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Skills for industrial design technology competition

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Foreword

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Skills for industrial design technology competition

1 Scope

This document specifies the basic requirements for technical training of industrial design technology contest, skill requirements of skill passport and performance evaluation method, including but not limited to resource requirements for personnel, site and equipment of industrial design technology contest. This document is applicable to the holding and organization of industrial design technical events.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

3.1

three-dimensional digital model

collection of geometric elements, constraint elements, and engineering element information reflecting mechanical products in computers

3.2

additive manufacturing; AM

manufacturing technology of producing parts or physical objects by material stacking based on three-dimensional model data

Note 1 to entry: also known as 3D printing.

3.3

additive manufacturing machine; additive manufacturing apparatus

part of an additive manufacturing system used to manufacture parts or physical objects, including hardware, software, and necessary accessories to complete a forming cycle

3.4

3D printer

equipment used for 3D printing

4 Competition general

4.1 Competition name and description

4.1.1 Name

Industrial design technology.

4.1.2 Definition

Operate and apply industrial software, use increase and decrease processing equipment, and engage in digital design and manufacturing of industrial products.

4.2 Professional technical level

Three professional technical levels are set, i.e. Level C (primary/intermediate workers), Level B (senior workers) and Level A (senior workers/technicians).

4.3 Competition environment conditions

Indoor, room temperature.

4.4 Professional competence characteristics

Ability to learn, analyze, judge, calculate, and collaborate in a sustainable design oriented manner, communication skills to express ecological design solutions, understanding user and social needs, spatial perception to optimize resource efficiency, normal color and form perception, and mental health

4.5 Skill training requirements

4.5.1 Training period

Full-time occupational skill education and continuous education for industry employees shall be determined according to their training objectives and teaching plans. Term of advanced training: Level C shall not be less than 108 standard class hours; Level B shall not be less than 72 standard class hours; Level A shall not be less than 72 standard class hours.

4.5.2 Training personnel

Level C training personnel shall have skill level certificates of Level B and above; Level B training personnel shall have level A skill level certificate for this competition; Level A training personnel shall have at least 2 years of level A skill level certificate for this competition item or at least 2 years of senior professional and technical post qualification in relevant disciplines.

4.5.3 Training site equipment

Theoretical knowledge training shall be carried out in the place with computer, and the computer shall be installed with industrial software meeting relevant parameters; the operation skill training shall be carried out in the place with computer and digital design and manufacturing hardware equipment. The computer shall be equipped with industrial software meeting relevant parameters. The hardware equipment includes reverse design tools meeting relevant parameters and processing units of added and reduced materials. See Clause 8 for specific requirements.

4.6 Professional technical conditions

4.6.1 Applicants requirements

4.6.1.1 Level C certificate

Applicants for Level C certificate shall meet one of the following conditions:

- a) Have been engaged in this occupation or relevant occupation for 1 year in total and pass the examination;
- b) The technical school of this major or relevant major has completed 1 school year;
- c) Obtain the graduation certificate of this major or relevant professional skill school.

4.6.1.2 Level B certificate

Applicants for Level B certificate shall meet one of the following conditions:

- a) Have been engaged in this occupation or relevant occupation for 3 years, and pass the examination;
- b) He/she has been engaged in the occupation or relevant occupation for 1 year after obtaining the class C certificate of the occupation or relevant occupation;
- c) At least 16 years of age, the vocational skill education of this major or related majors shall be no less than 3 academic years and the college degree or higher education related major graduation certificate (including current graduates).

4.6.1.3 Level A certificate

Applicants for Level A certificate shall meet one of the following conditions:

- a) Have been engaged in the occupation or relevant occupation for 5 years, and pass the examination;
- b) Have been engaged in this occupation or relevant occupation for 3 years after obtaining level B certificate of this occupation or relevant occupation;
- c) At least 18 years of age, this major or relevant professional professional skill education is studying at

least 5 academic years and general higher education college degree or higher graduation certificate (including current graduates).

4.6.2 Assessment method

It is divided into theoretical knowledge examination, operation skill examination and comprehensive review. The theoretical knowledge examination is in the form of comprehensive ability evaluation and item bank random test, which mainly assesses the basic knowledge and relevant knowledge requirements that the employees shall master in the occupation. The assessment of operational skills shall be carried out by on-site operations, simulated operations, etc., mainly assessing the skill level that practitioners shall possess in their profession. Theoretical knowledge exams and operational skills assessments shall both be based on a percentage system, and all scores shall reach 60 points or above to be considered qualified. See Clause 7 for specific weight allocation. The competition organizer should ensure that the assessment process and venue equipment conditions are fair and just to all participants, and strive to eliminate potential unfairness caused by regional and institutional resource differences.

4.6.3 Ratio of invigilators, assessors and examiners

The ratio of invigilators to candidates in theoretical knowledge exams shall not be less than 1:20, invigilator for every 20 candidates, and no less than two invigilators for each examination room; The ratio of assessors to candidates in the assessment of operational skills shall not be less than 1:10, with at least one assessor for every 10 candidates, and the number of candidates shall be an odd number of 3 or more. Each candidate shall be scored by no less than 3 assessors.

4.6.4 Examination time

The theoretical knowledge examination time of each level shall not be less than 90 min, and the skill examination time shall not be less than 120 min.

4.6.5 Equipment at the assessment site

Theoretical knowledge training shall be carried out in the place with computer; operation skill training shall be carried out at the place with computer and professional digital design and manufacturing equipment. See "Clause 8 for specific requirements.

5 Basic requirements

5.1 Professional ethics

5.1.1 Basic knowledge of professional ethics

Shall possess the following basic knowledge of professional ethics:

- a) Be truthful and provide design related information without concealing or distorting facts. Comply with the contract and complete the design task on time and with quality. Protection of customer trade secrets and intellectual property rights;
- b) Fair competition, following market rules and not obtaining competitive advantages by improper means. Respect the labor achievements of peers and do not copy or steal the design originality of others;
- c) Social responsibility, considering the impact of the design product on the environment, society and culture to promote sustainable development. Guarantee the safety and reliability of products and safeguard the legitimate rights and interests of consumers;
- d) Keep confidential and keep sensitive information and trade secrets in strict confidence. The employee shall still abide by the confidentiality agreement after leaving the post and shall not disclose the relevant information of the original unit.

5.1.2 Professional code of conduct

Candidates shall abide by laws and regulations, love their jobs and be dedicated, and possess the following professional codes of conduct:

- a) Comply with laws and regulations and be familiar with industry norms;
- b) Love the job and respect the customer's needs;

- c) Pursue innovation and excellence and strive for effect quality;
- d) Participate in team work and respect members' opinions;
- e) Constantly improve quality through lifelong continuous learning;
- f) Deepen scheme research and continuously optimize efficiency;
- g) Standardize the application of terminology and improve collaboration efficiency.

5.2 Basic knowledge

5.2.1 Basic knowledge of design

Shall possess the following basic knowledge of design:

- a) Color theory of design aesthetics;
- b) The law of point, line, plane and body and the rule of aesthetics;
- c) Proportional relation between scale and scale;
- d) Ergonomic anthropometry;
- e) Human-computer interaction, studying the information transfer and operation mode between people and products;
- f) Principles of sustainable design and fundamentals of environmental impact assessment.

5.2.2 Engineering technical knowledge

Shall possess the following engineering and technical knowledge:

- a) Mechanics of engineering;
- b) Mechanics of materials;
- c) Electrical and electronic technology;
- d) Mechanics of structure;
- e) Engineering survey;
- f) Engineering materials;
- g) Mechanical works;
- h) Computer and software engineering.

5.2.3 Basic knowledge of mechanical drawing CAD knowledge

Shall possess the following basic knowledge of mechanical drawing and CAD:

- a) Basic standard for mechanical drawing;
- b) Relevant provisions of national standard CAD engineering drawing rules;
- c) Concept of projection;
- d) Basic expression methods of machine parts.

5.2.4 Design process and method

Shall possess knowledge of the following design processes and methods:

- a) Market research collects and analyzes market information, including user demand diversity, environmental impact potential, social acceptance, etc;
- b) Research methods, scheme selection and optimization;
- c) Design and prepare engineering drawings, including parts drawings, assembly drawings, etc;
- d) Develop design specifications;
- e) Design evaluation model development and testing;
- f) Improve and perfect the design objective.

6 Skill knowledge requirements

6.1 Level C

Level C skill knowledge requirements see table 1.

Table 1 Level C skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Computer Graphics	Industrial product drawing	<p>Be able to accurately analyze the structure and size of each part of the part according to the given product part drawing and form analysis method</p> <p>Understand the 3D structure of parts through plan view</p> <p>The dimension, process and other information of parts can be clearly marked</p>	<p>Relevant specifications of national standard drawing</p> <p>Concept of form analysis method and common projection method knowledge of engineering drawings</p> <p>Principles and methods of dimension annotation and concepts of various technical requirements</p>
2	Product data acquisition	Drawing of part drawing	<p>Be able to skillfully express the shape of machine parts by means of view, sectional view, sectional view, etc</p> <p>Be able to select the appropriate expression method according to the structural characteristics of the parts</p> <p>Be able to use national standards to complete simplified drawing method for parts</p>	<p>Projection principle of basic view, sectional view, partial enlarged view and oblique view, relevant standards and application specifications</p> <p>Expression method and view selection of part shape</p> <p>Concept and application of various simplified painting methods</p>
		Computational modeling	<p>Be able to use computer plotting software tools to draw various two-dimensional graphics</p> <p>Generate corresponding 2D graphics according to 3D model</p> <p>Be able to use drawing software to complete various expressions of parts</p> <p>Be able to use the drawing software to complete the preparation of component assembly drawings</p>	<p>Draw and edit method of straight line, curve and basic graph.</p> <p>Usage of various tools for 3D model generation of 2D graphics</p> <p>Drawing method of part drawing view</p> <p>Drawing method of assembly drawing view</p>
		2D graphic annotation	<p>Be able to edit plotting template and create national standard template</p> <p>The drawing software can be used to mark the full size of the part</p> <p>Be able to use drawing software to mark various technical requirements of parts</p> <p>Be able to use the drawing software to mark the part number and part size of the assembly drawing and create the corresponding detail list</p>	<p>Function and manufacturing method of drawing frame and title block</p> <p>Principles and methods for dimensioning of parts drawings</p> <p>Concept of technical requirements and standard methods</p> <p>Fabrication method of assembly drawing lead sequence and detail list</p>
		Model data acquisition	<p>Be able to collect data from the model with a measuring instrument</p> <p>Capable of installing 3D scanner</p> <p>Be able to use a 3D scanner to collect data from the real product</p>	<p>Concept of contact data acquisition method, non-contact data acquisition method and fault data acquisition method</p> <p>Basic composition of 3D scanner</p> <p>Basic use method of 3D scanner</p>

Table 1 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
2	Product data acquisition	Model data processing	<p>The 3D scanner can be used to acquire the point cloud data of the measured model through multi-angle acquisition information</p> <p>The point cloud data obtained in the data acquisition stage will be subject to substantiation processing</p>	<p>Concept of point cloud and data acquisition method</p> <p>3D scanning data pre-processing process and method</p>
3	Digital product modeling	Product Part Modeling	<p>Be able to conduct feature analysis according to the given product part drawing and plan modeling steps</p> <p>Capable of accurately drawing 2D sketches required for modeling</p> <p>Be able to select proper modeling tools to create simple physical modeling of parts</p>	<p>Feature analysis and modeling planning method</p> <p>Sketch drawing, constraint and editing method</p> <p>Concept and application of part features</p>
		Assembly of product parts	<p>Parts and components can be installed in the component environment, and the fitting constraints of parts and components shall be reasonably set according to the characteristics of the components</p> <p>Be able to use the part moving or rotating tools in the part environment to adjust the part position or placement angle</p> <p>The freedom of parts in the component can be limited by the position constraint tool</p> <p>Be able to specify the motion mode of parts and components through motion constraint tools</p> <p>Be able to specify the position relationship and motion relationship of parts and components by connecting tools</p> <p>Demonstrate motion by driving constraints or coupling relationships</p>	<p>Assembly and fitting method of parts</p> <p>Moving and rotating methods of parts in components</p> <p>Concept of spatial degree of freedom and constraint method of parts</p> <p>Setting method of motion relation of parts</p> <p>Application method of connection Relationship</p> <p>Part movement and animation setting method</p>
		Product assembly and disassembly expression	<p>Capable of loading component files in presentation views</p> <p>The parts can be disassembled by adjusting the position of parts through linear motion and rotational motion</p> <p>Create assembly or disassembly views of product parts</p>	<p>Import method of production object of presentation view</p> <p>Disassembly action of parts and components and setting method of viewing angle position</p> <p>Setting method of presentation view location view (snapshot view)</p>
		Rendering production	<p>Appropriate scene style and light source style can be selected in the rendering module</p> <p>Set appropriate rendering parameters and output product rendering</p>	<p>Function and setting method of scene style and light source style</p> <p>Concept and setting method of resolution and iteration number</p>

Table 1 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Digital product modeling	Expression animation production	<p>Animation of product assembly and disassembly process can be output on the basis of presentation view</p> <p>Display animation of product functions in component rendering environment</p>	<p>Function and manufacturing method of component assembly and disassembly animation</p> <p>Working principle animation function and production method</p>
4	Prototype physical production	Material process selection	<p>Select reasonable additive manufacturing methods according to the structural features and application situations of the sample piece.</p> <p>Appropriate materials shall be selected according to the manufacturing method and application site of the sample piece.</p>	<p>Meaning and application of additive manufacturing technologies such as melt deposition, light curing and powder sintering</p> <p>Characteristics and application of ABS, PLA and other materials</p>
		Sample piece data processing	<p>Select additive manufacturing method according to the actual situation</p> <p>Be able to process data of basic additive manufacturing, including outputting correct 3D printing data format, setting printing parameters such as model layer thickness, wall thickness and filling rate, adding model support, slice layered output, etc</p>	<p>Type and application of additive manufacturing support</p> <p>Concept and application of layer thickness, wall thickness and filling rate of additive manufacturing parameters</p>
		Make simulation	<p>Be able to use simulation technology to check the impact of different printing methods on printing time and printing results</p> <p>Be able to integrate simulation data and other relevant data and select the optimal printing mode</p>	<p>Common printing methods and characteristics of additive manufacturing</p> <p>Parameter setting and result viewing method of additive manufacturing simulation software</p>
		Operation of additive equipment	<p>Be able to use commonly used FDM and SLA additive manufacturing equipment to complete printing</p> <p>Be able to install and remove the consumables of the FDM and SLA additive manufacturing equipment</p> <p>Be able to eliminate common faults of FDM and SLA additive manufacturing equipment</p>	<p>Additive manufacturing workflow</p> <p>Composition of additive manufacturing equipment and assembly and disassembly methods of consumables</p> <p>Failure analysis and troubleshooting of additive manufacturing equipment</p>
		Sample post-processing	<p>Appropriate tools and methods can be selected to remove the support of the model surface</p> <p>Appropriate tools and methods can be selected to treat the surface of additive manufacturing model</p>	<p>Removal method of additive manufacturing support</p> <p>Post-processing methods for additive manufacturing</p>

6.2 Level B

Level B skill knowledge requirements see table 2.

Table 2 Level B skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Product innovation Product innovation	Top down design	Formulate feasible top-down overall design scheme according to product characteristics Refine the structure of internal space by combining existing parts and standard parts	Concept and application scenarios of bottom-up and top-down design methods Top-down design scheme planning
		Component association design	The product model can be established according to the top-down design scheme by using the multi-entity modeling method Be able to edit and modify the entity or part created by multi-entity modeling Be able to generate parts and component documents from multi-physical parts Be able to create relevant sketches in the assembly using adaptive techniques Be able to create relevant features in the assembly using adaptive technology Be able to use adaptive technology to create parts with association and set the validity of association as required	Concept and application of multi-entity modeling Editing method of parts with multi-entity modeling Part generation method of multi-entity modeling Concept and application of adaptive design Application of sketch adaption and feature adaption Relevance setting method of adaptive parts
		Mechanism design calculation	Be able to draw the schematic diagram of the mechanism through the sketch tool The motion of the mechanism can be simulated by the sketch tool Be able to find the limit position of mechanism movement Limit dimensions of accounting organization and key dimensions of relevant parts	Drawing method of mechanism diagram Application method of mechanism motion simulation and sketch block technology Limit position analysis of mechanism motion Key data calculation method of mechanism
2	Product design	Product appearance design	Prepare overall product appearance design scheme according to product application scenarios Complete the feasibility analysis of appearance design scheme according to product manufacturing conditions	Product appearance design method Material selection method for product parts
		Curved surface modeling design	Be able to create surface modeling with tools such as sweeping, lofting and facing Precise control of surface modeling with 3D sketches Surface styles can be adjusted by changing sweep, lofting and facing	Functions and application methods of scanning, lofting and facing tools Application method of 3D sketch Methods for parameter adjustment of scanning, lofting and surface feature Surface editing method

Table 2 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
2	Product design		parameters Be able to edit and modify the surface modeling	
		Free-Surface applications	Surface can be created with T-spline T-spline surface can be edited and modified through control points and control lines Be able to apply T-spline surface to model innovative design	Concept of T-spline free form T-spline Surface Editing Method Combination method of T-spline modeling and other modeling methods
		Material endows	Be able to select proper part materials according to the application scenarios of parts Be able to view the physical information of the part material Be able to change or replace part materials	Engineering material foundation and common material selection method Physical and mechanical properties of parts Part material setting and replacement method
		Appearance design	Be able to select proper appearance style for each part according to the product appearance design scheme Appearance style can be customized, edited and modified	Design basis of appearance color and texture Selection and editing methods of appearance color and texture
3	Reverse model reconstruction	Reverse preliminary preparation	Surface pretreatment can be carried out according to the surface conditions of the data acquisition work piece Spray the model surface according to different collection technologies Be capable of fixture design for special part models	Basic knowledge of mechanical principle and manufacturing technology required for physical sample measurement, principle and application of high-precision measurement technologies such as 3D coordinate measurement and laser scanning Method for surface repair and spraying of measuring work piece Design requirements and basic principles of key elements in fixture design
		Data acquisition and processing	The data acquisition equipment can be selected according to the volume or surface material of the work piece to be measured Be able to use high-precision measuring equipment and measuring methods to collect three-dimensional coordinate data of physical work piece Point cloud processing tools can be used to process the collected data such as multi-view splicing, noise removal, data reduction and data patching	Significance of specifications and technical parameters of common measuring equipment, operation and maintenance of measuring equipment Be capable of data processing and analysis, and master the operation method of semi-automatic point cloud data processing software Conversion method between point cloud data and 3D model data

Table 2 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Reverse model reconstruction	Data acquisition and processing	<p>The data acquisition equipment can be selected according to the volume or surface material of the work piece to be measured</p> <p>Be able to use high-precision measuring equipment and measuring methods to collect three-dimensional coordinate data of physical work piece</p> <p>Point cloud processing tools can be used to process the collected data such as multi-view splicing, noise removal, data reduction and data patching</p>	<p>Significance of specifications and technical parameters of common measuring equipment, operation and maintenance of measuring equipment</p> <p>Be capable of data processing and analysis, and master the operation method of semi-automatic point cloud data processing software</p> <p>Conversion method between point cloud data and 3D model data</p>
		Reconstruction of model surface	<p>CAD software can be used for model reconstruction of processed data, including surface fitting, surface splicing, feature identification and matching, etc</p> <p>Structural optimization of reconstructed CAD model</p>	<p>Principles of surface creation and fitting in CAD software</p> <p>Modification and optimization methods for complex features</p>
4	CNC machining of sample piece	Process route planning	<p>Prepare processing technology according to processing drawings</p> <p>Use process flow chart, process card and other tools to express the process plan</p> <p>Be able to select tools for material reduction manufacturing of parts</p>	<p>Operating principle and processing capacity of common processing equipment, process route design method</p> <p>Types and selection methods of machining tools</p> <p>Preparation and filling specifications for process flow chart and process card</p>
		Selection of processing method	<p>Be able to analyze product design drawings and identify key information such as structural features, dimensional accuracy and material characteristics of components</p> <p>Select the material reduction manufacturing method according to the technical requirements, production cost, processing efficiency and other factors of the components</p>	<p>Classification, characteristics and application scope of common processing methods, processing performance and processing methods of common materials</p> <p>Concept of processing cost, processing efficiency, processing precision, etc</p>
		Implementation of reduced material manufacturing	<p>Be able to select machining equipment and auxiliary tools such as machine tools, cutters and fixtures according to product drawings and process requirements</p> <p>Be able to operate numerical control machine tool to complete numerical control programming and part processing</p> <p>Be able to monitor and adjust the processing process according to the processing quality and accuracy requirements</p>	<p>Structure, working principle and operation method of common numerical control machine tool and traditional machine tool, influence of tool material, geometric angle and cutting parameters on machining quality</p> <p>Computer aided manufacturing software application method and automatic programming application</p> <p>Inspection methods and evaluation standards for machining accuracy, surface roughness, form and position tolerance, etc</p>

Table 2 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
4	CNC machining of sample piece	CNC equipment maintenance	<p>Be able to judge the failure of mechanical system, hydraulic system, pneumatic system and cooling system of numerical control equipment</p> <p>Be able to judge the control system and electrical system faults of numerical control equipment</p> <p>Be able to carry out three-level maintenance for CNC equipment according to the requirements of keeping the equipment in the best state</p>	<p>Diagnosis methods for mechanical system faults of CNC milling machine</p> <p>Structure and working principle of hydraulic and pneumatic components, electrical components and electric spindle of CNC milling machine</p> <p>Equipment three-level maintenance system</p>

6.3 Level A

Level A skill knowledge requirements see table 3.

Table 3 Level A skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Typical industrial product design	Application scenario analysis	<p>Analyze and understand the working principle of the product according to the engineering drawing and task design</p> <p>The assembly relationship and structural requirements of parts and components can be determined through engineering drawings or design requirements</p>	<p>Operating principles of common products</p> <p>Assembly relationship of common products</p>
		Core part design	<p>Be able to determine the parts design scheme according to the functional requirements and assembly relationship characteristics of parts</p> <p>The design method from top to bottom, from bottom to top or from the middle can be flexibly used to build the model of core components</p> <p>Verify the rationality of part design through digital model</p>	<p>Meaning and application of top-down, bottom-up and middle design methods</p> <p>Design method of mechanical parts</p> <p>Specification design for digital model delivery</p>
		Typical part fabrication	<p>Select the processing method according to the characteristics of parts</p> <p>Prepare parts processing plan and fill in basic information of process card</p>	<p>Application of additive manufacturing and reducing manufacturing methods, manufacturing process and key characteristics of additive manufacturing</p> <p>Filling method and specification of process card</p>

Table 3 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
2	Intelligent design Intelligent design	Formulation of optimization scheme	<p>Be able to use derivative design method to complete component optimization design process</p> <p>Prepare part optimization design scheme according to optimization requirements</p>	<p>Concept, application and basic workflow of derivative design</p> <p>Types and ways of optimal design, scheme formulation methods</p>
		Boundary condition setting	<p>Be able to set derivative design conditions for component optimization using retention areas, barrier areas, starting shapes, loads, constraints, design objectives, manufacturing conditions, materials tools.</p> <p>Be able to select the parts meeting the requirements and optimize the design results according to the needs and export the model</p>	<p>Functions of reserved area, obstacle area and initial shape, contents and meaning of load and constraint conditions, contents and meaning of design objective, manufacturing conditions, materials and tools</p> <p>Derived design results view and model export methodology</p>
		Component optimization implementation	<p>Be able to use derivative design tools to complete lightweight design of parts and replace original parts design scheme</p> <p>The resulting components are exported and processed as necessary</p>	<p>Significance of lightweight design and the significance of derivative design methods in lightweight design</p> <p>Post-treatment methods for derivative design results</p>
3	Simulation analysis	Product movement analysis	<p>It can transform assembly constraint into motion connection relation</p> <p>Product movement can be simulated by adding driving conditions</p> <p>Draw motion tracks of key parts or key points as required, or obtain key information such as speed</p>	<p>Type and function of motion connection relation</p> <p>Method for adding driving conditions</p> <p>Part motion path analysis method</p>
		Product motion simulation	<p>Be able to specify the motion conditions of parts and simulate the product motion process</p> <p>The "danger point" of the motion process can be determined from the results displayed by the simulation analyzer</p> <p>Import the data corresponding to the dangerous point into FEA for analysis</p>	<p>Significance of motion simulation</p> <p>Meaning of dangerous point and engineering significance</p> <p>FEA parameter analysis method</p>
		Stress Analysis Verification	<p>Analyze the data imported from motion simulation to obtain the stress and strain of corresponding "dangerous point" parts</p> <p>Constraints and load conditions required for stress analysis can be added manually according to application conditions of parts</p> <p>Be able to add part material information and contact information between parts</p> <p>The stress analysis report can be obtained by further analyzing the stress and strain of</p>	<p>Relationship between motion simulation and stress analysis</p> <p>Boundary conditions and setting methods of stress analysis</p> <p>Flow of stress analysis</p> <p>Structure of analysis interface and its grid division form</p> <p>Judgment standard for design rationality of parts and design method for optimizing mechanical parts</p>

Table 3 (continued)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Simulation analysis	Stress Analysis Verification	parts and components through automatic grid division method Reasonability of parts design can be judged through stress analysis report	
4	Composite processing of increase and decrease materials	Part blank fabrication	Determine the method and parameters of additive manufacturing according to the characteristics of components Be able to operate the additive manufacturing equipment to make the blank of parts Be able to complete consumable installation of 3D printer, common fault analysis and troubleshooting, etc	Type and application of additive manufacturing Basic operation of 3D printing equipment Analysis and elimination of common faults of additive manufacturing equipment
		Precision requirement analysis	Be able to analyze the structure and accuracy requirements for further finishing according to the function of components Analyze the structure and precision requirements for further finishing according to the assembly requirements of components	Basis for mechanical accuracy design Measuring method and adjustment method of machining accuracy
		Tooling fixture application	Be able to define the material reduction process route according to the characteristics of the processed parts Be able to design necessary auxiliary tooling fixtures according to the processing process route Be able to use additive manufacturing and other methods to make auxiliary tooling fixtures	Work piece positioning method and clamping method General principles for fixture design Basic methods and steps of auxiliary tooling design for additive manufacturing
		Composite processing implementation	Be able to use CAM software and prepare processing program according to process route Be able to use numerical control milling machine and use the program output by CAM software to carry out material reduction and manufacturing Be able to use auxiliary tooling fixtures to finish the processing of each surface of the work piece Be able to measure the work piece surface according to the processing requirements	CAM Software Application Basic operation methods of CNC milling machine Function and design method of auxiliary tooling fixture Detection and inspection methods of mechanical parts

7 Weight table

7.1 Weight table of theoretical knowledge

Theoretical assessment is divided into 2 basic requirements and 14 related knowledge requirements, each of which is classified as A level, B level and C level. The corresponding weights for each item are shown in table 4.

Table 4 Weight table of theoretical knowledge examination

Skill Level	Item	Level C (%)	Level B (%)	Level A (%)
Basic Requirements	Professional Ethics	5	5	5
	Basic Knowledge	15	-	-
Relevant knowledge requirements	Computer aided drawing	20	10	5
	Product data acquisition	10	5	5
	Digital product modeling	25	20	10
	Prototype physical production	10	5	5
	Product inspection	10	5	5
	Innovative product design	-	10	5
	Product modeling design	-	15	10
	Inverse model reconstruction	-	10	5
	NC machining of sample piece	-	10	5
	Typical industrial product design	-	-	15
	Intelligent design	-	-	10
	Simulation analysis	-	-	5
	Composite processing of increase and decrease materials	-	-	5
	Training and management	5	5	5
Total		100	100	100

7.2 Skill requirement weighting table

The professional competence assessment includes 14 items such as computer graphics, product data collection, product digital modeling, and sample entity production. Each item is divided into A level, B level, and C level, and the corresponding weights for each item are shown in Table 5.

Table 5 Weight table of operation skill examination

Skill Level	Item	Level C (%)	Level B (%)	Level A (%)
Skill Requirement	Computer aided drawing	10	5	5
	Product data acquisition	20	10	5
	Investigation and analysis	10	10	10
	Innovative solutions for research and development	10	15	10
	Digital product modeling	30	10	10
	Prototype physical production	10	10	5
	Product inspection	5	5	5
	Innovative product design	-	5	5
	Product modeling design	-	10	5
	Inverse model reconstruction	-	10	5
	NC machining of sample piece	-	5	5
	Typical industrial product design	-	-	5
	Intelligent design	-	-	5
	Simulation analysis	-	-	5
Composite processing of increase and decrease materials	-	-	5	
Training and management	5	5	5	
Total		100	100	100

8 Training site conditions

8.1 Theoretical knowledge training site

Theoretical knowledge training shall be carried out in the place with computer, and the computer shall be installed with industrial software meeting relevant parameters. Specific requirements are as follows.

8.1.1 Computer requirements

The computer requirements are as follows.

- a) CPU: i5 and above, main frequency unlimited;
- b) Memory: 4G and above;
- c) Display: 19 inches, 1920 × 1080 resolution and above.

8.1.2 Requirements for industrial software

The software requirements are as follows.

- a) Bilingual version in Chinese and English, supporting fast switch of language version;
- b) It can inherit 2D historical design drawing data and provide further editing tools to convert 2D design data to 3D design data;
- c) Compatible with 3D design data provided by supporting enterprises;
- d) The data import model is accurate in reading, with the ability of measurement and quality inspection; The data export accuracy is accurate, without data loss, and can be used for 3D printing, numerical control processing, etc;
- e) Capable of project management and document management; Capable of recording complete operation history and returning historical version;
- f) Create team and support team management;
- g) It has the data model sharing and collaboration function, supports multi-user collaborative browsing, collaborative design and collaborative review, and can conduct classroom teaching, student homework submission and correction;
- h) Parametric solid and surface modeling, topology naming technology, and feature-based parametric modeling;
- i) It provides conventional feature modeling functions such as stretching, rotation, lofting, sweeping and punching, and quickly realizes real-time design modification through dynamic modification of features and sketches;
- j) Surface design capability, supporting solid and surface mixed modeling;
- k) Supports highlighting individual parts through the assembly tree for ease of modification;
- l) Animation, explosion, interference check, clearance check and model statistics functions are provided, and assembly, explosion and structure motion process can be displayed through animation effect. Interference check can find interference problems in the design;
- m) Supporting efficient parameterization design, with parameterization design capability, and parameter names can be in Chinese; Support the storage of design parameters through Excel, and write parameters into the model through Excel correlation;
- n) It includes commonly used GB, ISO and other international standard parts library, and has the function of custom parts library, supporting standardized design and series product development;
- o) Have product digital design case database;
- p) Including professional design tools, capable of digital product design involving sheet metal parts and welding assemblies;
- q) It includes 3D pipeline design tools, and has the digital design ability of products involving 3D wiring and 3D pipe layout;
- r) Capable of outputting engineering drawings meeting GB, ISO and other international general standards, and adding manufacturing information in 3D models to meet MBD engineering requirements;
- s) It has the ability to output the effect picture, production layout, working principle animation and component assembly and disassembly animation of the product;
- t) Including simulation analysis module, capable of motion simulation and stress analysis of mechanical products;
- u) With intelligent design module, shape structure of parts can be optimized by derivative design according to product application conditions, and strength simulation analysis can be carried out in real time to realize lightweight design of parts;
- v) With auxiliary manufacturing module, it can simulate the processing path, generate the processing code and complete the numerical control processing of the product;
- w) With virtual assembly module, assembly process can be planned, assembly technical requirements can be added, text description and relevant tools of key points in the assembly process of parts can be added, problems such as interference in the assembly process can be inspected, and assembly process animation can be output;

- x) Secondary development interface with data modeling tools, which can be used to create complex modeling models;
- y) With automatic saving and backup mechanism, it can retrieve files in case of network failure, crash, etc;
- z) Support network authorization and stand-alone installation, and support cloud native, private cloud and public cloud deployment.

8.2 Operation skill training site

The training venue for operational skills should be built on the basis of theoretical training venues, with the addition of specialized hardware equipment for digital design and manufacturing, including reverse design equipment and additive/subtractive processing units. A digital innovation platform integrating reverse design and additive/subtractive manufacturing should be constructed to connect theoretical training with practical operational skills. The specific requirements are as follows.

8.2.1 Reverse design equipment requirements

The reverse design equipment requirements are as follows.

- a) Color texture: support 24 true colors;
- b) Calibration and calibration: it supports one-time calibration and calibration without subsequent repeated calibration and manual adjustment of bracket positioning, with stable anti-shake scanning effect;
- c) Scanner camera: no less than 3×10^6 color cameras, no less than 2;
- d) Scanning mode: support two modes of turntable full-automatic scanning and free scanning;
- e) Scanning range: no less than $220 \text{ mm} \times 220 \text{ mm} \times 210 \text{ mm}$ under full-automatic scanning mode of the rotary table; $740 \text{ mm} \times 740 \text{ mm} \times 740 \text{ mm}$ in Free Scan Mode;
- f) Scanning time: no more than 2 min under the turntable full-automatic scanning mode; no more than 6 s in free scan mode (single);
- g) Splicing mode: support automatic splicing, mark point splicing, manual splicing and feature splicing of turntable;
- h) Scanning accuracy: volume accuracy not more than 0.1 mm;
- i) Output format: including STL, ASC, OBJ, PLY, VTX, OFF、FB;
- j) Rotary table requirements: it can not only cooperate with the 3D scanner for full-automatic scanning, but also can be controlled by the software independently;
- k) One-key additive manufacturing: the software includes one-key printing button, which can directly import the scanned STL data into the layered software for layered processing through shortcut button, and generate the layered file of corresponding model;

8.2.2 Requirements for additive manufacturing unit

The requirements for additive manufacturing unit are as follows.

- a) Manufactured by fusion deposition molding (FDM);
- b) Fabrication size: not less than $300 \text{ mm} \times 300 \text{ mm} \times 300 \text{ mm}$;
- c) Slice control: including interactive editing system, which can realize multi-layer and multi-characteristic work production;
- d) Maximum speed: no less than 80 mm/s;
- e) Minimum layer thickness: no more than 0.05 mm;
- f) Material: PLA, ABS;
- g) Data transmission: support USB and other data transmission modes.

8.2.3 Requirements for material reduction manufacturing unit

The requirements for material reduction manufacturing unit are as follows.

- a) Stroke: transverse (X-axis), longitudinal (Y-axis) and vertical (Z-axis) strokes shall not be less than 200 mm, 90 mm and 200 mm respectively;
- b) Repeated positioning accuracy: the error is not more than 0.02 mm;
- c) Maximum spindle speed: no less than 3 500 r/min;
- d) Maximum milling diameter: not less than 60 mm;
- e) Maximum borehole diameter: not less than 16 mm;
- f) Safety protection: comply with IP54 requirements, fully enclosed structure, with automatic switch device of safety protection door and internal lighting;

- g) Electrical control: reliable numerical control system (such as FUnumerical control system) shall be used as the control core to realize three-axis linkage and complex processing path control;
- h) System requirements:
 - 1) The software shall support mainstream 3D model format (such as STL/STP);
 - 2) The numerical control system shall also be provided with friendly human-computer interface and rich programming functions, which is convenient for the operator to program and debug the machine tool;
 - 3) Implement international general standard G code programming, support M code and S code;
 - 4) dynamic path simulation capability shall be provided for 360-degree dynamic speed change view after generation of printed path;
- i) Data transmission: support USB and other data transmission modes;
- j) Communication function: support Modbus communication protocol and MES system communication with network port.

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