Original Research

The effects of designing quality management technical standards on product maturity and excellence

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Abstract
Due to the development of specialized quality management standards and the importance of product design and development in design and manufacturing organizations, the need to use them correctly and appropriately could help grow and improve the overall quality of the product. For this reason, in this article, we have focused on product design and development requirements in these technical quality management standards. Our methodology is the combination of careful study and numerical methods for analyzing the impact and overlap of the product design and development clause in technical quality management standards that have led to the proper choice of standard and the correct sequence of implementation for product excellence and maturity and the impact of each of these standards in the product's maturity. Our most important findings are the weight of each of these standards on the maturity and quality of the product and the amount of growth resulting from the correct order of use in a defined period that can create up to 70% growth in product quality. Because product design is a specialized and complex process, these findings help better understand practical requirements and provide a consistent logical path to growth and overall quality based on these recommended standards that are worth using in organizations without considering the scope of their activities.

Keywords- Management System; Product Quality; Product Development; Quality Standard; Excellence

INTRODUCTION

International Electrotechnical Commission (IEC) defines the design review to ensure that the design scope is specified & followed with its specifications for good design. Before designing the details, ensure that the design team members have first-hand knowledge of all the rules. Definition of documents scheduled for submission and approval between the parties; at the appropriate points while designing the components, check all the interface provisions and agree on it. Test methods to verify compliance of the design with the contract's requirements [1]. An optimal design based on the original models has only limited effects for estimating two-factor interactions, while the robust designs provided in the presence of two-factor interactions perform well [2] [3]. Also, important design factors in quality management standards are visible. Research has been done in the past in terms of the impact of ISO 9001 standard on the quality of defense suppliers' products, and ISO

9000 defines the design and development set of processes that transform requirements for an object into more detailed requirements [4] [5].Most organizations have either a quality checking facility in-house or outsourced or third-party testing laboratories. Good quality documentation processes are followed & shown an above-average consciousness of the respondent organizations towards customers [6]. ISO 9001, ISO 13485& ISO/TS 16949 have affected the emergence of industrial property rights [7]. Design and development focus on market research, identifying new products, product engineering & design, prototype development & product testing [8]. Montgomery and Borror discussed the foundations of Schwartz's work and his influence on other leaders in the field. Planning-Do-Check-Act (PDCA) by Deming becomes the Definition-Measure-Analysis-Improvement (DMAIC) process that is a part of QMS [9]. The technical standards' product design section (design planning, design inputs, design outputs, design review, design verification, design validation, and design change) was introduced for reviewing them with an engineering design approach [10]. IATF 16949 is a quality management system for design, development, production, assembly, fittings, and service, automotive products, including products with embedded software that divides the same section titles and paragraph structure with ISO9001: 2015 [11] [12]. ISO13485 specifies risk-based applications, evaluation of risks & opportunities, actions taken for controlling risk, and periodic decision-making levels [13]. Do-It-Yourself (DIY) is a process in which the end-user designs and builds a product for personal use instead of commercial production. This type of design and construction is mainly used in medical equipment by physicians who produce valuable artifacts with limited resources [14]. Niu et al. found that more factors affect the product; they mainly influence product design quality depending on quality control, quality management, and assurance policies [15]. In the epistemological design method, procedural aspects of the design process are integrated with the structural elements of the design problems. The structure could be presented in the QMS in the design department [16]. Addressing the unique challenges associated with quality engineering of manufacturing processes is critical to ultimate success. This review provides an overview of quality-related issues for processes and products, focusing on opportunities and challenges in quality inspection, monitoring, control, optimization, learning transfer, and building-to-product quality through design. This structure is also significant in technical quality management standards [17]. In design, following customer requirements and innovation and quality management are emphasized in particular [18]. Atman shows that people with more expertise have more complex processes, consider a more comprehensive range of information, spend more time solving the problem. It has indicated the pattern of the waterfall in the design process. It provided a single research method for creating a visible design plan for telling a fixed story about design processes by trained designers [19]. A three-phase implementation methodology for achieving sustained success, offering helpful, practical relevance for any aerospace industry based on a foundation for future studies in implementation of AS9100 [20]. Peter Lloyd believed design thinking changes cause changes in design systems, which is the change reason and maturity of design disciplines [21]. ISO9001 defined process capability that reduced the ability of the process to deviate from its goal and is an important issue in process design that underlies quality management system standards [22]. They provided a method that evaluates and improves the perceived quality by examining its needs, which decomposes from the bottom of the initial specifications to a bottom-up sensory approach, covering almost all engineering parameters. It provided the perceived quality characteristics of the relative importance of the ranking, resulting in a balanced perceived quality of the final product [23]. Design framework by experiences and practices of participatory design and analytical insights from actor-network theory analyzes the staging, facilitation, and formulation of negotiations during a collaborative design process [24]. The design team comprises interdisciplinary specialties, described by cognitive hierarchy problems and incomparable categories in a common research topic. If such differences are dealt with sensitively, progress will be made on the common issue [25], why is applicable, given that the technical QMS interdisciplinary. The scope of activities is now much broader; however, one of the main pillars remains the TL 9000 model based on the general requirements of ISO 9001:2015 and adds industry-specific requirements [26]. ISO29001 manages supply chain risks and opportunities associated with the petroleum, petrochemical, and natural gas industries and provides a framework for aligning requirements with complementary standards employed within the sectors [27]. ISO 13485 focuses on a medical device manufacturer's quality management system [28]. This article helped build an array of complementary user views to eliminate previously accumulated knowledge in their business with predictive technology. The overlap between key user profile profiles helps the design team gain an overview to design product features [29]. Wang et al. provided a quality assessment index system that comprises four sub-models of three-dimensional

components: the design model, the process model, the tool model, and the test model. Also, their model works on the degree of quality of indices and fuzzy triangular numbers [30]. Systematic condition-based maintenance programs provide significant benefits to industrial plants. To achieve such benefits, a comprehensive model must be considered that includes the ability to execute, execute, and evaluate program performance. In this paper, a three-step strategy is applied, which first makes it possible to measure the launch of the program, then allows the selection of the most satisfactory forecasting technique based on a fuzzy DEMATEL-fuzzy ANP approach [31]. Engineers must process tools and tolerances that ensure acceptable design goals, so the use of standard approaches in product design increases product capability in the design process [32].

I. Study of product design clause in technical and structure comparison: In this stage, key points and their process performance have been reviewed and determined.

- (2.1) ISO 9001- Quality management standard requirements: In engineering design projects, comprehensive planning is required according to the activities, responsibilities & authorities. The planning document must be continuously reviewed, updated, and recorded. Designers convert design requirements to design inputs in the right & correct way. Design inputs content functional requirements, specific standards, applicable rules, regulatory requirements, and other committed criteria. Also, engineering design inputs that can include the needs and conditions of the customer or consumer, legal requirements, requirements, mechanical engineering principles, and other safety, environmental, and ergonomic issues are considered. This step should ensure that all inputs are defined. Design outputs are established of the conceptual design, embodiment design, and detailed design. In the conceptual design phase, the principle solution is created. In the embodiment design phase, the physical layout of the solution is determined. During the detail design phase, the materials are specified, the production systems are finalized, and lower-level dimensional issues are resolved [33]. Conceptual design is the earliest stage that idea is shaped. The recognized solutions in this sub-process are boundary shifting for delivering the identification of constraints, brainstorming, morphological analysis, and functions tree. In the design control phase, the design review steps are performed, where a systematic assessment of the compliance of the outputs with the inputs is performed. Then in the design validation phase, the design is performed by comparing the invention with similar structures or using the design validation recalculation methods. The next step is to validate the design in operating conditions, which is done by making a prototype and testing it in working conditions. Control design shall be recorded and maintained [34].
- ISO 29001- Quality Management Systems for Petroleum, Petrochemical and Natural Gas Industries Sector: This standard in design and development of the product has the same approach, such as ISO 9001 but has new mandatory requirements for increasing completion in some sections. In the design planning section, all prioritized risks should be identified, managed, and controlled. For design planning, a documented implementation process should be created that shows the design's implementation path. For the determination of design data, consideration of health, safety & environment is mandatory. The risk outputs determined in the design planning should be considered, which indicates the reliance on sustainable product design. Other design requirements are precisely the same as ISO 9001 requirements [35].
- ISO 13485- Medical Device Quality Management Systems: To Pay attention to the product's engineering design with the standard approach of quality management in medical manufacturer industries. In that case, a documented procedure method is required. In design planning, the actions, responsibilities, authorities, review, verification, validation, and tracking of design outputs compared with design inputs and attention to providing the necessary resources in product design, especially to the designer's qualified staff, should be considered. In determining design inputs, it focuses on functionality, functionality, usability, safety, legal requirements and standards, risks, similar designs, and other conditions related to the nature of the product and process, and records must be recorded in the product design documentation. Design outputs must ensure that all inputs are met**.** Any required information related to purchase, production, and related information must be specified through the design outputs stage. All product acceptance criteria and specifications related to proper operation and product safety are defined or referenced**.** In the design review phase, with the participation of influential groups in product design and other related representatives and other experts, the meeting of design outputs to inputs is evaluated through specific and appropriate methods. The quality management standard in ISO 13485 medical equipment, in

addition to the requirements of the ISO 9001 quality management standard, places great emphasis on risk identification and management [36]. There is a need for a written plan in the design verification stage, including work method, acceptance criteria, and statistical techniques applicable to the product volume [37]. If the medical equipment has a shared connection and communication with other medical equipment, the design outputs should be verified in conjunction with requirements interfaces. In the design validation stage, all the verification steps should be performed on one sample or the number of prototypes made. Besides, performance evaluations of legal and standard requirements should be considered. All steps related to design validation before product clearance are completed for full use. A documented method for transferring the design to the manufacturing and production department should be provided to ensure manufacturing the structure. Suppose in implementing any of the steps of review, verification, validation, and transfer to construction. There is a need for design changes. In that case, all actions should be done relying on risk management before implementing the design changes. Design documents should be maintained for each of the medical devices. [38]

- AS 9100- Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations: AS 9100 has all the requirements of ISO 9001, and in addition to the following, it has been taken into consideration. In the design planning phase, all planning activities should be divided into tasks, efforts, and required resources as much as possible. At the design input stage, the potential effects of lack of necessary resources should be considered. The designers should also clearly demonstrate the ability to provide, verify and test products and services. It also used benchmarking, external supplier feedback, and internal data to determine design inputs. In the design control phase, the authority to execute the following design steps should be clearly defined for the design control team. When the testing process is required, test methods, test designs, test factors, acceptance criteria, calibration of test equipment, and measurement and recording of results Tests with traceability to invoices must be performed accurately. In design outputs, specific specifications of components that play a crucial role in component performance are considered, and actions related to these critical specifications must be predetermined**.** Data of design outputs could be in the form of raw materials, parts, engineering drawings, a list of tolerances, product quality plans, specifications of manufacturing and assembly processes, handling, and product maintenance operations throughout the manufacturing and delivery process should be considered. In the design changes, any design changes must be notified to the design customer before implementation. In design changes, configuration management should be considered to identify and track changes and the effects of changes on other related parts. [39]
- TL9000- Telecom Quality Management Systems: The project management perspective defines the critical design planning stage. It is necessary to determine all activities, responsibilities, risks, resources, budgeting, employee competency requirements, related training, and other items such as design for x in the product life cycle. Design planning relies on two fundamental issues: configuration management planning and migration management planning. In the design phase, methods should be created and used to cooperate with customers and suppliers in designing new products. All of the design requirements should be considered, such as functional, quality, and reliability requirements. Safety, environmental, privacy, security, and sustainability requirements are given special consideration**.** Product design needs design conditions for manufacturing, design for assembly, design for installation, design for repair, and design for use. Test requirements, including software and product-related hardware, are considered in the design process. [40]
- IATF16949- Automotive Quality Management Systems: The standard emphasizes creating a product design and development process. Based on the nature and type of activities and their complexity level, make a plan that includes all stages of scheduling design, responsibilities, authorities, and resources. Design planning includes customer and supplier requirements. In this design, items such as advanced product quality planning (APQP), identification and design failure modes and effect analysis (DFMEA), design's project management, risk management in product design, and design for manufacturing and assembly (DFMA) are emphasized as additional requirements. In designing this standard engineering, simultaneous engineering is considered a multi-specialized design, a critical approach. Also, in this standard, particular importance is given to the competence of design's employees, which can be more effective by managing design software. In the design inputs section, functional

requirements, efficiency, legal, contractual, customer, past designs, and potential risks are considered. Designers should also consider other factors such as identification and tracking, packaging, labeling, alternative designs for potential hazards, product protection, reliability, durability, compensation, health, safety, environment & cost. The effects of design inputs can be considered in the design of the production process. These factors are included: design outputs data, special characteristics; Productivity goals, process capability, time, cost, manufacturing technology issues, new materials, and human factors. Special attention to the design for manufacturing and assembly for making a mistake-proofed production process has been recommended. Design control activities, design certification, and practical design validation are performed precisely in the design control department, like ISO 9001. In addition to them, design monitoring on quality risks, costs, waiting times, critical path, and Other measurements is also considered. The design control process, customer requirements, and production parts approval process(PPAP) are also embedded. In the design outputs, the fulfillment of the design input requirements, dimensional specifications, tolerances, product engineering drawings of the product, functional characteristics, packaging and labeling, identification and tracking methods, acceptance criteria, inspection testing methods, and sampling designs are considered. Design changes include all the changes specified in the design control phase and involve changes in reviews of customers & suppliers. The final point is that design changes can consist of changes and improvements in performance, efficiency, form, durability, cost, and price. The product design and development clauses in all different standards have been studied & compared topically. (Table 1)

TABLE 1
COMPARE THE EXISTENCE OF PRODUCT DESIGN TOPICS IN DIFFERENT STANDARDS

Product Design and Development	ISO 9001	AS 9100	TL 9000	ISO 29001	ISO 13485	IATF 16949
General	x	x	x	x	x	x
Design & development process/procedure		x			x	x
Design planning	x	x	x	x	x	x
Design project planning/detail planning		x	x		x	x
Configuration/traceability management planning			x		x	x
Migration planning			x			
Design inputs	x	x	x	x	x	x
Customer/performance & external provider inputs		x	x			x
Requirements allocation			x			
Design control	x	x	x	x	x	x
Testing for verification & validation		x			x	x
Design outputs	x	x	x	x	x	x
Define the engineering data		x			x	x
Design Changes	x	x	x	x	x	x
Configuration/traceability management		x				x

RESULTS, ANALYSIS, AND DISCUSSION

The number of requirements of each QMS has been identified separately to achieve the level of evolution in the product design by normalizing the number of mandatory requirements. The higher the evolution rate, the more advanced the relevant standard is compared to ISO 9001 and can be more suitable for the product's engineering design. (Table2)

TABLE 2
COMPARISON OF THE REQUIREMENTS OF THE DESIGN CLAUSE BY SPECIALIZED STANDARDS

Standard Number	ISO 9001	AS 9100	TL 9000	ISO 29001	ISO 13485	IATF 16949

Number of Mandatory Requirements	42	74	92	47	60	104
Evolution Coefficient	1	1.76	2.19	1.12	1.43	2.48
Normalized Evolution Coefficient	0.10	0.18	0.22	0.11	0.14	0.25

The last row of table 1 states the rate of performance improvement in engineering design. (Figure 1)

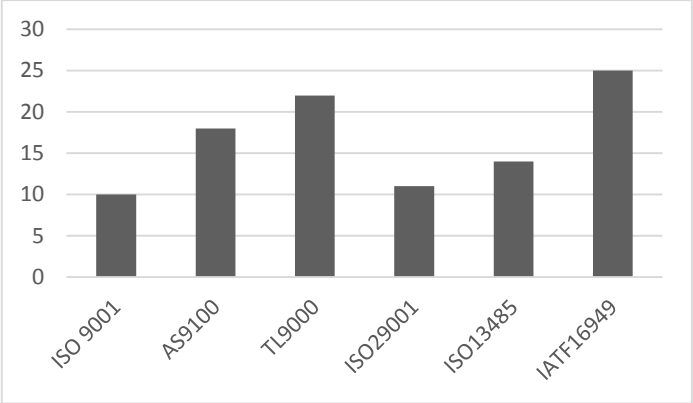

FIGURE 1
PERCENTAGE OF PERFORMANCE IMPROVEMENT IN MECHANICAL DESIGN

These standards are common to ISO 9001, and each has its own specific and complementary requirements. Here, by dividing each standard's number of requirements by the total ISO 9001 standard requirements with other non-common requirements of different means & each standard's overlap grade could be achieved concerning all product design needs. The higher the overlap amount, the better and more comprehensive the standard for improving the product's engineering design performance. (Table3)

TABLE 3
COMPARISON OF THE UNCOMMON REQUIREMENTS OF THE DESIGN CLAUSE OF STANDARDS

Standard Number	ISO 9001	AS 9100	TL 9000	ISO 29001	ISO 13485	IATF 16949
Number of Mandatory Requirements	42	74	92	47	60	104
Number of Uncommon Mandatory Requirements	42	32	50	5	18	62
Overlap Grade	0.20	0.35	0.44	0.22	0.29	0.497
Percent of Overlap Grade In Engineering design	20	35	44	22	29	50

FIGURE 2
CLEARLY SHOWS THE PERCENTAGE OF OVERLAP BY EACH TECHNICAL STANDARD

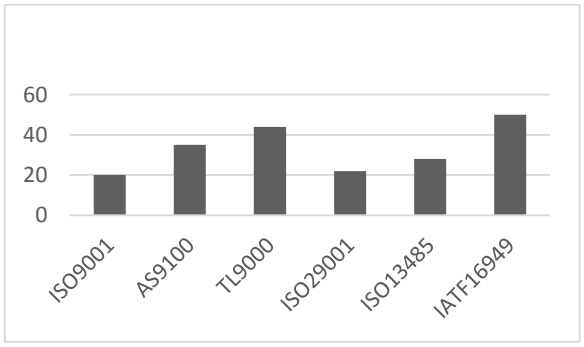

FIGURE 2

PERCENTAGE OF OVERLAP GRADE IN ENGINEERING DESIGN

The degree of evolution and overlap has been evaluated & compared. It shows that the IATF 16949 standard will be the most appropriate and effective in the engineering design of the product. (Figure 3)

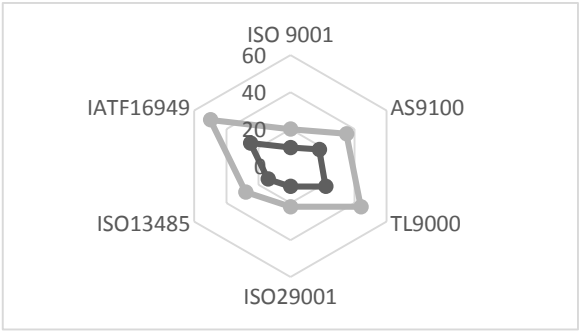

FIGURE 3
COMPARISON OF OVERLAP (GRAY COLOR) AND EVOLUTION GRADE(BLACK COLOR)

A number of QMS requirements are given in the following matrix to determine the importance of design and development clauses to improve performance in engineering design. (Table 4)

TABLE 4
OMMON REQUIREMENTS MATRIX OF STANDARDS

Standards	***XIJ***	General	Design Planning	Design Inputs	Design Control	Design Outputs	Design Changes
ISO9001	$x1j$	3	12	9	6	5	7
ISO13485	$x2j$	1	9	11	16	7	4
AS9100	$x3j$	3	17	11	19	15	9
ISO29001	$x4j$	3	14	12	6	5	7
IATF16949	$x5j$	4	20	31	20	32	11
TL9000	$x6j$	3	50	21	6	5	7

It is needed to specify the number of requirements for each factor by using a matrix with (m) rows (number of options) and (n) columns (number of indicators/factors). Each element of this matrix; x_{ij} is called decision-making matrix data, and to normalize the data matrix values using equation one and the entropy of the probability distribution. E_{ij} has been calculated. After calculating the degree of deviation dj,, specify the weight rate by using Shannon's methodology [41]. (Table 5)

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \; ; j = 1,2, \dots ,n \qquad (1)$$

$$Ej = -\left[\frac{1}{Ln\,(m)}\right] * \sum_{i}^{m} (Pij \times Ln\, Pij) \; ; i = 1,2, \dots ,m \qquad (2)$$

$$dj = 1 - Ej \qquad (3)$$

$$Wj = \frac{dj}{\sum_{j=1}^{n} dj} \qquad (4)$$

TABLE 5
THE WEIGHT OF EACH OF THE SUB-CLAUSES OF PRODUCT DESIGN IN THE ENGINEERING DESIGN

XIJ	General	Design Planning	Design Inputs	Design Control	Design Outputs	Design Changes
SUM Pij	17	122	95	73	69	45
E1j	0.176	0.098	0.095	0.082	0.072	0.156
E2j	0.059	0.074	0.116	0.219	0.101	0.089

E3j	0.177	0.139	0.116	0.260	0.217	0.2
E4j	0.177	0.115	0.126	0.082	0.072	0.156
E5j	0.236	0.164	0.326	0.274	0.464	0.244
E6j	0.176	0.41	0.22	0.082	0.0725	0.156
Ej	0.97	0.9	0.94	0.92	0.83	0.98
dj	0.034	0.104	0.061	0.077	0.168	0.023
Wj	0.07	0.22	0.13	0.17	0.36	0.05

The last row of Table 5 shows the weighting coefficient of each product design sub-sections, which can be seen by converting these values into percentages (figure 4).

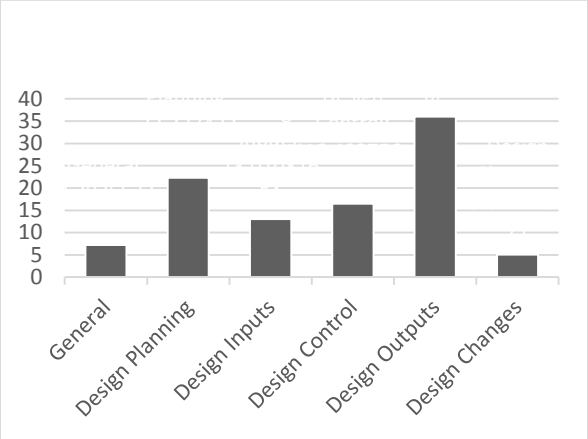

FIGURE 4
THE WEIGHTING COEFFICIENT OF EACH OF THE SUB-SECTIONS OF PRODUCT DESIGN

Next, the data in Table 5 are multiplied by the weight of each factor (Wj), and the last column of the following table is set with five descriptive variables that show these results. (Table 6)

TABLE 6
WEIGHTED MATRIX OF DIFFERENT STANDARDS

No.	Standard	General	Design Planning	Design Inputs	Design Control	Design Outputs	Design Changes	Total	Descriptive Variable
1	ISO9001	0.22	2.67	1.17	0.99	1.8	0.35	7.2	Low
2	ISO29001	0.22	3.12	1.56	0.99	1.8	0.35	8.04	Low
3	ISO13485	0.07	2	1.43	2.64	2.52	0.2	8.87	Low
4	AS9100	0.22	3.79	1.43	3.13	5.4	0.45	14.42	Medium
5	TL9000	0.22	11.14	2.73	0.99	1.8	0.35	17.23	High
6	IATF16949	0.29	4.46	4.03	3.3	11.52	0.55	24.15	Very High

Regression is a statistical procedure for calculating the value of a dependent variable from an independent variable. Linear regression measures the association between two variables. It is a modeling technique where a dependent variable is predicted based on one or more independent variables. Linear regression analysis is the most widely used of all statistical methods [42] [43] By drawing the total column of Table 6, we can see the impact of different QMS in the engineering design process. For example, the following figure shows the exponential trend effect of each of these standards on the design process. (Figure 5)

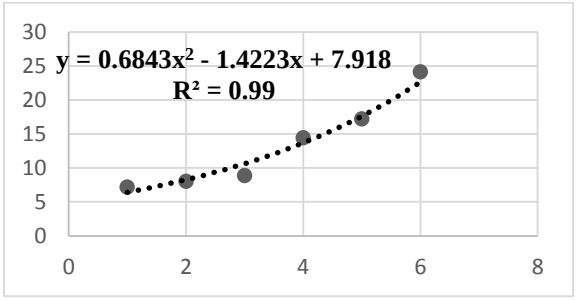

FIGURE 5
DESIGN IMPACT EXPONENTIAL DIAGRAM OF TECHNICAL QMS

Figure 5 shows the exponential growth of product design performance using standards that encourage organizations to create product design quality over a predetermined period. Figure 6 shows the linear growth of product design performance using standards that encourage organizations to create product design quality over a predetermined period. (Figure 6)

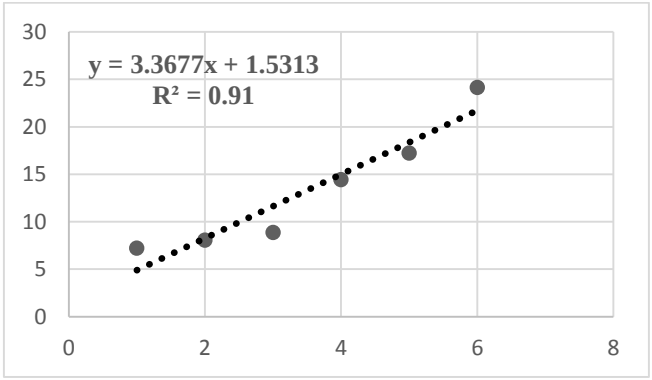

FIGURE 6
ENGINEERING DESIGN IMPACT LINEAR DIAGRAM OF TECHNICAL STANDARDS

Figure 6 shows if the designer firms use the design and development clause of introduced QMS to increase the product's appearance and performance (quality of the designed product) by utilizing these standards in a planned time frame, varying according to organizations' ability. The slope of Figures 5 & 6 shows the growth in the maturity of the mentioned standards from ISO 9001 to IATF16949 could be 30% approximately.

By studying the results of Table 4 and Figures 5 & 6, It is stated that ISO 9001, ISO 29001& ISO 13485 standards have a low impact on improving product design results. The AS 9100 standard had a moderate effect. TL 9000 & IATF 16949 standards have the most efficiency in design improvement. To create a better picture of the results of our applied research, the effect of product design and development clause in these technical standards is determined separately in product maturity in the form of the following tables. The practical achievements of these standards(ISO 9001, ISO 29001& ISO 13485)on the product are transparent. (Table7)

TABLE 7
COMPARISON EFFECTS OF ISO 9001, ISO 29001& ISO 13485 STANDARDS ON PRODUCT

Clause	ISO 9001	ISO 29001	ISO13485
General	An operational process for designing products based on the firm's context		A documented procedure for designing products based on the firm's context.
Design Planning	A total scheduling & resource management plan for executing & controlling the design steps.	A total scheduling & resource management plan for executing & controlling the design steps with the risk management approach .	A total scheduling & resource management plan for executing & controlling the design steps.
Design Inputs	Functional, performance, legal, related standards & potential failures specifications.	Functional, performance, legal, related standards, potential failures, health & safety specifications.	Functional, performance, legal, related standards & potential risks specifications

Design Control	Review checklist, verification (i.e.re-calculation & previous similar designs) & validation(i.e. operational tests) methodologies for comparison between design outputs & inputs.	Review checklist, verification (i.e.re-calculation & similar previous designs) & validation(i.e. operational tests) methodologies for comparison between design outputs & inputs.	Review checklist, verification (i.e.re-calculation & previous similar designs) & validation(i.e. clinical evaluations) methodologies for comparison between design outputs & inputs.
Design Outputs	Product specifications (safe and proper use) matching inputs, monitoring, measuring & acceptance criteria.		
Design Changes	Design changes and design improvement through the design control stage.		

The following table shows the effects of AS9100, TL9000, and IATF16949 standards on the product in practice. (Table 8)

TABLE 8
COMPARISON OF THE EFFECTS OF AS9100, TL9000 & IATF 16949 STANDARDS ON PRODUCT

Clause	AS9100	TL9000	IATF16949
General	An operational process for designing products based on the firm's context.		An operating process for designing products based on the firm's context with an error
Design Planning	A total detailed scheduling & resource management plan for executing & controlling the design, verify & test steps.	A total project & resource management plan for executing & controlling the design steps with a risk, health, & safety management approach.	A total project & resource management plan includes all affected stakeholders for executing & controlling the design steps with FMEA(Failure Modes & Effects Analysis), DFMA(Design for Manufacturing &
Design Inputs	Functional, performance, legal, related standards & potential obsolescence specifications.	Functional, performance, legal, related standards, potential failures specifications, customer & supplier requirements, quality, reliability, testing health, safety, sustainability	Functional, performance, legal, related standards, potential failures specifications, customer & supplier requirements, quality, reliability, testing health, safety, sustainability, cost, handling, ergonomic and special
Design Control	Review(i.e. Checklists),verification(i.e.re-calculation & previous similar designs) and validation(i.e. testing plans , procedures & acceptance criteria) methodologies for comparison between	Review(i.e. Checklists),verification(i.e.re-calculation & previous similar designs) and validation(i.e. operational tests) methodologies for comparison between design outputs & inputs.	Review(i.e., Checklists), verification(i.e.re-calculation & previous similar designs), & validation by PPAP(Production Parts Approval Process) (i.e., monitoring & testing plans, procedures, and acceptance criteria) methodologies for comparison between design
Design Outputs	Product specifications (safe and proper use), matching inputs, monitoring, measuring & acceptance criteria.		Product specifications (safe & proper use)matching inputs, monitoring, measuring, acceptance criteria, Design Failure Modes & Effects Analysis (DFMEA), Geometric Dimensioning & Tolerance (GD&T) &
Design Changes	Design changes & design improvement through the design control stage.	Design changes and design improvement based on the results of design control with notifying its customers for approvals.	

CONCLUSION

The subject of mechanical product design as a comprehensive and practical process used in various industries can use the concepts and methods in different general and specialized quality standards without limitations to increase design performance and quality. Since engineering design is considered a practical and essential process in aerospace, automotive, petrochemical, petrochemical medical equipment, and other industries, comparing standards' general and specialized requirements improves the engineering design. It used all common and non-common conditions as a model to increase the efficiency and effectiveness of the product's engineering design process. This study tried to compare different standards' attitudes to product design with various dimensions of this critical and critical part and use these general and specialized requirements in the product's engineering design with a choice based on comprehensiveness and evolution. We also tried to make an appropriate quantitative and qualitative comparison between these standards to determine the extent of overlap and development of each product design criterion. Users can consciously choose each of the requirements to improve the quality of engineering design. And be more aware of its output before use. According to the data collected from each of these standards' requirements, we could obtain the weight coefficient of the importance of each of the sub-sections of product design and development in the overall design process, respectively; and the lowest weight is related to design changes. Suppose the three factors of time, quality, and cost are considered dimensions of product design. In that case, the sub-sections of product design and development of these technical standards will improve and upgrade factors. This effect is further strengthened by deepening these parts. So that organizations can improve product design using these standards. Implementation of the technical

standards in the product design process could be affected on design time, design delivery time, conformed product with design & engineering requirements and legal requirements, customer and supplier needs, product design for manufacturing and assembly, the product with proper performance and reliability, product design with cost and risk control and designed product with controlled design changes. Therefore, this research could help predict the impact of these standards on improving engineering design performance so that design organizations can use any of these standards' requirements to determine their success in this direction.

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