

Instructional Design of Ideological and Political Elements in the Course “Measurement of Tolerance and Verification of Geometrical Quantity”

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Abstract: "Measurement of Tolerance and Verification of Geometrical Quantity" is a required professional core course for the major of "Mechanical Design, Manufacturing, and Automation" in China. It is the link between the design course and the manufactrue course in the teaching plan, and the bridge from the basic course to the professional course. Introduction of the positive energy of age and society contributed to improve the sense of identity and pride in the Chinese traditional culture. In this investigation, ideological and political elements which were contained in the knowledge points including tolerance and detection of geometric quantities, were investigated and integrated into class teaching activities for the mechanical professional talent training. As a result, a correct outlook on life and good professionalism was cultivated and established for mechanical professional talents.

1. Introduction

There are big quality and price differences among the same kind of mechanical products, even with the same structure and material. The reason was that the quality and cost of a machine largely depends on the tolerance of the part design and the fits between the parts. For a machine, the parts can be disassembled. Structure size and dimensions of kinematics are often measurable. Materials of the parts can also be detected and analysed. However, tolerance of the parts and the fits between the parts were unpredictable. Therefore, tolerance and fits are absolute technical secrets for a machinery manufacturing company. The correct and reasonable design of tolerance and fits is the key to obtain the best technical and economic benefits and enhance the market competitiveness.

Under the background of the new era, the goal of education is not only to impart knowledge, but more importantly to cultivate students' comprehensive quality and social responsibility. Therefore, the integration of ideological and political elements into professional courses is an important direction of the current higher education reform[1]. Taking the course of "Measurement of Tolerance and Verification of Geometrical Quantity" as an example, this study discussed how to integrate ideological and political elements into professional courses to improve students' ideological and

political quality and professional skills[2]. The goal was to develop and enhance students' cultural and professional confidence, to cultivate and establish the correct outlook on life, values[3]. Therefore, with the organic combination of moral education and intellectual education, rigorous and meticulous craftsmanship spirit was nurtured. Patriotism, dedication, excellence in professional quality was enhanced.

2. Features and Challenges of the Course of Measurement of Tolerance and Verification of Geometrical Quantity

Course of "Measurement of Tolerance and Verification of Geometrical Quantity", as the linkage between the design course and the manufacture course, is a professional basic course for the major of "Mechanical Design, Manufacturing, and Automation". As an important course of mechanical engineering, it relates to mechanical design, manufacturing, testing, and other fields, has a strong practicality and applicability. The main teaching content includes interchangeability, standards and standardization, mechanical precision, limits and fits, testing technology, tolerances for various parts, surface roughness, dimensional chains, etc.

However, involving a wide range of knowledge and is theoretical, students often feel difficult in the learning process. At the same time, the traditional teaching model often ignores the cultivation of students' ideological and political quality, resulting in students learning professional knowledge while ignoring their responsibilities and missions to the society and the country.

3. Integration of Ideological and Political Elements

Combined with the current political news of science and technology development, important national meetings and guidance documents, examples such as dimensional tolerance in spacecraft, face profile tolerance and fit in "Jiaolong" deep-sea manned submersible were introduced and integrated with the knowledge points such as dimensions, deviations, tolerance and fits. Ideological and political elements including the patriotism, meticulous craftsmanship spirit and professional quality of keep-improving were designed based on the Outcome Based Education (OBE)[4] concept in this study.

3.1. Teaching content and objective

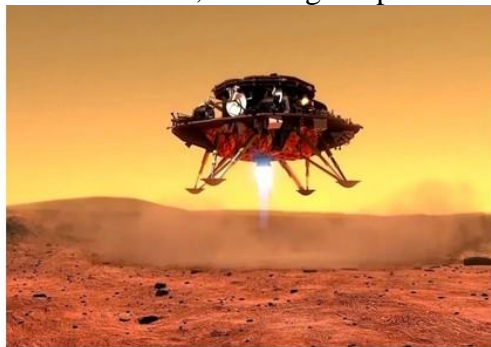
In the teaching activities of introducing the definitions and calculation formulas of dimensions, tolerances, deviations and fit, the importance of tolerance design in industrial production for the development of the country and society was demonstrated through several examples, and the craftsmanship spirit and the professional quality of excellence were cultivated.

3.2. Ideological and Political Cases

3.2.1. Case 1- Dimensional Tolerances in the Spacecraft

Case description: In 2020, the "Tianwen-1" Mars probe and the "Chang'e-5" lunar probe were successively launched successfully, as shown in Figure 1. The "Long March 5" rocket carrying them completed multiple missions smoothly. One of the key components in determining the rocket's flight trajectory is the inertial navigation system. And within this system, the accelerometer plays a crucial role. Reducing the deviation by 1 micrometer during processing can decrease the orbital error in space by several kilometers. Therefore, although the designed dimensional tolerance for the parts in the accelerometer was 5 micrometers, the milling workers strived for perfection and dedicated over 20 years to studying the craft. By using high-powered microscopes to conduct microscopic inspections

and continuous grinding and corrections on numerically-controlled machine tools, they achieved parts with near-zero tolerance, ensuring the precise trajectory of the rockets.



(a) Tianwen-1 Mars probe
Screenshot from the promotional video of the National Space Administration's News and Publicity Center



(b) Chang'e-5 lunar probe
Screenshot from the promotional video of China Science communication



(c) Long March 5 rocket
Screenshot from the promotional video of China Science communication



(d) Accelerometer
Screenshot from the documentary "Great Nation Craftsmen"

Figure 1: Dimensional tolerances in the spacecraft.

Ideological and political goals: Significance of high-precision manufacturing in the accelerometers of spacecraft for controlling rocket trajectories was introduced in this case, with the purpose of fostering students' craftsmanship spirit as well as pursuit of excellence in their professional ethics.

3.2.2. Case 2- Geometric Tolerances in the Submersible "Jiaolong"

Case description: The "Jiaolong" is China's first deep-sea manned submersible, composed of over a hundred thousand components, as shown in Figure 2. The greatest challenge in its assembly was to ensure its sealability with precision requirements of silk level. For watertight assembly withstanding immense underwater pressure, the difficulty lied in the contact surface between the sphere and the glass, which should be controlled to less than 0.2 silks, which meant the margin was only 1/50th the thickness of a human hair. Such a small gap might not be difficult to be obtained detected by precision instruments. However, the glass of the observation window in the manned cabin was exceptionally delicate and could not be contacted with any metal instruments. A tiny scratch caused by friction could lead to leakage or even shattering of the glass under the pressure of several hundred atmospheres in the deep sea, endangering the lives of those diving. Therefore, installing the glass of the manned cabin was one of the most meticulous tasks in assembling the manned submersible. During the entire testing and assembly process, Gu Qiuliang worked until the early hours of the morning every day. In addition to relying on precision instruments, Gu Qiuliang relied more on his own experience and judgment, using his eyes to observe and his hands to repeatedly feel the surface, ultimately achieving a contact surface between the sphere and the glass of over 70%, meeting the

sealability requirements.

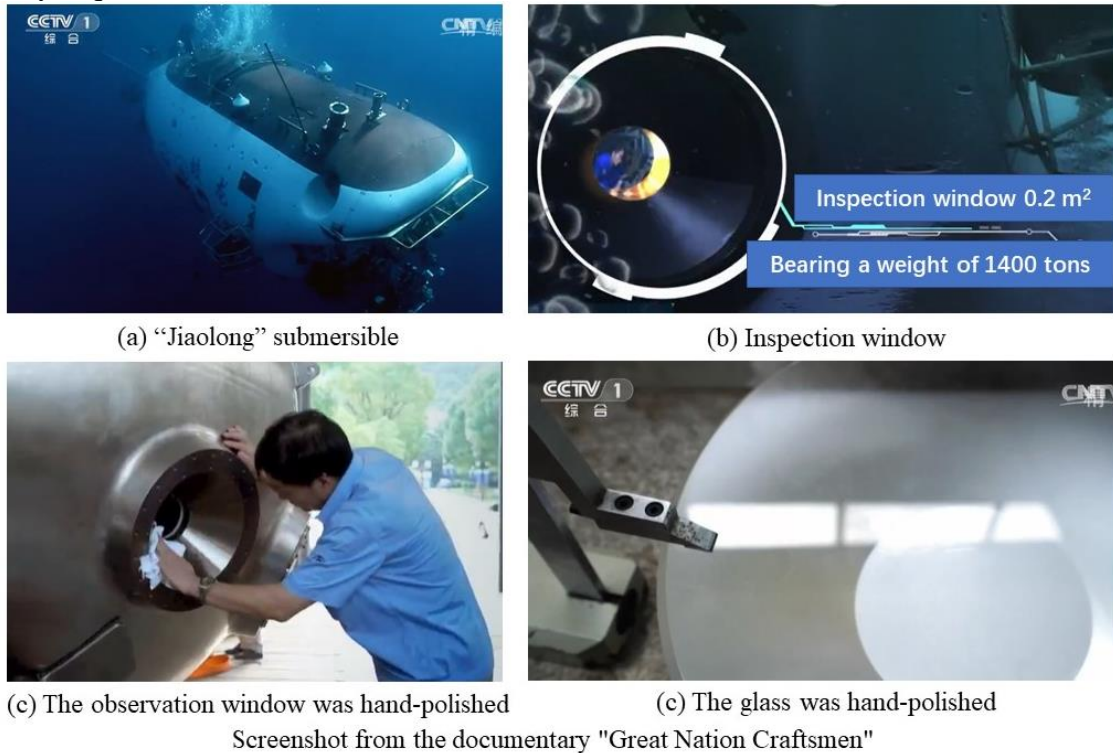


Figure 2: Geometric tolerances in the submersible "Jiaolong".

Ideological and political goals: By introducing the story of Gu Qiuliang, who has been wielding a file for over 40 years, students' meticulous craftsmanship spirit, as well as their patriotic dedication and pursuit of excellence in professional ethics can be further cultivated. In addition, from this case, the students can be guided to start from the basics and work on every detail in their professional studies. Through the honing of both their technical skills and inner selves, students will contribute to the development of the country.

3.3. Explanation of Knowledge Points

To ensure the interchangeability of parts, tolerances must be specified during the design stage. Since the errors occur during manufacturing, it is essential to keep these errors within the designated tolerance limits. The designer's task involves setting the correct tolerances and clearly indicating them on the engineering drawings.

In this study, the knowledge point of "The importance of tolerance design in the design and assembly of mechanical parts" is scheduled to be introduced through ideological and political cases 1 and 2, followed by an introduction to the basic terminology, definitions, and calculation formulas of tolerances, deviations, and fits.

3.4. Effect of Ideological and Political Elements Integration Cases Design

3.4.1. Enhance Students' Learning Initiative

The course "Measurement of Tolerance and Verification of Geometrical Quantity" is characterized by a multitude of abstract concepts, terminological definitions, symbolic codes, annotation tables, and empirical solutions. Students often struggle with the extensive basic concepts, terminology, and theories, resorting to passive memorization, which can lead to less than ideal teaching outcomes.

By using the aforementioned ideological and political cases as an introduction to explain these knowledge points, we can effectively enhance the intrinsic motivation of students to learn and clarify the significance of studying tolerances and the related theories.

3.4.2. Improve Students' Professional Quality

By integrating the positive energy of the era and society into the classroom, such as the famous craftsmen and their deeds, it fosters cultural and professional confidence in students, cultivating and establishing correct life perspectives, values, and good professional ethics for the students.

4. Conclusions

Integrating ideological and political elements into the course of "Measurement of Tolerance and Verification of Geometrical Quantity" can not only improve the ideological and political quality of students, but also improve their professional skills. At the same time, through reform and innovation of teaching methods and evaluation methods, the teaching effect was further improved, outstanding engineering and technical personnel both with professional skills and social responsibility were cultivated.

In the future teaching practice, we will continue to explore and practice to improve the quality of teaching and better cultivate students' ideological and political quality and social responsibility.

References

- [1] Dong, L.L., Huang, L., Han, C. J. and Li, B. L. (2023) *Ideological and Political Objectives and Typical Case Analysis of Tolerance Fit and Technical Measurement*. *Education and teaching forum*, 36, 91-94.
- [2] Li, X. S. (2023) *The Application of Course Ideological Education in the Teaching of Geometric Tolerance and Testing*. *Journal of Jilin Institute of Chemical Technology*, 40(4), 25-28.
- [3] Cheng, X. F. (2021) *Exploration and Practice of the Curriculum Ideology and Politics "Tolerance Fit and Technical Measurement"*. *Theory research and practice of innovation and entrepreneurship*, 21, 115-117.
- [4] Li, Z. Y., Zhu, H., Liu, Z. J. and Xia, Y. J. (2014) *Guiding the Reform of Higher Engineering Education with Result-oriented Educational Ideas*. *Research on Higher Engineering Education*, 2, 29-34.