International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 15, Issue 3 [March 2026] PP: 06-09

Two-pitch worm gear transmission and automated calculation of machine-tool kinematic adjustments in machining

Duong Cong Dinh
Faculty of Mechanical Engineering, Thai Nguyen University of Technology, Thai Nguyen, Vietnam
Corresponding Author: dcdinh@tnut.edu.vn

ABSTRACT: *The worm gear transmission is widely used in rotary motion drives. It is commonly applied in machine tools to provide motion for actuating mechanisms such as worktables and tool slides of gear hobbing machines, gear shaping machines, gear grinding machines, etc. For worm gear transmissions, the ability to adjust the backlash is required to ensure proper meshing. A two-pitch worm gear transmission allows the backlash to be adjusted easily; however, its manufacturing process is more complex. This paper presents the basic principles of the two-pitch worm gear transmission, the technological characteristics of its manufacturing process, and the calculation of machine adjustments during the machining of the worm wheel in this transmission.*

Keywords: *Worm wheel; Worm; Machining; Adjustment; Transmission ratio; Transmission mechanism; Kinematic chain; Adjustment link; Tooth pitch; Machining deviation, …*

Date of Submission: 05-03-2026 Date of acceptance: 17-03-2026

I. INTRODUCTION

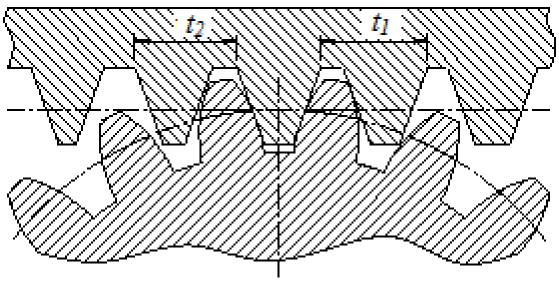

Fig. 1. Two-pitch worm gear transmission

In a two-pitch worm gear transmission, the two thread flanks of the worm have different pitches. As shown in Fig. 1, with the mean module mmm, the right-hand thread flank of the worm has a pitch $t_1=\pi m+\Delta t$ while the left-hand thread flank has a pitch $t_2=\pi m-\Delta t$ thus $t_1>t_2$, consequently, the thickness of the worm thread gradually decreases, while the width of the thread groove gradually increases toward the left. When the worm is moved axially to the left, the increase in the thread thickness eliminates the backlash between the worm and the worm wheel. With this characteristic, the meshing adjustment of the transmission becomes relatively simple.

However, the manufacturing of the worm, and particularly the worm wheel, becomes more complicated. In practice, the worm wheel is usually machined on gear hobbing machines using the generating method. During the generating process, the tooth profile of the worm wheel must be accurately generated to ensure proper meshing with the two-pitch worm.

II. MACHINING OF THE WORM WHEEL MESHING WITH A TWO-PITCH WORM

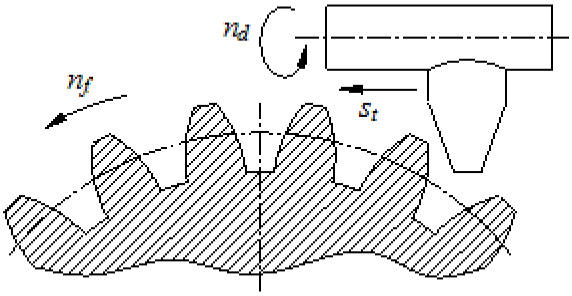

Fig. 2. Scheme of Worm Wheel Machining

The worm wheel is machined on gear hobbing machines with an axial (tangential) feed kinematic chain, according to the machining scheme shown in Fig. 2. In order to cut the worm wheel of this transmission, a worm hob with only one cutting tooth (single-tooth worm hob), acting as a fly cutter, is used. The generation of the worm wheel tooth profile is performed by successively generating each flank of every tooth. When generating the right flank of the worm wheel tooth, the process follows the thread pitch t_2 of the worm, whereas the generation of the left flank follows the thread pitch t_1 of the worm. In this case, the generating process reproduces the meshing of a rack-and-pinion gear pair.

III. CALCULATION OF MACHINE KINEMATIC ADJUSTMENTS IN WORM WHEEL MACHINING

3.1. Kinematic Structure of the Machine in Cutting a Two-Pitch Worm Wheel

The kinematic structure of the machine for machining the worm wheel using a fly cutter is shown in Fig. 3 [1]. The following kinematic chains must be adjusted: the speed chain (i_v), the axial feed chain (i_s), the indexing chain (i_x), and the differential chain (i_y)

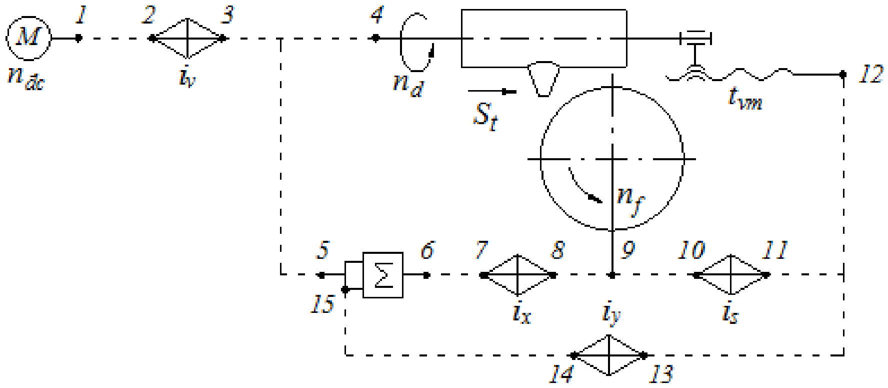

Fig. 3. Kinematic Structure Diagram of a Gear Hobbing Machine for Worm Wheel Machining

The adjustment of the links i_v, i_s, i_x is carried out in the same manner as in conventional worm wheel cutting. The differential chain i_y is adjusted according to the thread pitches t_1 và t_2 when generating the corresponding tooth flanks. The adjustment formula for the differential chain is:

$$i_y = \frac{a}{b} \times \frac{c}{d} = C_y . \frac{1}{m.K} = C_y . \frac{\pi}{t \times K}$$

Where C_y is the constant of the kinematic chain; m and K are the module and the number of starts of the worm.

To ensure an accurate transmission ratio, the adjustment link of the differential chain i_y in the gear hobbing machine employs a set of change gears, as shown in Fig. 4:

$$i_{tt} = \frac{a}{b} \times \frac{c}{d}$$

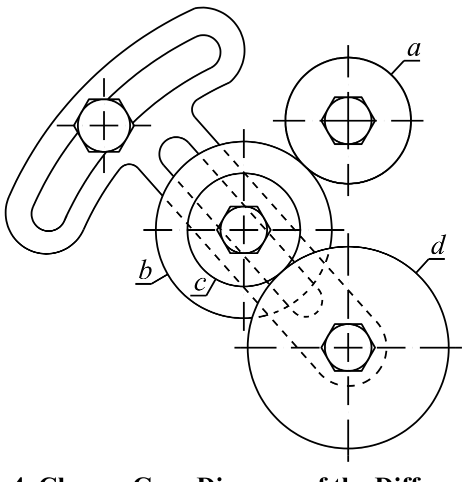

Fig. 4. Change Gear Diagram of the Differential Chain

Where a, b,c and d denote the numbers of teeth of the change gears. The numbers of teeth of these gears must satisfy the following conditions:

a+b > c + (20÷25) và c+d > b + (20÷25) [2]

The numbers of teeth a, b, c, and d determine the accuracy of the transmission ratio of the kinematic chain and consequently affect the accuracy of the worm wheel pitch t. If the allowable pitch error is f_{ptr} , the selected change gears a, b, c, d must satisfy the condition:

$$\left| t - C_y \times \frac{\pi}{K \times \frac{a}{b} \times \frac{c}{d}} \right| \leq f_{ptr}$$

3.2. Automation of the Calculation Process

Various methods can be used to calculate the numbers of teeth of the change gears. At present, the use of computers with specialized software allows calculations to be performed quickly, accurately, and conveniently. The following presents the results obtained using a computer program written in Pascal [4], [5] to calculate the transmission ratio i_y of the differential chain of the Z1-6 gear hobbing machine when machining a worm wheel meshing with a worm having a mean module m=3, Δt=0.0943, and two thread pitches $t_1=9,5190$ and $t_2=9,3305$. The allowable pitch error is $f_{ptr}=0,05\mu m$ [3].

The adjustment formula for the differential chain of the Z1-6 machine is:

$$i_y = \frac{a}{b} \times \frac{c}{d} = \frac{35}{4.m.K}$$

The coefficient C_y is determined from C_{y1}=35 and C_{y2} =4; $C_y = \frac{C_{y1}}{C_{y2}} = \frac{35}{4}$

The change gear set $Z[i]$ of the differential chain of the Z1-6 gear hobbing machine includes gears with the following numbers of teeth: 20 22 25 28 30 36 40 46 49 50 51 53 54 55 56 57 58 59 60 61 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 82 83 84 85 87 89 90 94 95 96 97.

The results of running the calculation program are displayed on the screen as shown in Fig. 5 and Fig. 6.

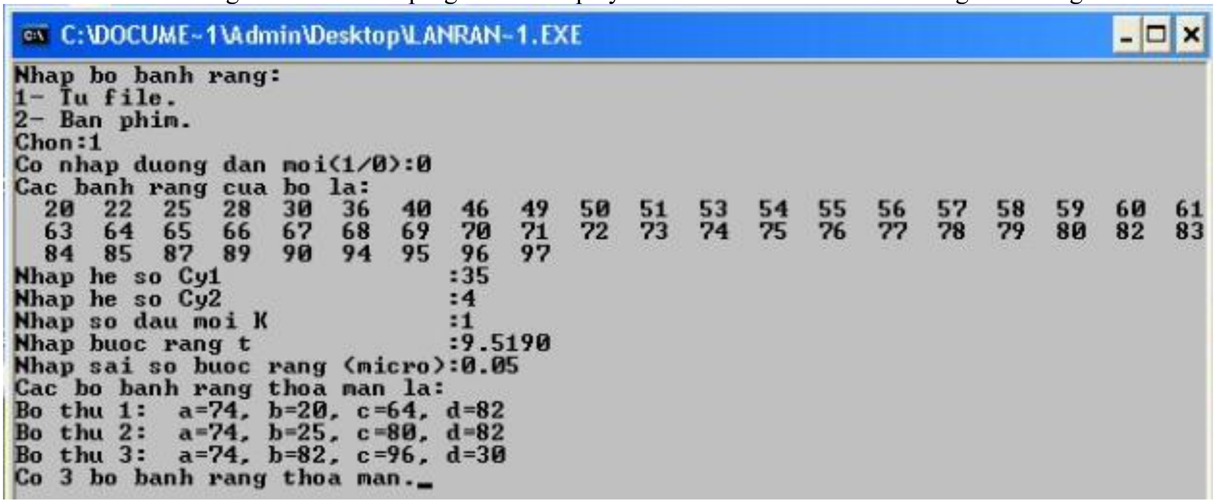

Fig.5. Program execution screen for t_1=9,5190

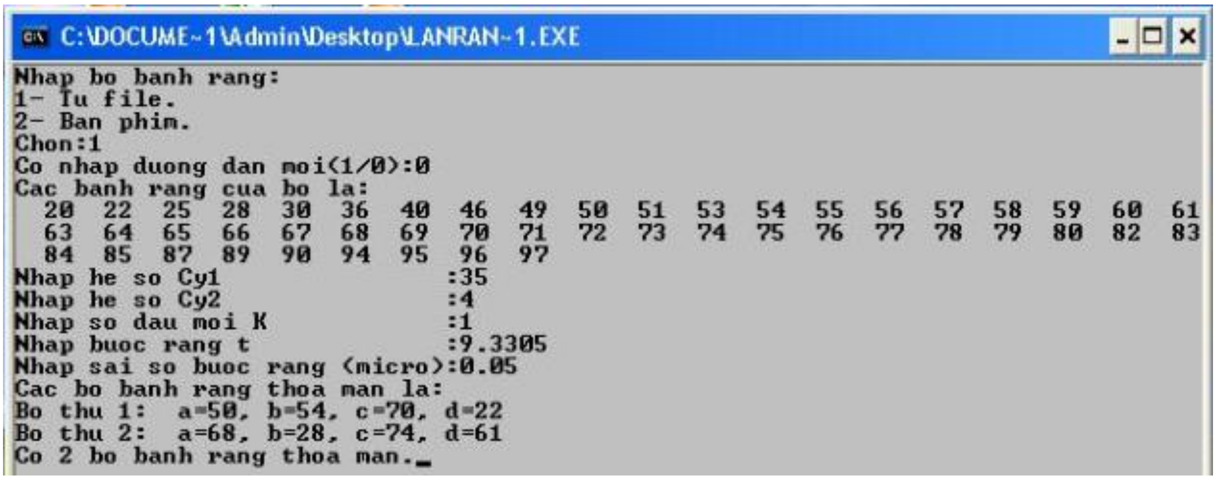

Fig.6. Program execution screen for t_2=9,3305

There are three sets of change gears that satisfy the requirements when generating the tooth flank corresponding to the pitch t_1*=9,5190:*

First set: $\frac{a}{b} \times \frac{c}{d} = \frac{74}{25} \times \frac{80}{82}$; Second set: $\frac{a}{b} \times \frac{c}{d} = \frac{74}{20} \times \frac{64}{82}$; Third set: $\frac{a}{b} \times \frac{c}{d} = \frac{74}{82} \times \frac{96}{30}$

There are two sets of change gears that satisfy the requirements when generating the tooth flank corresponding to the pitch t_2*=9,3305:*

First set: $\frac{a}{b} \times \frac{c}{d} = \frac{50}{54} \times \frac{70}{22}$; Second set: $\frac{a}{b} \times \frac{c}{d} = \frac{68}{28} \times \frac{74}{61}$

IV. CONCLUSION

The application of computers with automated programming tools to develop calculation programs for assisting the adjustment of machine kinematics provides accurate and fast computational results, thereby improving machining accuracy. The results of this research on automated calculation programming can be further developed and applied to the kinematic adjustment of various other machine tools. It can also serve as instructional and reference material for students in their studies and scientific research, contributing to the improvement of training quality and facilitating practical applications in manufacturing.

ACKNOWLEDGMENT

The authors would like to express their thanks to all supports from Thai Nguyen University of Technology - Thai Nguyen University.

REFRENCES

[1]. N. Acharkan, *Machine Tool Design*, Mir Publishers, Moscow, 1968.
[2]. V.A. Mimetric, B.A. Shishov, *Tables for the Selection of Gear Wheels*, Mashinostroenie Publishers, 1973.
[3]. A.N. Zuravlev, *Tolerances and Measurement Techniques*, Workers and Technicians Publishing House, 1987.
[4]. Bui The Tam, Vo Van Tuan Dung, *Pascal 7.0*, Transport Publishing House, 1998.
[5]. Nguyen Viet Trung, Hoang Hong, *Turbo Pascal 7.0 – Sample Programs in Engineering Fields*, Transport Publishing House, 1997.