Skills for additive manufacturing competition

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Contents

Foreword

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This document was proposed and prepared by Asian Welding Federation Standardization committee.

Skills for additive manufacturing competition

1   Scope

This document specifies the skill requirements, safety regulations, assessment weights, and performance evaluation for the additive manufacturing event of Skills Competition.

This document is applicable to the organization and organization of the Skills Competition Additive Manufacturing Competition and training, as well as the construction of skill level bases and the basis for international cooperation.

2   Normative references

There are no normative references in this document.

3   Terms and definitions

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

3.1
additive manufacturing
also known as 3D printing, is a process of manufacturing parts or physical objects based on 3D model data through material stacking

3.2
additive manufacturing equipment
used to complete the necessary components of a molding cycle in the production process of parts or physical objects, including hardware, equipment control software and setting software

4   Job overview

4.1   Name of occupation

Additive manufacturing equipment technician.

4.2   Definition of occupation

Personnel engaged in installation, commissioning, repair and maintenance of additive manufacturing equipment, production operation and operation management.

4.3   Occupation level

There are three levels for this occupation, i.e. Level A, Level B and Level C from top to bottom.

4.4   Occupational environmental conditions

Indoor, normal temperature.

4.5   Vocational competence characteristics

Have certain learning, expression and computing abilities, strong sense of space and form, normal hearing and color vision, naked vision or corrected vision of both eyes reaching 4.9 above the logarithmic vision table, flexible fingers and arms, and strong motion coordination.

5 Basic requirements

5.1 Professional ethics

5.1.1 Code of ethics

Candidates should abide by laws and regulations, be dedicated to their work, and possess the following professional ethics:
    a) Good faith and honesty;
    b) Respect for others;
    c) Fair and just;
    d) Confidentiality and privacy;
    e) Responsibility and reliability;
    f) Continuing learning and professional development.

5.2 Basic knowledge

5.2.1 General basic knowledge

General basic knowledge includes 12 aspects, including mechanical drawing standards and methods of recognizing and drawing, mechanical principles and basic knowledge of mechanical parts:
    a) Standard for mechanical drawing and methods for drawing reading and drawing;
    b) Mechanical principles and basic knowledge of mechanical parts;
    c) Basic knowledge of tooling, tools and mould design and manufacturing;
    d) Basic knowledge of tolerance fit;
    e) Common equipment and processing technology for machining;
    f) Basic knowledge of materials and mechanics;
    g) Basic knowledge of electricians and electronics;
    h) Basic knowledge of digital technology;
    i) Basic knowledge of installation, commissioning and maintenance of mechanical and electrical equipment;
    j) Knowledge of safe use of electricity;
    k) Terms and symbols related to additive manufacturing;
    l) 3D scan related terms and symbols.

5.2.2 Basic knowledge of safety production and environmental protection

The basic knowledge of safety production and environmental protection includes four aspects: current health and safety regulations related to additive manufacturing industry, labor protection, safety production, and environmental protection:
    a) Current health and safety regulations for additive manufacturing industry;
    b) Basic knowledge of labor protection;
    c) Basic knowledge of safety production;
    d) Basic knowledge of environmental protection.

6 Work requirements

6.1 Classification of professional skill levels

The standard progressively sets skill and knowledge requirements for levels C, B, and A, with higher levels covering lower level requirements.

6.2 Level C

Professional skill level C includes relevant skill requirements for digital modeling, data processing and slicing, additive manufacturing molding, post-processing, equipment maintenance and upkeep. Specific skill requirements and related knowledge requirements are shown in table 1.

Table 1　C-level skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Digital modeling	Drawing of engineering drawing	Be able to draw engineering drawings according to the projection characteristics of three views Drawing of mechanical parts The tolerance and fit between parts can be selected according to the additive manufacturing process Be able to read simple assembly drawings	Drawing method of 2D plan Drawing specification of mechanical part drawing Function of common tolerance and fit in engineering design Functions and contents of assembly drawings of mechanical parts, and understanding the position relationship between parts and assembly sequence
		3d modeling	Be able to use 3D software for solid modeling Capable of editing 3D model Capable of correctly exporting STL files from 3D software	Methods of 3D software for constraint, dimension, assembly drawing, coordination and other operations 3D software parametric modeling method Export method of STL file in 3D software
		Reverse data acquisition	Be able to complete the adjustment and calibration of 3D scanner Pre-treatment before scanning of scanned parts Pre-treatment before scanning of scanned parts Correctly use 3D scanning equipment to obtain point cloud data Basic operations such as impurity removal, noise reduction, smoothing and filling can be carried out for the scanned data, and the data can be packaged into formable documents	Operating principle and calibration method of 3D scanner Pre-treatment methods for different types of scanning parts before scanning Pre-treatment methods for different types of scanning parts before scanning Parameter setting and scanning method of 3D scanning equipment Scanning Point Cloud Data Processing and Model Packaging Method
2	Data processing and slicing	Model Evaluation	Be able to evaluate the integrity of 3D model data Select additive manufacturing equipment for evaluating 3D model data	Integrity inspection and repair methods of 3D model data Characteristics and application scope of additive manufacturing equipment
		Slice processing	The molding model can be imported into the corresponding slice software, reasonably placed, adjusted in scale and added with support Be able to select molding materials according to product process requirements Set common slice parameters Be able to check the forming track and output the forming procedure	Slicing software model operation method Characteristics and application of common additive manufacturing materials Usage of slicing software Inspection method of forming trace in slice software and export method of file

Table 1　(*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Additive manufacture and molding	Equipment preparation	Be able to adjust the additive manufacturing equipment to normal use state Be able to inspect and handle forming materials	Operating specifications and methods of additive manufacturing equipment Types, characteristics and handling methods of additive manufacturing materials
		Grinding and Polishing of Formed Parts	The polishing tool can be used for manual polishing The grinding paste can be used for manual grinding	Polishing process and method Grinding process and method
		Assembly and commissioning of shaped parts	Be able to use installation tools to complete the assembly of formed parts according to the design requirements Be able to debug the assembled products to meet the functional requirements	Parts assembly requirements Reading essentials of assembly drawing Usage of common measuring tools and basic knowledge of tooling fixtures
4	Post processing	Removal and cleaning of molded parts	Can use tools to remove molded parts Can use tools to remove support Can use tools to clean residues Can install the work platform back into additive manufacturing equipment	Precautions for removing molded parts Instructions for using tools for removing molded parts and removing supports Precautions for cleaning residues from molded parts Precautions for restoring the work platform
		Grinding and polishing of molded parts	Can use polishing tools for manual polishing Can be manually ground using grinding paste	Polishing process and method Grinding process and method
		Assembly and debugging of molded parts	Able to use installation tools to complete the assembly of molded parts according to design requirements Ability to debug assembled products to meet functional requirements	Key points for reading assembly drawings for component assembly requirements Basic knowledge of using commonly used measuring tools and fixtures
5	Equipment maintenance and service	Daily maintenance of equipment	Be able to carry out daily maintenance according to the instructions of additive manufacturing equipment Be able to clearly understand the contents of daily maintenance of additive manufacturing equipment and record and file	Daily maintenance methods and precautions for additive manufacturing equipment Document arrangement and archiving method
		Fault record	Be able to stop the equipment in case of failure of additive manufacturing equipment Be able to accurately record the fault	Stopping method in case of failure of additive manufacturing equipment Judgment methods and skills for common fault state of additive manufacturing equipment

Table 1   (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
5	Equipment maintenance and service		state of additive manufacturing equipment	
		Equipment maintenance	Contact the maintenance personnel of additive manufacturing equipment according to the fault state, and accurately describe the fault state of additive manufacturing equipment.　Be able to pretreat additive manufacturing equipment according to remote guidance of maintenance personnel　Be able to check and evaluate the loss of parts of additive manufacturing equipment	Daily maintenance process, troubleshooting method and safety protection knowledge of additive manufacturing equipment　Pre-treatment methods in case of failure of additive manufacturing equipment　Evaluation method for loss of parts of additive manufacturing equipment

6.3   Level B

The professional skill level B includes relevant skill requirements for digital design, data processing and program optimization, additive manufacturing molding, post-processing, equipment maintenance and upkeep. Specific skill requirements and related knowledge requirements are shown in table 2.

Table 2   B-level skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Digital design	Structure Design	Analyze product functions according to customer requirements and collect relevant data to prepare requirement documents　Be able to carry out product structure design according to industry standards and complete digital appearance design and rendering of products　Digital assembly of no more than 5 moving parts　Complete the motion simulation of the product	Design and analysis methods of industrial products　Structure optimization method of 3D model　Technical specifications for product assembly and identification essentials for 3D assembly drawings　Production related knowledge of motion simulation
		Data acquisition	Be able to select 3D scanner specifications as required　Be able to complete the data acquisition of formed parts with no more than 20 characteristics within the specified time　It can complete the front and back splicing scanning of molded parts	Application Scenario of 3D Scanner　Scanning data acquisition method of multi-feature forming parts　Splicing method of forward and reverse scanning data　Methods for repairing scanned data

Table 2 (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Digital design	Reverse Design	Be able to repair defects of scanned data Model reconstruction of scanned data with software Reverse modeling and reconstruction of solid model	Reverse modeling method of scanning data Reverse modeling method of solid model
2	Data processing and program optimization	Model optimization	Model splitting can be carried out according to product characteristics and forming process Be able to repair defects in 3D model data	Model splitting method of 3D modeling software Repair methods for common defects of 3D modeling software
		Program optimization	Optimize the 3D model according to the process characteristics, shape characteristics and stress requirements of different additive manufacturing	Optimization method of 3D model structure
		Optimization of forming parameters	The slice parameters can be optimized according to the needs Be able to read and edit slice program code Be able to complete repair and reconstruction, placement and arrangement, manual addition of support and other work through auxiliary software	Optimization method of slice parameters and support structure Edit Slicer Code Method Method of model optimization with auxiliary software
3	Additive manufacture and molding	Equipment environment inspection and preparation	Be able to check the temperature, humidity, flammable and explosive sources around the additive manufacturing equipment and estimate the possible faults Be able to check the power load and network coverage of the place where the additive manufacturing equipment is located and estimate the possible faults Environmental maintenance according to equipment requirements It can be replaced or added according to the material characteristics of additive manufacturing equipment The loading quantity of additive manufacturing equipment and materials can be calculated according to the 3D model Be able to find out the faults and causes of test molding parts of additive manufacturing equipment	Requirements for ambient temperature, humidity and fire protection of additive manufacturing equipment Electrical load requirements and network signal requirements for additive manufacturing equipment Environmental maintenance requirements for ventilation, lighting, fire prevention and explosion prevention of additive manufacturing equipment Ratio requirements for new and old materials of different additive manufacturing equipment Requirements of different 3D models on loading quantity of additive manufacturing equipment and materials Failure analysis method for test molding parts of different additive manufacturing equipment

Table 2 (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Additive manufacture and molding	Forming monitoring	Be able to set and optimize parameters of additive manufacturing equipment Be able to set and optimize the parameters of additive manufacturing and forming process Be able to conduct simulation analysis on additive manufacturing process and guide additive manufacturing process Analyze the influencing factors of part forming according to the forming effect of parts, optimize and adjust the process parameters and build the process database Prepare process specification documents for additive manufacturing	Parameter setting and optimization method of additive manufacturing equipment Parameter setting and optimization method of additive manufacturing process Key points of simulation analysis technology of additive manufacturing process The influence law and mechanism of different processes of additive manufacturing, including the optimization knowledge of raw material properties, equipment accuracy, processing and production parameters Process knowledge of additive manufacturing
		3D digital detection	Extraction of feature elements of model scanning data Coordinate System Alignment Capable of Scanning Data Be able to complete 2D and 3D dimension evaluation on scanning data Capable of completing geometric tolerance evaluation on scanned data	Operation method of test software Alignment principle of scanned data and CAD 2D and 3D dimension evaluation methods Geometric tolerance evaluation method
		Quality evaluation	Be able to comprehensively evaluate the quality of molded parts and adjust model data or slice parameters due to abnormal reasons of additive manufacturing molded parts Propose improvement measures for defects of molded parts Be able to analyze and judge the causes affecting the mechanical property and dimension error of molded parts	Method for quality analysis of additive manufacturing molding parts Improvement methods for defects of molded parts Mechanical property judgment, analysis method and size error analysis method of forming parts of additive manufacturing equipment
4	Post treatment	Post-production of molded parts	Selection of post-processing environment for additive manufacturing of molded parts Repair defects of additive manufacturing molding parts Post-treatment by sand blasting, painting, electrolytic polishing, chemical polishing、surface strengthening and other methods can be carried out as required	Environmental Requirements for Post-treatment of Additive Manufactured Molded Parts Repair methods for defects of molded parts Physical and chemical methods for post-treatment of moulded parts

Table 2 (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
4	Post treatment	Post-production of molded parts	Post-treatment of cutting according to the demand The molded parts can be cured Be able to track, analyze and summarize the forming process and improve the design and forming process Assemble the product according to the assembly accuracy requirements and ensure the assembly accuracy requirements Be able to handle the harmful substances generated in the post-treatment process of molded parts	Use of common equipment for post-treatment of molded parts Solidification treatment method of molded parts Common machining methods Product assembly accuracy requirements Treatment method for harmful substances generated from post-treatment of molded parts
5	Equipment maintenance and service	Anomaly cause analysis	Be able to analyze and judge abnormal reasons such as temperature and humidity of additive manufacturing equipment Be able to analyze and judge the causes of abnormal molding of additive manufacturing equipment Be able to analyze and judge the causes of abnormal attachment of molding parts of additive manufacturing equipment	Technical requirements for temperature and humidity of additive manufacturing equipment Common causes for abnormal molding of additive manufacturing equipment Common causes for abnormal attachment of molding parts of additive manufacturing equipment
		Troubleshooting	Troubleshoot the faults according to the common fault manual of additive manufacturing equipment Propose solutions according to the fault state of additive manufacturing equipment	Troubleshooting methods for additive manufacturing equipment Fault analysis and troubleshooting of additive manufacturing equipment
		Equipment maintenance	Be able to judge the nature and degree of additive manufacturing equipment faults Be able to complete the replacement of vulnerable parts of additive manufacturing equipment Regular inspection and maintenance of mechanical mechanisms and electrical components of additive manufacturing equipment	Judgment method for fault nature of additive manufacturing equipment Replacement methods for common parts of additive manufacturing equipment Regular inspection and maintenance requirements for mechanical mechanisms and electrical components of additive manufacturing equipment

6.4 Level A

Professional skill level A includes relevant skill requirements for product integrated design, professional molding scheme formulation, equipment operation and molding processing, Internet plus additive manufacturing, training and management. See table 3 for specific skill requirements and relevant knowledge requirements.

Table 3 A-level skill knowledge requirements

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
1	Integrated product design	Structure Design	Product design can be carried out according to standardization, serialization and generalization Be able to carry out structural optimization design according to structural process, reliability and economical efficiency Be able to carry out innovative design and optimize product structure according to product requirements	Application principle of standardization, serialization and generalization in product design Application principle of manufacturability, reliability and economical efficiency in product structure optimization design Understand the concept of innovation, and use innovative thinking to optimize the product structure
		Curved surface reconstruction	Be able to complete the data acquisition of formed parts with no more than 50 features (including free curved surface, hole, rib plate, etc.) Model reconstruction of free surface with software Be able to analyze the data of the reconstructed model and output the test report	Scanning data acquisition method for free curved surface, hole, rib plate and other features Model reconstruction method of 3D modeling software for various free surfaces Analysis and judgment method of reconstruction model
		Topology	Topology optimization of parts The model after topology optimization can be repaired Be able to analyze the optimized model and generate the optimization report Be able to optimize models by AI technology	Usage of topology software Topology analysis knowledge Compilation method of topology optimization report Usage of AI technology
2	Formulation of professional forming scheme	Selection of forming materials	Be able to analyze the causes of poor molding of new materials, and re-prepare the molding parameter optimization process scheme according to the characteristics of new materials Be able to formulate molding scheme for molding parts according to the characteristics of molding materials Be able to prepare the support setting scheme for special-shaped parts The placement direction and array quantity of the forming model can be selected according to the forming batch or quantity requirements	Forms and countermeasures for forming defects of various forming materials, influence factors of material characteristics on forming parameters and analysis methods Technical requirements for formulation of forming scheme Setting method of special-shaped part support Batch forming process

Table 3 (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
2	Formulation of professional forming scheme	Equipment selection	Be able to select equipment based on product demand and forming process The molding equipment can be selected according to different post-processing requirements Be able to judge possible faults in the forming process in advance and prepare solutions	Function analysis methods for molding parts of various additive manufacturing equipment Post-treatment process essentials of relevant additive manufacturing equipment Prediction and handling methods for forming faults of additive manufacturing equipment
		Equipment control and parameter setting	Be able to formulate additive manufacturing and molding process for integrated molding parts of multiple materials Be able to operate the additive manufacturing equipment to complete the forming of the integrated product composed of at least 3 parts with relative motion determined and free from assembly Be able to use software technology to simulate simulation operation, add and optimize support structure Be able to adjust parameters and use the development package to set parameters	Analysis method of additive manufacturing integrated molding process Setting method of integrated product support Simulation optimization support design method Considerations for development package parameter setting
		Quality evaluation	Be able to put forward a quality improvement plan according to the requirements of the quality management system Optimize process parameters according to quality analysis results and customer feedback	Formulation method of quality plan Method for optimizing process parameters according to quality analysis results
3	Equipment operation and forming treatment	Overall planning	Be able to prepare the manufacturing process and scheme of molded parts Prepare post-treatment scheme according to material characteristics	Preparation method for production process and preparation method for production plan of additive manufacturing molding parts Preparation method of post-treatment scheme for different materials
		Post-production of molded parts	Be able to heat treat metal materials Be able to check the ventilation and other working environment conditions of metal materials Be able to mix and match different materials for printing Be able to propose post-processing methods for non-assembly integrated molding products	Heat treatment methods of relevant metal materials Ventilation requirements for metal additive manufacturing Multi material printing method Post-treatment methods for non-assembly integrated molding products

Table 3 (*continued*)

NO.	Occupation function	Content of work	Skill requirements	Relevant knowledge requirements
3	Equipment operation and forming treatment	Impact assessment	Overall evaluation of additive manufacturing products Be able to prepare the final product evaluation form Be able to identify whether the final product is qualified by reading the inspection report of additive manufacturing product	Evaluation methods for additive manufacturing products Inspection methods for mechanical products Total quality evaluation method
4	Digital technology +additive manufacturing	Remoting	Be able to remotely monitor the whole process of additive manufacturing with multi-terminal equipment Be able to utilize "Digital technology+" technology to implement remote control and operation of additive manufacturing equipment	Operation method for remote monitoring of multi-terminal equipment Method for remotely controlling and operating additive manufacturing equipment via digital technology
		Remote customization	Be able to utilize "Digital technology+" technology to meet the demand of users for remote production of 3D data models; Be able to utilize "Digital technology+" technology to meet the demand of users for remote customization of molded parts	Method of transmitting 3D data model via digital technology Method for realizing user remote transmission of demand order of molded parts via digital technology
5	Training and management	Equipment operation training	Be able to prepare the operation training plan for additive manufacturing equipment Be able to provide technical training for operators of additive manufacturing equipment Be able to prepare teaching courseware, micro-class video and other teaching resources for training, and prepare additive manufacturing equipment operation training materials	Planning essentials for operation training scheme of additive manufacturing equipment Teaching strategy and teaching method The latest development direction of additive manufacturing technology and process, operating procedures of various additive manufacturing equipment and key points for making training cases
		New Technology Application	Be able to quickly accept new technologies, new equipment, new materials and new forming methods such as artificial intelligence (AI), and promote the latest material manufacturing technology achievements Guide the additive manufacturing equipment operators to carry out process technology improvement projects	Organization mode of technology application promotion Application methods of classic cases of additive manufacturing process technology improvement

7 Weight table

7.1 Assessment method

The assessment methods are divided into theoretical knowledge examination and skills assessment.

7.2 Weight table of theoretical knowledge

The specific weight table of theoretical knowledge is shown in table 4.

Table 4 Weight table of theoretical knowledge

Item		Level C（%）	Level B（%）	Level A（%）
Basic Requirements	Professional ethics	5	5	5
	Basic knowledge	20	15	10
Relevant knowledge requirements	Digital Modeling/Digital Design	30	30	-
	Data Processing and Slicing/Data Processing and Program Optimization	10	10	-
	Manufacture and molding of additive	15	20	-
	Post treatment	10	10	-
	Equipment maintenance and service	10	10	-
	Integrated product design	-	-	25
	Formulation of professional forming scheme	-	-	20
	Equipment operation and printing processing	-	-	15
	Digital technology+additive manufacturing	-	-	15
	Training and management	-	-	10
Total		100	100	100

7.3 Skill requirement weighting table

The specific weight table of skill requirements is shown in table 5.

Table 5 Skill requirement weighting table

Item		Level C（%）	Level B（%）	Level A（%）
Skill Requirement	Digital Modeling/Digital Design	25	30	-
	Data Processing and Slicing/Data Processing and Program Optimization	20	20	-
	Manufacture and molding of additive	25	20	-

Table 5   (*continued*)

Item		Level C（%）	Level B（%）	Level A（%）
Skill Requirement	Post treatment	15	15	-
	Equipment maintenance and service	15	15	-
	Integrated product design		-	30
	Formulation of professional forming scheme	-	-	25
	Equipment operation and printing processing	-	-	20
	Digital technology+additive manufacturing	-	-	10
	Training and management	-	-	15
Total		100	100	100

8   Equipment configuration table

This configuration table mainly requires the standard configuration requirements for assessment bases at levels C, B, and A, as detailed in table 6.

Table 6   The standard configuration requirements for the assessment base

Name of equipment and instrument	Quantity of equipment	Function & Main technical parameters
3D modeling software	20	Provide digital design application software
Reverse engineering software	20	Provide parameterized modeling processing function for industrial design
Analysis and comparison software	20	Provide CAD deviation analysis, geometric dimension analysis and geometric tolerance analysis software
Topology optimization software	20	Software that can optimize the material distribution in a given area according to a given load case, constraint conditions and performance indicators
Computer	20	System: Windows 10-64 and above
		Processor: i7 Processor above 9 generations
		Operating memory: 32G and above
		Hard disk space: 1T hard disk
		Display card: above NVIDIA RTX3060 8G
3D scanner	10	Scanning technology: red and blue light double-color scanning technology
		Data output format: export results in formats such as ASC and STL

Table 6 *(continued)*

Name of equipment and instrument	Quantity of equipment	Function & Main technical parameters
Additive manufacturing equipment	10	Molding process: laser melting technology
		Printing materials: titanium alloy, aluminum alloy, superalloy, stainless steel
	20	Molding process: light curing molding process
		Data format: support all output STL format 3D software
Additive manufacturing equipment	20	Molding process: Fusion deposition technology (FDM)

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