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Main Problems of Thread Knurling That Affect Product Quality

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Annotation. The article covers the main factors affecting product quality in thread knurling, the main problems of obtaining a high-quality thread by rolling method are considered.

Keywords: threaded connection, thread rolling, roller, defect, knurled tool, blank, threading die, threading machine.

Threaded connections are one of the most known elements in machine parts. The advantage of such elements is high their reliability and durability. This fastening is responsible for the invariance of the position of the part that makes up the assembly unit of any equipment or machine. In addition, the threaded connection is easy to assemble and disassemble, has a wide range of standard sizes of various threaded parts, and is also easily interchangeable. Despite the fact that the threaded connection is regulated by various regulatory documents and standards, they are trying to modify it and develop a new and improved fastening model.

There are several ways to form a thread:

- injection molding, pressing, stamping (depending on the material: metal, plastic, glass);
- rolling, extrusion (by extrusion of screw protrusions);
- electroerosive;
- cutting machining.

The most commonly used thread knurling methods are knurling and cutting [1].

Thread knurling is the processing of a part without removing chips with a force exceeding the yield strength, which makes the process irreversible. The knurled thread has a number of technical advantages, such as:

- thread profile accuracy
- thread strength
- high quality of the side surface
- high speed and performance.

In addition, knurled thread has disadvantages:

- high demands on the plasticity of the material
- high cost of tools and consumables (rollers)

Therefore, thread knurling is used only in cases of large volumes of mass production.

Let us consider the process of thread knurling with rollers. This process is based on the principles of radial feed [2; 3]. Fig. 1 describes the thread knurling process itself: the movable roller (2) is fed towards the blank (3) and the fixed roller (1). Both rollers are equally involved in the formation of the thread. In this regard, the rollers move to the center of the blank at the required distance, which is equal to the height of the thread stem. However, the following condition must be observed: the diameter of the blank must be equal to the average diameter of the thread. The thread itself is obtained when the turns of the rollers come together and are pressed into the blank forming a thread.

The rollers perform the process of rotation only in one direction with a certain identical speed, and force the blank to perform rotational movements without slipping. In order to form the thread during the rolling process, there must be no slip between the blank and the rollers. The blank is installed by the following method: it is installed on the support ruler (4), while it rests with its end against the stop (5). There is a hard alloy plate on the working part of the ruler. This helps increase its durability. During the knurling process, it is possible for the blank to be pushed out of the rollers upwards. To avoid this, it is necessary to

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place the center of the blank higher than the centerline of the roller by about 0.1 - 0.3 mm for screws and 0.2 - 0.9 mm for taps. A ruler helps the blank to be between the rollers during the rolling process. When thread formation is completed, the radial feed stops, but the rollers continue to calibrate the thread in order to increase the surface cleanliness and compaction.

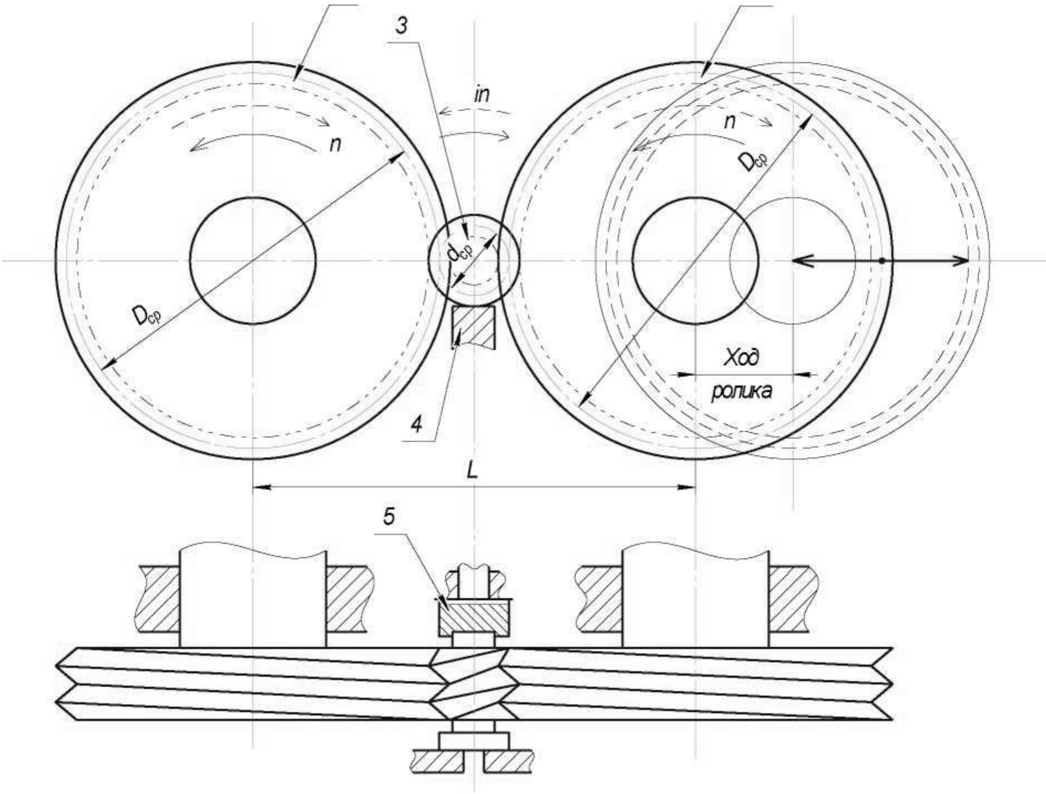

Fig. 1. The process of thread knurling with the roller.

During the rolling process, the movable roller and the blank must be thoroughly cooled with sulfofresol or spindle oil.

Prediction and classification of emerging defects during thread rolling is one of the main elements of modern technology for the production of fasteners, which allows ensuring the required quality.

During the rolling process, a cylindrical blank, which has an equal outer diameter with an average thread diameter, performs rotational movements between the working surfaces of the tool having a given profile. The threaded ridges of the rolling tool are smoothly introduced into the surface layer of the blank, thus forming cavities, and the extruded metal is displaced in the radial direction, forming thread ridges on the blank.

To obtain a threaded profile on fasteners, a variety of thread knurling tools are used: thread-rolling flat dies, roller-roller and roller-segment. The designs of the thread-forming tool are vary and depend on the type and manufacturer of the tool.

In flat dies, as a rule, three working zones are used: the intake zone, which provides capture of the blank and preliminary profiling; a sizing zone that provides the final geometric dimensions of the thread; a reset zone that allows releasing the blank from the threading tool without sticking.

In thread knurling rollers and roller segments, there may be no strict division into working areas.

The defects that are present in practice during thread knurling are associated with mechanical action in this process. During the rolling process, the following defects may occur:

- chipping of metal;
- metal peeling;
- metal flaking;
- tearing out the surface layer of metal;

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- cracking of metal;

- the formation of surface defects (laps, folds, layers, burrs, etc.), which can affect the statistical and cyclic strength of the thread connection.

One of the main reasons for the formation of defects during the mechanical knurling process is the conditions for the formation of thread profiles. The thread profile is created by repeatedly and sequentially copying the tool profile (moving and stationary dies, rollers, roller and segment).

The extrusion of the profile is carried out in connection with the redistribution of the elementary volumes of the metal of the blank under study, which are displaced by the working coils of the thread knurling tool. In this case, the surface of the extruded thread is in contact with the working surface of one, and every half a turn with another part of the tool.

It can be assumed that in the process of extrusion of the profile, the appearance of symmetric and asymmetric deformation is possible. The appearance of these deformations depends on the paths of the working turns of the tool along the surface of the thread being rolled. They either match or they don't.

During symmetrical deformation, defects can form at the top of the full thread profile. In addition, defects can appear in various places of the thread profile. It depends on how much the top of the tool profile will be displaced in each deformation cycle of the blank body.

In practice, the violation of the symmetry of the deformation of the metal, during thread rolling, occurs in the following situations:

- due to inaccurate adjustment of the threading tool, that is, the installation of a tool with an incorrect offset along the thread pitch;

- due to the low quality of the thread-knurling tool, both in terms of the thread pitch, and in the shape of the profile and the angle of inclination of the turns;

- because of knurling with complete filling of the profile of the turns of the thread-knurling tool;

- with insufficient accuracy and rigidity of the design of the thread rolling machine.

Inaccurate adjustment of the machine, especially the installation of a thread-knurling tool along the end run out and thread pitch, violates the symmetry of the metal deformation, since the paths of the tool turns do not match [4]. These actions lead to the creation of large defects, such as laps, folds, layers, etc.

Practice has shown that a threading tool, which has an error in the angle of elevation of the working turns or in a step, regardless of the degree of filling of the tool contour, forms surface defects in the form of various folds.

This is because that during each cycle of creating a thread profile, the top of the coil of one threading tool from a pair is displaced relative to the other.

The interruption of the fibers and the appearance of surface defects (e.g. laminations) at the root of the turns are due to the flow of surface layers of metal in the filled axial direction contour during thread rolling. These defects also appear if any other causes that accompany the asymmetric deformation of the metal during the formation of the thread profile are eliminated.

From the foregoing, it can be concluded that the formation of surface defects is affected by the divergence of the paths of the working turns of the tool along the surface of the blank, which violates the symmetry of the deformation of the metal by rolling in the filled contour of the working turns of the tool, leading to axial displacement of the metal layers on the surface [5].

Rolling and wrinkling on the flanks of the thread profile and on the inner diameter of the thread occur in most cases because the setting of the thread rolling tool does not provide the same insertion of the tool parts into the surface of the blank.

This defect occurs both when using flat dies, and when forming a thread using rollers and segment rollers.

As a result, the thread profile previously rolled by one part of the tool is subjected to lateral displacement by the other part of the tool.

In the process of thread rolling, such a defect can be constantly repeated, since the rolling that occurs on the flanks of the thread profile propagates in a spiral manner up to the radius of the base.

The occurrence of such a defect is due to the following reasons:

- inaccurate setting of the thread-forming tool;

- different angles of inclination of the thread on the used thread-forming tool;

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- large backlash in the calipers for fastening the thread-forming tool;
- discrepancy between the diameters of the thread-forming rollers working in pairs.

Rolling, in other words, the formation of folds on the sides and based on the thread profile, reduces its fatigue strength. As a result, defects of this kind that occur on threaded connections cannot be normalized only by the tolerance field.

One of the most important conditions for quality assurance in thread knurling is the correct choice of rolling modes: forces, speeds and feed rates. These parameters largely depend on the dimensions of the rolled thread and the mechanical properties of the rolled material.

The quality of the knurled thread and its accuracy depend on the circumferential speed, on the rolling time, and on the radial feed rate of the tool.

With an increased speed and feed rate, peeling is observed, and even detachment of the thread from the body of the part during mechanical tests.

Such defects are formed during external action and are not associated with the mechanical process of plastic deformation during thread knurling, so the causes of their formation can be distinguished into a separate group.

These damages appear during the destruction of the threaded tool turns. Small chips significantly increase the surface roughness of the rolled thread cavities, large ones form critical surface defects.

Minor mechanical damage is also possible. They appear due to the ingress of various solid particles into the contact area of the thread forming tool and the blank. Such particles can be any small chips, abrasives or something else. These materials may be in the cutting fluid or directly on the surface of the blank or tool being machined.

Scratches, nicks and other defects, as a rule, are formed because of the collision of parts when falling at high speed into a technological container.

It should also to draw attention to surface defects present on the blank, their appearance will be slightly changed due to metal deformation during the rolling process, but they will inevitably remain on the thread of the finished product.

With significant defects on the surface of the blank, such as stamping cracks, hair crack, laps, etc., high-quality thread production may be impossible.

From the foregoing, we can conclude that the main factors affecting the quality of the product during thread rolling are:

1. The quality of the material used;
2. The quality of the blank for thread knurling;
3. Quality of manufacture of the applied thread-forming tool;
4. The quality of the setting of the thread knurling machine and the quality of the setting of the thread-forming tool (qualification of workers);
5. Selection of optimal thread rolling modes, depending on the parameters of the material used and the quality of the blank;
6. Technical condition of the equipment.

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