STANDARDIZATION IN THE FIELD OF MACHINE ELEMENTS AND DESIGN

Ivan Simonovic, Pavle Ljubojevic, Tamara Vasiljevic
Faculty of Mechanical Engineering, University of Belgrade, Serbia
isimonovic@mas.bg.ac.rs

Abstract. *This paper presents a study of machine elements and design standardization. The primary objective of the standards is to eliminate discrepancies between subjects and concepts that serve the same function. This paper aims to catalogue the ISO technical committees that operate in these fields. There are 12 technical committees, with 256 published standards, 68 under development, 587 withdrawn projects, and 7 projects that have been deleted as of the publication of this report. In addition to the committee's review, the most essential and widely used standards for general-purpose machine elements, including screw threads, rolling bearings, plain bearings, and gears, are provided.*

Key words: *standardization, ISO, machine elements, machine design*

1. INTRODUCTION

Standardization of components and product quality is one of the pillars supporting the success of businesses engaged in the design of mechanical systems and elements. Standardization is defined as a set of inter-dependent protocols and activities that lead to the consolidation of the most common solutions. By using standardization, every task is performed according to precise protocols, which improves not only security but also lower costs by lowering scrap [16]. Standardization and its benefits, which are evident in nearly every aspect of daily life, are ensured by numerous international standards; machine elements and systems are not an exception.

The most important and internationally recognized standards are International Organization for Standardization (ISO) standards. To ensure and enforce international ISO standards, and consequently improve trading potentials of the country, standards are further elaborated and find their place in national and union-level legislation. Thus, we have European Committee for Standardization (CEN) standards, which are relevant at the EU level, and national standards such as ISS - SRPS (Institute of Standardization of Serbia – Serbian standards) in Serbia. About the importance of standardization speaks the fact that compliance with Europe's technical legislation, which is predicated on standardization, satisfies one of the four conditions for the free movement of goods within the EU market. The International Organization for Standardization is the most significant organization for developing and disseminating international standards. The organization was formed at a conference held in London from October 14 to October 26, 1946, by the merger of two organizations, the ISA (International Federation of the National Standardization Associations), founded in New York in 1926, and the UNSCC (United Nations Standards Coordinating Committee) founded in 1944 in London [14]. There are two versions of how the ISO acronym is chosen. According to the organization's website, the term ISO was chosen based on the Greek word "isos," which means equal. Preference is given to the ISO term because 'International Organization for Standardization would have different acronyms in different languages. However, in the book [14] published by the organization itself, where the English author Jack Latimer was entrusted to systematize the organization's first fifty years from 1947 to 1997, it is explicitly stated that the term "isos" was not discussed at the conference in London.

Attempts at standardization began centuries before the formation of the ISO. When discussing the standardization of machine elements and design, the Crimean War of 1885 and British efforts to construct 90 marine engines in 120 days must be mentioned. At the time, its aim was improbable. However, John Penn, on the other hand, devised a strategy to deconstruct one marine engine and ship its components to manufacturers throughout England in order to accelerate manufacturing. This is considered the beginning of production standardization, which was based on standardized machine elements. However, the standardization of machine elements can be traced back to the past even further. In 1845, screw joints were standardized in England by a British toolmaker named Joseph Whitworth. He was the first to standardize screw threads, which are now known as British Standard Whitworth (BSW) screw threads, in his honor. On November 18, 1848, a document titled the Declaration of Accord with respect to the Unification of Screw Threads formalized the unification of the American standard with the European standard [18].

The rapid development of 21st-century technology and the implementation of Industry 4.0's fundamental concepts have created new production, improvement, and distribution challenges. Standardization, as one of the most important components of interconnection, is required for the implementation of existing technologies and the development of new ones in numerous fields. Consequently, numerous studies have been written on the standardization of areas of interest. In the study [1], the authors attempted to resolve the issue of gearbox and gear tooth rating standards for selecting appropriate gearboxes based on power transmitting ability. In order to optimize the selection of the appropriate gearbox, this paper presents a comparative analysis of the problem according to the currently applicable standards in this field - the standards issued by the American Petroleum Institute (API), the American Gear Manufacturers Association (AGMA), the International Organization for Standardization (ISO), and the German Institute of Standardization (DIN). In addition, they reviewed changes to the ISO and API standards that will be implemented in the near future.

In paper [11], the current state of Geometrical Product Specifications (GPS) standards, which belong to the ISO/Technical Committee (TC) 213 and are crucial to the globalization of design in the context of Industry 4.0, is explained. The purpose of the study was to demonstrate trends in GPS standardization that are continually evolving and developing in order to standardize technological communication all across the world. To do so, the paper investigated arbitrary standards. In their study [12] the same authors provided an assessment of the situation after ten years, with an emphasis on recent changes in the standardization of GPS. The authors presented not only a systematic approach to the construction of a coherent system of GPS standards but also the faults and limits of various standards.

The development and standardization of the formula for calculating the working life of a deep groove ball bearing were investigated in a study [15]. In this study, the authors tracked all improvements related to increasing the accuracy of the formula, keeping it up to date with the most recent research. They are also providing an examination as well as the development of the formula that is used to calculate the working life of a deep groove ball bearing, beginning with its definition provided by A. Pelmegren more than seven decades ago and ending with the most recent standard ISO 281:2007. This standard was established in 2007, and it was reviewed again in 2021; nevertheless, it wasn’t changed [8].

In the publication [17], a full description of the revisions to the ISO 6336 - Part 3 standard related to the analysis of the tooth-bending strength of involute gears is provided, with the introduction of a new factor relating to load distribution being the most noteworthy. This paper's research sheds light on the influence of the standard on the more precise and reliable calculation of load carrying capacity.

The purpose of these review was to gain a comprehensive understanding of the standardization of specific machine elements and design-related subfields. In the following chapters, ISO standards relevant to machine elements and construction will be reviewed, with a special highlight and interest for machine elements for wide usage.

2. ISO AND DESIGN OF MACHINE ELEMENTS

Development of standards and strategic technical issues are entrusted to 258 ISO technical committees. The committees listed in Table 1 perform in the field of mechanical elements and design. The table indicates that there are four possible statuses for a standard: published, under development, withdrawn, and deleted. If at least five countries do not adopt the standard, it cannot be called international and is withdrawn. In addition, the standard may be withdrawn if it does not reflect the current state of practice and research, if it does not relate to new and existing usage, or if it does not meet

quality, safety, or environmental standards. The use of withdrawn standards is permissible if there is no suitable successor, notwithstanding the fact that the withdrawn standard is no longer applicable at the international level and no further maintenance or upgrading is performed. Every five years, the standards are reviewed and amended [7].

Table 1. ISO standard status review (machine elements and mechanical design)

ISO standards				
The technical committee	P u	S f	W i	P
ISO/TC1 Screw threads	28	4	24	0
TC4/Rolling bearings	61	8	68	2
TC 14/Shafts for machinery and accessories	4	0	16	0
TC 41/Pulleys and belts (including veebelts)	76	10	116	0
TC 60/Gears	41	7	39	1
TC 98/Bases for design of structures	21	1	20	0
TC 100/Chains and chain sprockets for power transmission and conveyors	15	0	28	0
TC 105/Steel wire ropes	22	4	23	0
TC 111/ Round steel link chains, chain slings, components and accessories	21	1	19	0
TC 123/Plain bearings	86	15	101	3
TC213/ Dimensional and geometrical product specifications and verification	141	16	132	1
TC 227/ Springs	10	2	1	0

The status of the first committee was given to the technical committee dealing with screw threads due to the wide use of screw threads in all fields of industry. The importance of threads is reflected in the fact that they can be assembled and disassembled, which further enabled designers and manufacturers to design complicated mechanisms and machines. Terms, definitions, symbols, basic dimensions, tolerances, etc. are defined for 4 types of threads included in the standard. The most used standards in this area are:

- ISO 68-1: ISO general purpose screw threads — Basic profile — Metric screw threads,
- ISO 261: ISO general purpose metric screw threads — General plan,
- ISO 262: ISO general purpose metric screw threads — Selected sizes for screws, bolts, and nuts,
- ISO 965: ISO general purpose metric screw threads — Tolerances.

The growth of the industry brought the need for ISO standards in areas that are not yet covered, such as Metric threads with transition fit, Metric threads with interference fit, and Assistant standards for screw threads such as the designation of screw threads and gauging systems of screw thread [2].

The standards of all types and dimensions of rolling bearings, as well as their elements such as balls, and cages, belong to the ISO/TC 4. They are standardized on the principle of rolling motion, their accessories, application, and performance criteria. Without standardized terms and technical characteristics, and above all the dimensions, interchangeability would be impossible, which would represent a big problem in the production of several billion pieces per year. One of the tasks of the committee is the application of GPS, wherever possible, then the improvement of the methodology for calculating bearing load carrying capacities and live predictions, as well as the standardization of terms. The committee is divided into 7 subcommittees due to the interdependencies between the different projects [4]. Important standards in this area are:

- ISO 76:2006 which specifies methods of calculating the basic static load rating and the static equivalent load for rolling bearings within the size ranges shown in the relevant ISO standards [13],
- ISO 5593:2019: Rolling bearings — Vocabulary, this document establishes a vocabulary of terms, with their definitions, applied in the field of rolling bearings and their technology [9].
- ISO 464:2015 specifies the snap ring groove dimensions and tolerance values, chamfer dimensions on the snap ring groove side of the outer ring, and the snap ring dimensions and tolerance values for radial bearings [10].

Gears have found use in a variety of industries across the globe, so their demand as spare parts is extremely high. Because gears frequently operate under extreme conditions, they must be designed, manufactured, and measured using standardized methods [3]. The TC 60 is responsible for gear standardization, including terminology, nominal dimensions, tolerances, and manufacturing and control tools [5]. TC 60 has two

subcommittees, the first deals with nomenclature and wormgearing and the second with gear capacity calculation. The essential standards in this field belong to ISO/TC 60/SC 2/WG 6 and refer to gear calculation, namely a group of 11 standards covering the calculation of load capacity of spur and helical gears. In addition to spur and helical gears, the subcommittee standards ISO/TC 60/SC 2/WG 13 and ISO/TC 60/SC 2/WG 14 cover bevel gears as well as the strength and quality of materials used in the production of gears.

Sliding bearings are used in almost all types of machines and are widely distributed throughout the world due to their simple design, compact size, and excellent performance characteristics. Standardization was required for the following aspects of these machine elements: classification, definitions, and terminology; materials and characteristics; dimensions and tolerances; methods of tests and quality control, including methods of calculation [6]. There are six subcommittees devoted to bearings. ISO/TR 27507:2010 gives recommendations for automotive crankshaft bearing environments; 6 standards that belong to ISO/TC 123/SC 6 refer to Terms, definitions, classification, and symbols of plain bearings; and standards that belong to ISO/TC 123/SC 8 and refer to calculation methods for plain bearings and their applications are the most frequently used standards.

3. CONCLUSIONS

The significance of standards has been acknowledged for a century, and most nations have had national standardization agencies for even longer. In the field of machine elements and design, the ISO standards family is always evolving and developing. This study demonstrates that the ISO standards in this domain encompass a vast array of applications, calculations, and laboratory testing methodologies. Standardization has enabled greater innovation, the solving of everyday problems, and the exchange of technology, thus enhancing the efficiency of product development, production, and exchange.

REFERENCES

[1] BECKMAN, Ken, et al. Review Of API Versus AGMA Gear Standards-Rating, Data Sheet Completion, And Gear Selection Guidelines. In: Proceedings of the 29th Turbomachinery Symposium. Texas A&M University. Turbomachinery Laboratories, 2000.

[2] https://isotc.iso.org/livelink/livelink/fetch/2000/2122/687806/ISO_TC_001__Screws_.pdf?nodeid=4938938&vernum=-2

[3] https://isotc.iso.org/livelink/livelink/fetch/2000/2122/687806/ISO_TC_060__Gears_.pdf?nodeid=1162299&vernum=-2

[4] https://www.iso.org/committee/45544.html

[5] https://www.iso.org/committee/49212.html

[6] https://www.iso.org/committee/52090.html

[7] https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100413.pdf

[8] https://www.iso.org/standard/38102.html

[9] https://www.iso.org/standard/50185.html

[10] https://www.iso.org/standard/60130.html

[11] HUMIENNY, Zbigniew. State of art in standardization in GPS area. CIRP Journal of Manufacturing Science and Technology, 2009, 2.1: 1-7.

[12] HUMIENNY, Zbigniew. State of art in standardization in the geometrical product specification area a decade later. CIRP Journal of Manufacturing Science and Technology, 2021, 33: 42-51.

[13] ISO 76: 2006. Rolling bearings-static load ratings. 2006.

[14] LATIMER, Jack. Friendship among equals. Geneva, ISO, 1997.

[15] LAZOVIĆ, Tatjana; TOPALOVIĆ, Ivana. Evolution of rolling bearing life rating through the standardization. Machines. Technologies. Materials., 2020, 14.6: 222-225.

[16] MĹKVA, Miroslava, et al. Standardization–one of the tools of continuous improvement. Procedia Engineering, 2016, 149: 329-332.

[17] SENDLBECK, S., et al. Effect of the ISO 6336-3: 2019 Standard Update on the Specified Load Carrying Capacity Against Tooth Root Breakage of Involute Gears. In: *Fall Technical Meeting 2021*. 2021.

[18] WERTHEIMER, E. G. New screw thread standards. *Science*, 1949, 110.2850: 155-159.