear and incremental type feed.
The radial infeed method, figure 1.1 (a), is the conventional way of threading. It is used in case the thread is at a right angle to the workpiece. The method is suitable for fine pitches and the wear of the edge of the tool is more even.
The modified flank wear method is done by feeding the insert at an angle of the profile less a clearance angle. This method is suitable for threading on numerical controlled lathes, figure 1.1 (b). The advantages of this method are less heat is generated in the insert point and vibration tendencies are reduced in case of long length of thread or coarse thread.
Incremental type method, figure 1.1 (c), is mainly use in case of threads with large pitch. The profile is done by cutting on one flank and then on the other flank until the profile is completed. A plus for this method is an even wear of the insert.

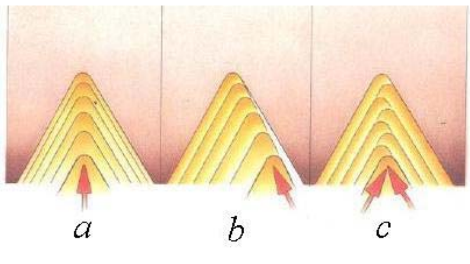

Fig. 1.1 – Types of threading [2]

A frequent use of trapezoidal thread is in construction of industrial valves for open and close actuating mechanism.
Programming the threading cycle for trapezoidal thread is usually done eider by programming every cutting pass or by using a universal threading cycle. Programming every cutting pass is done by wasting lots of time and memory space considering the industries with small batches or the use of old numerical controlled turning machines with low memory storage space. On the other hand programming

the thread using a universal threading cycle is not recommended by the threading insert manufacturer due to the fact that these cutting passes are far from those recommended [2].

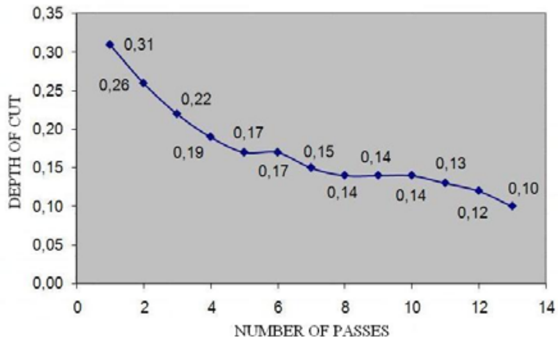

Fig. 1.2: Depth of cutting passes recommended by insert manufacturer

In figure 1.2 and 1.3 can be seen the depth of each cut for manual programming every cutting pass for a trapezoidal thread with 4 mm pitch recommended by the insert manufacturer and for threading using a universal threading cycle [2][3].

Analyzing the graph from figure 1.3 can be observed a big step at the beginning of the graph followed by lots of passes of small steps. Also, there are 16 passes with the universal threading cycle compared with 13 passes for programming every cutting pass.

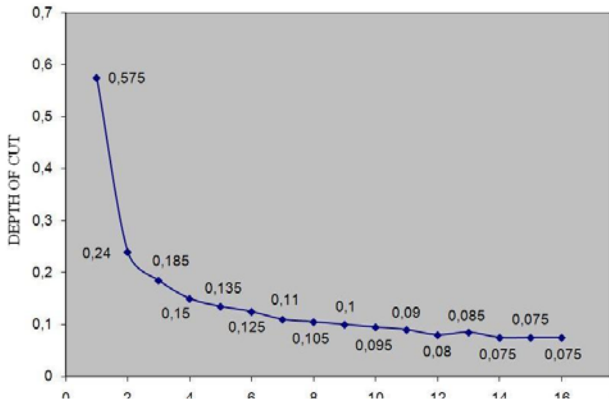

Fig. 1.3 – Depth of cutting passes for universal threading cycle

In the two figures above, 1.2 and 1.3, can be noticed a significant difference at first four cutting passes. If the first cutting pas is bigger for universal threading cycle all the rest are smaller than the recommended cutting passes, thus the impact on the cutting edge of the insert is significant.

2. Mathematical model

The depth of cut will be considered to be the product between the height of the thread profile and a constant value:

$$a_{pi} = A_i \cdot h \qquad (1)$$

where:

a_{pi} – depth of cut [mm]

$A_0 \ldots A_n$ – constant; $\sum_{0}^{n} A_i = 1 \qquad (2)$

h – height of tooth [mm]

$i = 1 \ldots n$ – counter

In order to have the values of a_{pi} of a shape of a parabola, the values of A_i has to be of a shape of a parabola having in mind that the height of the tooth is a known constant value.

We will assume that A_i can be writen as:

$$A_i = A_{i-1} - a \cdot A_{i-1}^2 \qquad (3)$$

where: a – constant value

The values for A_0 and a have to be found in order to calculete the values of $A_1 \ldots A_n$ with equation (2). To do so we will assume the last two values a_{n-1} and a_n for the depth of cut are 0.09 and 0.1 and considering these values all values for $A_0 \ldots A_n$, are observing condition (2). Using the values calculated with equation (3), the dpth of cut $a_{p0} \ldots a_{pn}$ can be calculated.

3. Results

Considering the exemple above, trapezoidal thread with 4 mm pitch, the values for a and A_0 are: $a = 1.43$ and $A_0 = 0.175$.

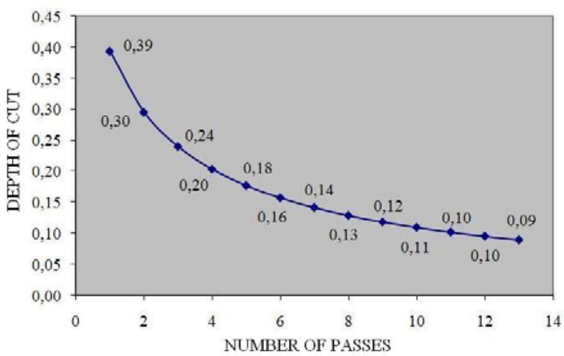

Fig. 3.1 – Depth of cutting passes calculated with equation (1)

In figure 3.1 can be seen the depth of cutting passes calculated with equation (1) for a trapezoidal thread with 4 mm pitch.

If a comparison between figure 3.1 and 1.2 is made, meaning a comparison between the universal threding cycle and the threading cycle with the methode described above, can be observed that using equation (1) the results are more balanced and closer to the recommended threaded insert values (see figure 3.2).

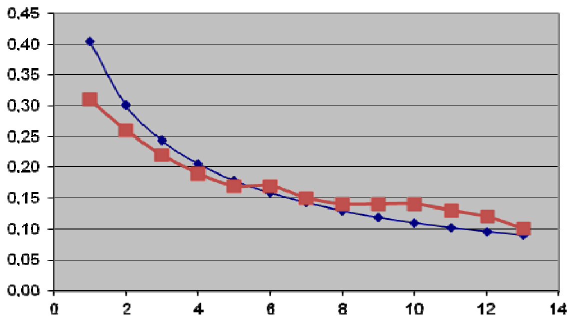

Fig. 3.2 – Universal threading cycle (red) versus threading cycle calculated with equation (1)

Moreover the number of cutting passes with this methode is identical, in this case, with the number of threading passes recommended by the insert manufacturer (see figure 3.2).

Like we allready said before the results presented above are for a trapezoidal thread of 4 mm.

Using the method described in this paper the values for a and A_0 can be calculated for diferent pitches, see table 3.1 and with this values the depth of cut can be found.

Table 3.1

Pitch	3 mm	4 mm	5 mm
a	1.49	1.43	1.38
A_0	0.22	0.175	0.16

In figure 3.3 is a sample code for a threading cycle for a Fanuc numerical control [5] for a trapezoidal thread Tr18×4.

In lines 13, 15 and 17 are initiated the parameters used in the calculations made in the cycle.

#10 – Major diameter
#11 – Height of tooth
#13 – Constant A_0
#14 = #13
#15 – Constant a
#16 – Minor diameter

The value of parameter 13 will be altered by calculations and it's saved in parameter 14 for each pass.

From line 31 to line 49 are the calculations made with equation (3) and (1).

The condition to jump up at the end of one threading pass is in line 57. If condition is true the jump is made to line 29 in order to calculate the values for the next threading pass and if

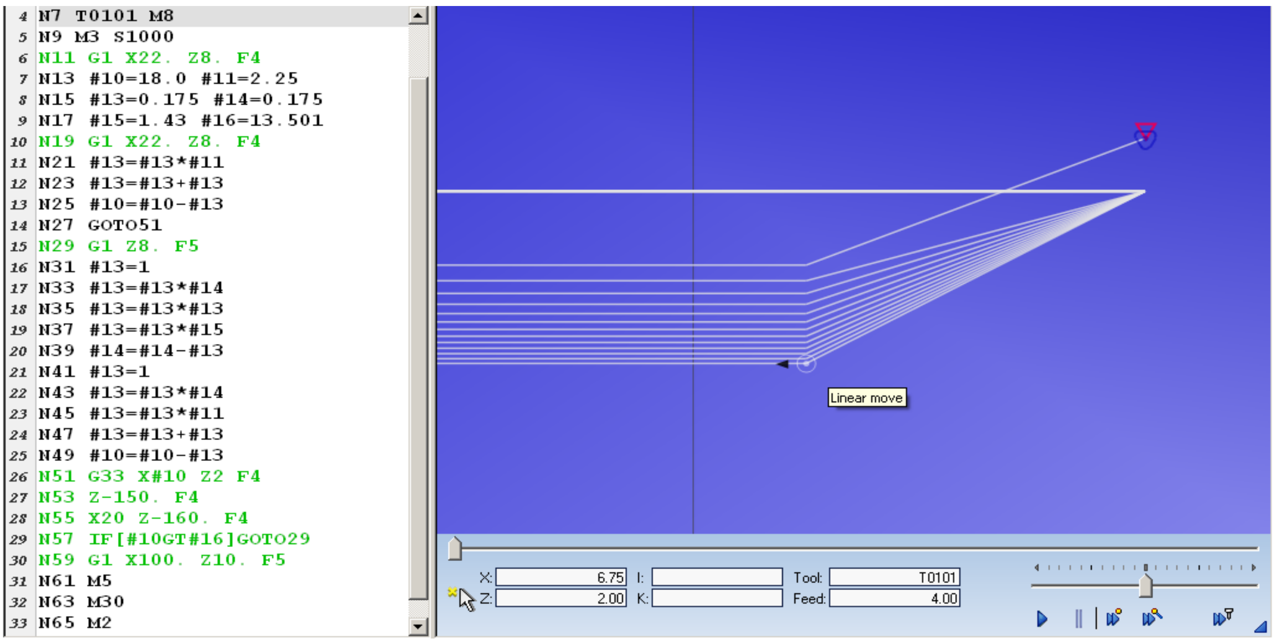

Fig. 3.3 – Sample code for Tr18×4 for a Fanuc control [4][5]

condition is false the code will continue with line 59.
This code was writen using Cimco Edit 6 [4] and on the right side of the figure 3.3. can be seen the backplot of the cutting passes.
The backplot shows the depth of cut being bigger at the beginning of the cycle and it is gradualy decreasing until the minor diameter.

4. Conclusions

Considering the exemple of threading passes for Tr18×4, presented above, the following conclusions can be drawn:

- equation (1) can be used to find threading passes close to those recommended by the threading insert manufacturer;
- the number of threading passes is the same or less compared with the number of threading passes recommended by the threading insert manufacturer, thus leading to shorter machine time;
- having the values for the threading passes closer to those recommended by the threading insert manufacturer means close to optimum tool life of the threading insert;
- in case of turning machines of old generation with small memory storage using a threading cycle can lead to shorter machine setup time.

5. References

[1] Marghitu, D., *Mechanical Engineer's Handbook*, ISBN 0-12-471370-X, Academic Press, USA, 2001
[2] Sandvik Coromant, Metalcutting Technical Guide, C-2900:3 ENG/01, Sjostroms Grafisk Production, 2005;
[3] www.seco.com
[4] www.cimco-software.com
[5] www.fanuc.com

Ciclu de filetare filet trapez pentru strunguri cu comandă numerică

Rezumat: În această lucrare se descrie o metodă matematică pentru generarea trecerilor la ciclul de filetare filet trapez pentru centre de prelucrare prin strunjire cu comandă numerică. Scopul lucrării este de a propune un model matematic pentru generarea unor valori apropiate de valorile recomandate de producătorul de plăcuțe de filetat. **Cuvinte cheie:** filetare trapez, filetare, ciclu de filetare, strung cu comandă numerică.

Calin BELDEAN, Ph.D. student, eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, clbeldean@google.com, Bd. Muncii, no.103-105, Cluj-Napoca

Ioan VUSCAN, Prof. Dr. Eng., Technical University Of Cluj-Napoca, Romania, Manufacturing Engineering Department, givuscan@yahoo.com, Bd. Muncii, no.103-105, Cluj-Napoca

Nicolae PANC, Asist.Ph.D., Eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, nicolae.panc@tcm.utcluj.ro, Bd. Muncii, no.103-105, Cluj-Napoca

Marcel MARIES, Ph.D. student, eng., Technical University of Cluj-Napoca, Manufacturing Engineering Department, maries_marcel_vasile@yahoo.com, Bd. Muncii, no.103-105, Cluj-Napoca