GRANT journal
ISSN 1805-062X, 1805-0638 (online), ETTN 072-11-00002-09-4
EUROPEAN GRANT PROJECTS | RESULTS | RESEARCH & DEVELOPMENT | SCIENCE

Unconventional methods of thread measuring and checking

Alžbeta Archalousová[1]
Jaroslav Fábera[2]
Veronika Šulcová[3]

[1] Center of Engineering Research Development, VÚTS, a.s., Svárovská 619, 460 01 Liberec XI – Růžodol I, alzbeta.archalousova@vuts.cz
[2] Center of Engineering Research Development, VÚTS, a.s., Svárovská 619, 460 01 Liberec XI – Růžodol I, jaroslav.fabera@vuts.cz
[3] Center of Engineering Research Development, VÚTS, a.s., Svárovská 619, 460 01 Liberec XI – Růžodol I, veronika.sulcova@vuts.cz

Grant: LO1213
Název grantu: Excelentní Strojírenský Výzkum
Oborové zaměření: JQ Strojní zařízení a nástroje

Abstract Determining the definition dimensions of metric thread by conventional methods, such as by a micrometer or a gauge, is for external threaded bolts relatively accu-rate and reliable. For internal threaded nuts, procedures are slightly more compli-cated. The specification of this work is to use an unconventional means of thread measuring in the form of visual inspection made on the In-Sight Explorer soft-ware platform of a Cognex industrial camera. Specifically, using inspection, the problem of the incompatibility of metric thread is investigated here when the thread in nuts does not correspond with the bolt. It is not possible to screw the bolt; therefore, the joint does not do its job. Internal and external metric threads were measured when using the geometric and measure-ment functions of the In-Sight Explorer, aimed at obtaining clear results that could be the basis for determining the cause of thread incompatibility, which succeeded in the end.

Key words machine vision, metric thread, measuring, Cognex In-Sight

1. INTRODUCTION

Metric thread is one of the most used joints in these latitudes. This joint is formed by screwing the external threaded bolt and the internal threaded nut. The thread is characterized by its D diameter and thread lead. The just complicated verification of those parameters with internal threads and the specific case of the problem of incompatibility of external and internal threads has led to examining the use of machine vision as a possible alternative of measuring internal threads.

With physical parts, a problem of thread incompatibility occurred that was neces-sary to be solved. The thread in nuts on a sheet metal part did not correspond with the bolt. It was not possible to screw the bolt and thus, the joint did not fulfill its function. The entire article on the possible use of camera inspection to measure internal threads will be related to this case due to a better demonstration of the results.

1.1 Metric thread definition

The thread shape and dimensions are defined by the ISO 68-1 standard [3]. Its specification is given in Fig. 1.

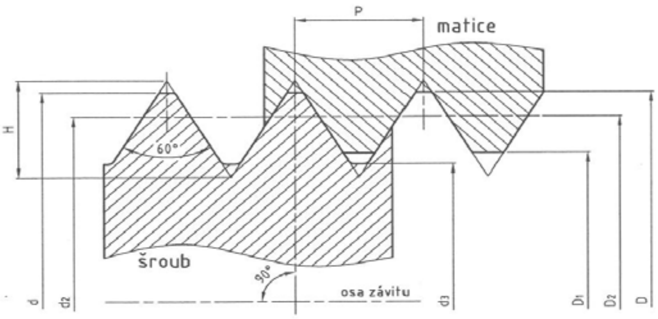

Fig. 1 Metric thread definition [1]

- D Nut internal thread large diameter (nominal diameter)
- D_2 Internal thread mean diameter
- D_1 Nut internal thread small diameter
- P Thread pitch
- H Unit triangle height (thread carrier depth)
- d Bolt external thread large diameter (nominal diameter)
- d_2 External thread mean diameter
- d_3 Bolt thread core diameter (sometimes referred to as a small diameter as well)

2. THREAD MEASURING USING A MICROMETER

As outlined in Paragraph 1, identifying the definition dimensions of internal threads is much more complicated than those of external threads. Therefore, for the problem of thread incompatibility, it is the easiest to measure the parameters of external thread with conventional methods. The bolt large diameter was verified by a micrometer and at the same time, the bolt lead (pitch) was checked using a comb thread gauge. The measured values: $d = 6\,\text{mm}$, pitch $P = 1\,\text{mm}$. According to the measured bolt dimensions, other definition dimensions will be de-termined from the machine tables.

From the found out values it is obvious that we should approach the tabular values (Tab. 1) which describe nuts and bolts in a size of M6×1. [6]

Bolt and nut dimensions in a size of M6×1 [mm]					
$D = d$	$P = P_h$	$D_2 = d_2$	$D_1 = d_1$	d_3	H
6	1	5,35	4,917	4,773	0,866

Tab. 2 Tabular values for bolt and nut

P_h lead is equal to P pitch. Designation d_1 is the small diameter of the bolt external thread.

3. THE BRIEF DESCRIPTION OF AN INDUSTRIAL CAMERA AND ITS SOFTWARE PLATFORM

The Cognex industrial camera works on a visualization platform of the In-Sight Explorer software. In this case, the Cognex 5100 C type with the Computar manual lens and the In-Sight Explorer 4.9.1 software version were used.

When measuring with the help of an industrial camera, a very important factor is capturing pictures of sufficient quality, on which various software filters can be applied that will adjust the image for subsequent inspection. The data are pro-cessed in the visualized environment of In-Sight Explorer whose sophisticated system comprises a plurality of functions allowing precise identification (shapes, characters, colors, codes) and measurement. These can then communicate via discrete I/O, Ethernet or an industrial fieldbus with other functional devices (PLCs, robots, other cameras). In this task, the possibilities of evaluation are demonstrat-ed, using In-Sight Explorer's geometric tools. Samples for measuring the definite values of nut threads were cut in a Fanuc instrument with a brass wire in a diame-ter of 0,25 mm for measurement procedure by means of a Cognex camera sys-tem. Gradually, four of them were captured along the axis of the cut nut. An ex-ample of the prepared sample is presented in Fig. 2.

4. MEASURING USING THE IMAGE INSPECTION

Measurement was carried out using simple inspection in applying geometric and measurement functions offered by the In-Sight Explorer environment, functions were applied for the most accurate reading of the thread definition dimensions as shown in Fig. 2.

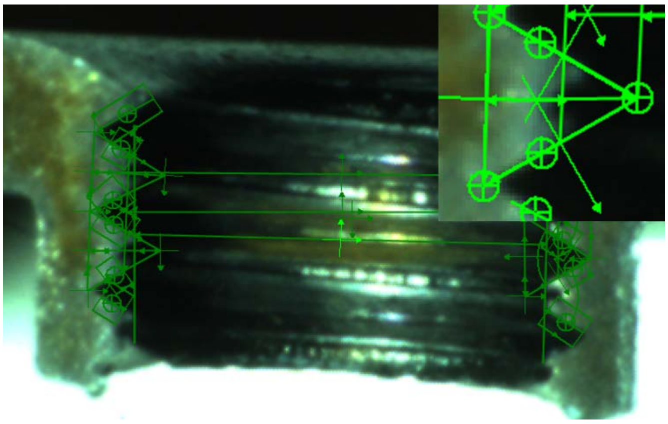

Fig. 2 Application created in the In-Sight Explorer environment with a measurement detail of one tooth

Geometric functions allow spacing (interlaying) points and edges that are detected automatically from the scanned image. After calibration, it is possible to measure distances, angles, diameters, curvatures, etc. with a program. By the process of calibration, to a certain number of pixels, the distance in their measurement units, in mm in this case, is assigned.
The functionality of the entire application is conditioned by ensuring the constant lighting terms to capture images of the most possible similar quality. It is caused by the need of measuring really very small details and any unevenness greatly affects the results, as well as the detection of the thread itself.

A certain measurement error can be entered by cutting which could deviate from the originally planned cut through the thread axis. This deviation is also measured by inspection using Cognex visualization tools.

In Fig. 3, there is shown an inspection for detecting the cut deviation from the nut axis.

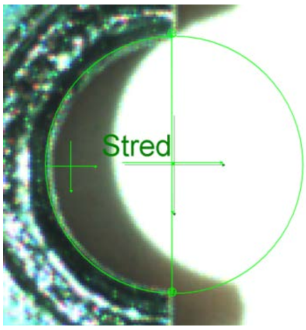

Fig. 3 An application for detecting a cut deviation

It was used a simple tool – point definition from the scanned hole through which a circle was spaced (interlaid); from the distance between the center point of this circle and the center point of the distance of the end points of the hole it is calcu-lated the cut deviation. It results from the inspection that the cut is not led through the center with a deviation of 0,1 mm, which represents an average difference in a value of 0,020 mm of the measured diameters according to Fig. 2. Thus, diameter measuring is loaded with an error of 0,40% and its relevance is neglected in the resulting measured values.

The cut deviation from the axis (misalignment) is very similar for all samples; at the same time, the pictures of all samples were captured under the same lighting conditions. Therefore, the following tab. 2 compares the average measured values of the nut thread obtained by an inspection with the tabular values and their tolerance is mentioned. Tolerances are determined by tolerance grades and the positions of tolerance zones (fields). Among others, tolerances are set by the ČSN ISO 965-1 standard [4], in this case, tolerance for M6 internal thread (nut) is 6H.

Nut thread tolerance [mm]					
	D	D_1	D_2	H	$P = P_h$
Tabular value	6	4,917	5,350	0,866	1
Average measured value	5,737	4,720	5,139	0,828	0,991
Measured difference	-0,263	-0,197	-0,211		
6H tolerance (upper deviations)	-	0,236	0,150		

Tab. 2 Quantifying the results measured versus tabular values and internal thread tolerances

In the Table, there are shown the upper deviations from the diameters only since the lower deviations of H tolerance zone are zero. D and D_1 values are calculated from the well-known relations resulting from fig. 1, particular conversion relations are depicted by the ČSN ISO 68 – 1 standard [3] and expressed as follows:

$$D = D_N - \frac{2H}{8} \quad (1)$$

$$D_1 = D_{1N} + \frac{2H}{4} \quad (2)$$

D_N and D_{1N} are values read by spacing (interlaying) the angle top points of indi-vidual thread teeth into the unit triangle, but in practice, a similar shape of thread profile is not accessible or usable, therefore, distances for both external and inter-nal threads were introduced. Those distances are converted and related to the H unit triangle height, and the result are just definition values of D, D_1 nut large and small diameters and those of d, d_1 bolt, which are numerically equal.

From the measured values of nut thread, deviations from the tabular values are obvious, which occur with D_1, D_2 small and mean diameter (D_2 – in the inspection, expressed geometrically as a ½ of H unit triangle height). Even taking into account an insertion of errors of both the cut deviation from the thread axis and an inadequate one-point lighting, when the emerging shadow optically distorts the resulting plot of contours in the image, we can consider the measured differences in D_1 and D_2 values as a reason for the problem when the nut does not correspond with the bolt. From the difference of the values in the tab. 2 it is evident that D_1 and D_2 nut measured values do not fall into 6H small and mean diameter tolerance for M6×1 internal thread, thus, the problem of incompatibility of bolts and nuts is actually based on the improperly manufactured internal thread, where 6H lower tolerance is zero, whereas in the measured difference, we will get into negative numbers in comparison with the tabular values.

5. CONCLUSION

The use of an industrial camera together with its visualization tools has its foundation in thread measuring. In an illustrative example, using a camera inspection, it succeeded in obtaining the sufficiently accurate data, demonstrating the cause of a particular problem of incompatibility of external and internal metric thread. It should be noted that any algorithm that is comprised in the visualization tools is evaluated from the groups of pixels that the camera will scan in the similar color spectrum and the presence of shadows or other negative phenomena greatly affects the resulting values. When using a more appropriate lighting, for example, a circular LED lighting that would appropriately shade the scanned object, even more precise and satisfactory results can be achieved. To obtain a suitable image of the nut internal thread from which it is possible to read the required data it is necessary to cut the thread along its axis. It is therefore a destructive method, rather suitable for analytic measurements, for examining deficiencies in the initialization of a new manufacturing facility or innovation of manufacturing processes. For routine thread checking it is better to use a caliber.

References

1. Admin E - ekonstruktér - Metrický závit - rozměry [Online], [26_07_2014], dostupné z: http:// e-konstrukter.cz/prakticka-informace/metricky-zavit-m0-25-m600-rozmery
2. Šulc J a kol. Technická a strojnická měření, Praha : STNL, 1986.
3. ČSN ISO 68 - 1 // Závity ISO pro všeobecné použití - Základní profil - Část : Metrické závity,: Český normalizační institut, Srpen 2000.
4. ČSN ISO 965 - 1 Metrické závity ISO pro všeobecné použití - Tolerance - část 1 Základní pravidla a údaje, Český normalizační institut, Srpen 2000.
5. ČSN EN ISO 4762 Šrouby s válcovou hlavou s vnitřním šestihranem, Český normlizační institut,. - Srpen 2004.
6. Leinveber J Vávra P Stronické tabulky. - Úvaly : Albra - pedagogické nakladatelství, 2003.