TECHNICAL SCIENCES
Abbrev.: Techn. Sc., No 8, Y. 2005

DISTRIBUTION OF THE ALLOWANCE OF MATERIAL DISPLACED DURING THREAD ROLLING BY THE LONGITUDINAL METHOD

Kazimierz Łyczko
Production Engineering and Automation
Częstochowa University of Technology

K e y w o r d s: Thread rolling, longitudinal method, thread rolling die design.

A b s t r a c t

The design and dimensions of the contour of the working part of thread rolling dies for rolling external threads by the longitudinal method. Analysis of the allowance as measured by the volume of displaced material in relation to particular threads of embossing parts.

ROZKŁAD NADDATKU PRZEMIESZCZANEGO MATERIAŁU PRZY WALCOWANIU GWINTU METODĄ WZDŁUŻNĄ

Kazimierz Łyczko
Instytut Technologii Maszyn i Automatyzacji Produkcji
Politechnika Częstochowska

S ł o w a k l u c z o w e: walcowanie gwintów, metoda wzdłużna, konstrukcja rolek.

S t r e s z c z e n i e

Przedstawiono konstrukcję i wymiary zarysu części roboczej rolek walcujących do wykonywania gwintów zewnętrznych metodą wzdłużną. Poddano analizie naddatek mierzony objętością przemieszczanego materiału w odniesieniu do poszczególnych zwojów części wygniatających.

Introduction

The design, shape and dimensions of the embossing part of thread rolling tools have a significant influence on material displacement, the wear of particular threads and the accuracy of thread being made. When rolling threads by the longitudinal method with threading heads, and in part by threading holders, the threads on the working part have a contour in the form of rings, corresponding to the thread contour. The thread roots along the whole length of the working (embossing and sizing) part (Fig. 1) are determined by the generating line of the cylindrical surface of the cylinder of the diameter D_{1R}.

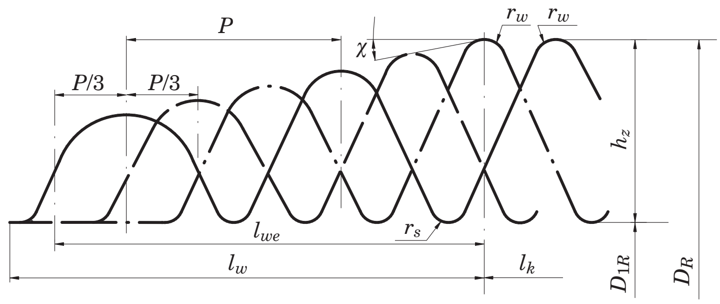

Fig. 1. Axial contour of threads on the embossing part of thread rolling dies

The axial contour is characterized by the variable radius r_w of rounding of thread vertices, while the remaining, lateral part of the contour is coincident with the contour of the thread being rolled.

The shape and dimensions of working part threads

For rolling external threads with small pitches, one of the three basic constructional solutions of thread rolling dies is used (ŁYCZKO 2003), as shown in Fig. 2.

The theoretical relationships describing the shape and particular components of the contour of the specific i-th thread on this part for triangular-contour (metric and unified) threads for this design have the following form:

$$r_w = \frac{P}{16} \operatorname{ctg} \alpha_1 \tag{1}$$

$$r_{w_i} = \operatorname{ctg} \alpha_1 \left[\frac{P}{16} + \frac{1}{2} \operatorname{tg} \frac{\alpha}{2} \left(d_{w\max} - d_{3\max} \right) \left(1 - \frac{i}{z_w} \right) \right] \tag{2}$$

$$f = \left(d_{w\max} - d_{3\max}\right)\mathrm{tg}\frac{\alpha}{2} + \frac{P}{8} \tag{3}$$

$$h_i = r_{w_i}\left(1 - \cos\frac{\alpha_2}{2}\right) \tag{4}$$

if: $h_i < i \cdot g$

$$c_i = 2\sqrt{ig\left(2r_{w_i} - ig\right)} \tag{5}$$

if : $h_i > i \cdot \mathrm{g}$

$$c_i = 2r_{wi} \cdot \sin\frac{\alpha_2}{2} \tag{6}$$

where:

g – value of thread penetration into the material
r_w – radius of the tops of threads of the sizing part,
r_{wi} – radius of the top of a given thread on the embossing part,
α_1 = 30° – for either metric or unified threads with α = 60°,
α_1 = 31°15' – for unified threads with α = 55°,
$\frac{P}{16}$ – half the value of the tangent to the radius r_w on the sizing part (ŁYCZKO 2000),
$d_{w\max}$ – max limiting value of the diameter of the workpiece to be threaded (ŁYCZKO 2002),
d_3 – minor thread diameters equal to ($d_{3\max}$ – 0.07 P),
i – successive embossing thread
z_w – number of embossing threads over the length l_{we}.
α_2 = 120° for either metric or unified threads with α = 60°,
α_2 = 125° for unified threads with α = 55°.

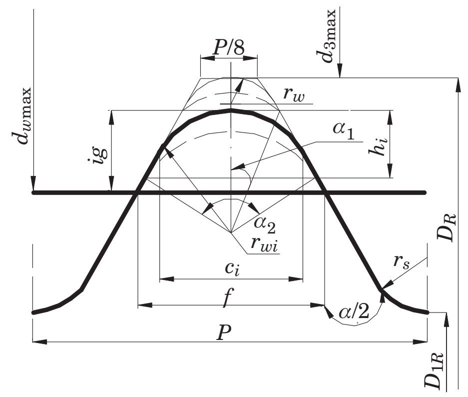

Fig. 2. Shape and dimensions of an embossing thread

The length l_{we} depends on the adopted number of embossing threads z_w and on the number of thread rolling dies z_R (e.g. with 6 threads, there are 2 threads per die). The sizing part l_k with threads of the height h_z = 0.5 $(D_R$-$D_{1R})$ and radius rw imparts the final shape and dimension to the thread.

The volume of displaced material

By using the theoretical relationships describing the shape and particular components of the contour and the derived formula (Łyczko 2003) it has been determined by calculation that for the adopted model shown in Fig. 3 the value of allowance as measured by the volume of displaced material per respective individual embossing threads.

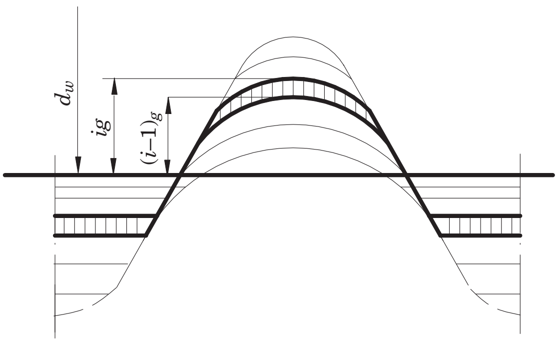

Fig. 3. Position of successive threads and their corresponding layers of displaced material

Calculation results related to 4, 6 and 9 embossing threads, respectively, are shown in Fig. 4.

The contribution of threads to the displacement of material in relation to the overall volume, calculated for the thread range from M3 to M20 and three different lengths l_{we}, is as follows:

– for 4 embossing threads:

$\frac{V_{j1-4}}{\sum V_j} \times 100\%$: from 24% to 26%, 33-34, 25-26, 14-16,

– for 6 embossing threads:

$\frac{V_{j1-6}}{\sum V_j} \times 100\%$: 14-16, 21-23, 22-23, 18-19, 13-14, 8-10,

– for 9 embossing threads:

$$\frac{V_{j1-9}}{\sum V_j} \times 100\%\text{: } 7–9,\ 13–14,\ 14–16,\ 14–16,\ 13–14,\ 11–12, 9–10,\ 7–8,\ 5–7.$$

Taking the mean value of the percentage proportions of threads in material displacement shown above and assuming that $Vj1 = 1$, the coefficient of volume change related to successive threads is as follows:

– with 4 threads:
  1, 1.34, 1.02, 0.6;
– with 6 threads:
  1, 1.46, 1.43, 1.23, 0.9, 0.6;
– with 9 threads:
  1, 1.68, 1.87, 1.87, 1.68, 1.5, 1.43, 0.93, 0.75.

The data shown above indicate that particular threads emboss different parts of the material – lower values occur at the beginning and at the end of the embossing part. Assuming that the value of displaced material volume has direct influence on the loading of threads, this distribution of allowance can be regarded as favourable in the process of shaping the thread contour. A decreasing allowance value with approaching to the sizing part facilitates the deformation of the top layer already hardened by the preceding threads, and contributes to a reduction of the wear of the embossing part performing the main function in shaping the thread contour.

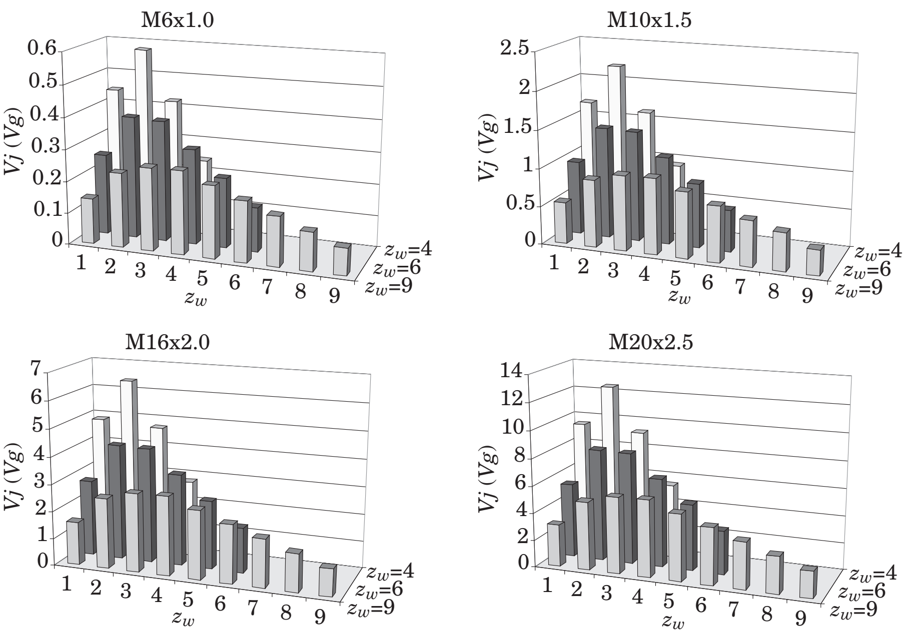

Fig. 4. Distribution of allowance as measured by the volume of displaced material per respective individual embossing threads

The calculated values of V_j were used for the determination of theoretical relationships between the thread penetration "g" into the material being worked and the displaced volume, expressed in the form of the function $g = f\,(\Sigma V_j)$. From the analyzed M3-M20 range of metric coarse and fine threads, for which the calculations were performed, the results of approximation

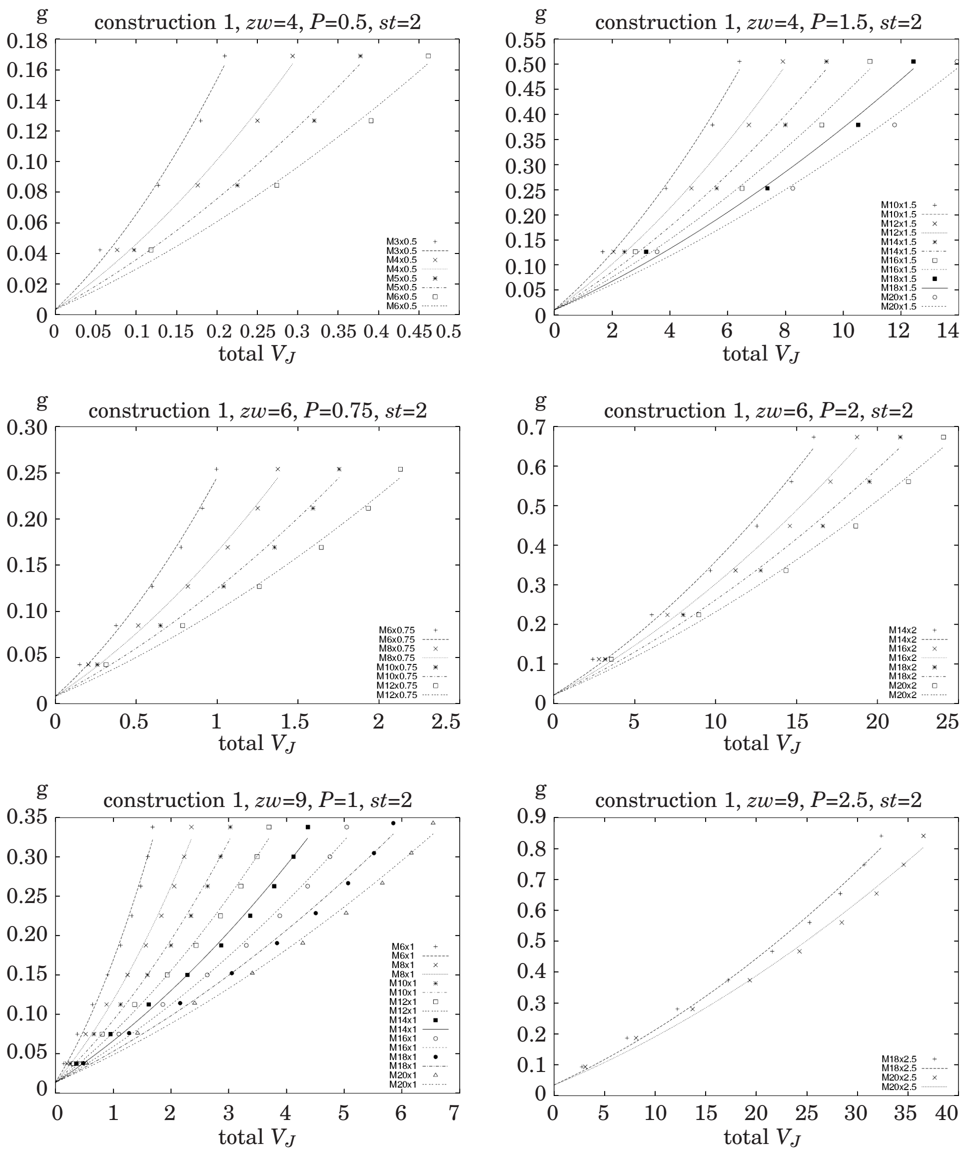

Fig. 5. Dependence of die thread penetration on the volume of displaced material

are shown, as an example, in Fig. 5 for six thread sets and a different number of embossing threads. In each thread set, the threads had the same pitch.

For the group of threads with $P = 0.5$ mm, the equations have the following form:

M3 $g = 1.292(\Sigma V_j)2 + 0.492(\Sigma V_j) + 0.004$,

M4 $g = 0.619(\Sigma V_j)2 + 0.364(\Sigma V_j) + 0.003$,

M5 $g = 0.360(\Sigma V_j)2 + 0.289(\Sigma V_j) + 0.003$,

M6 $g = 0.235(\Sigma V_j)2 + 0.240(\Sigma V_j) + 0.003$.

The function in the form presented above allows the choice of a specified distribution of allowance for a given length lwe, and then the calculation of the value of "g" defining the position of the top of a given thread on the working part of the thread rolling die. To reduce the number of equations, an attempt can be made to determine a relationship in the form $g = f(\Sigma V_j, d, P)$ for each set, which, at the same time, will simplify the program of the computer-aided design of this type of tools.

Summary

The distribution of material allowance onto particular threads, which exists in the design analyzed, assures the correct process of shaping thread. A small allowance at the beginning facilitates starting threading, and the threads in the central part are uniformly loaded, and the volume of displaced material in relation of the last threads decreases again, which has a positive effect as far as the hardening of the top layer of the formed thread is concerned. In addition, the arrangement of thread tops along the generating line cone makes this design technologically easy to execute.

References

ŁYCZKO K. 2003. *The construction of the embossing part of rollers for thread rolling by the longitudinal method*. Computer Integrated Manufacturing. WNT Warszawa, 325-332.

ŁYCZKO K. 2000. *The shape and dimensions of the sizing part of external thread rolling tools*. The International Scientific Conference. Materials Working OM'2000. Volume II, Cracow, 163-170.

ŁYCZKO K. 2002. *The starting diameter of a semi-finished product for thread rolling*. The Third International Scientific Conference. MECHANICS. Scientific Bulletins of Rzeszów University of Technology, Mechanics, 193 (58) 233-240.

Reviewed linquistically by Aleksandra Poprawska Accepted for print 2005.03.03