Exploration on Reform of Materials Forming and Control Engineering for Intelligent and Additive Manufacturing

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Abstract. With the development of new technologies such as intelligent manufacturing and additive manufacturing, it is necessary to reform and upgrade traditional major of materials forming and control engineering. In 2019, the major of materials forming and control engineering in University of Shanghai for Science and Technology successfully passed China engineering education certification. In order to meet the requirements of continuous improvement, new courses on intelligent manufacturing and additive manufacturing are added into the new training program of the major, and new major orientations are designed in the curriculum system, which can better fit the training demand of excellent talents from advanced manufacturing industries of Shanghai and Yangtze River Delta.

1. The Goal and Significance of the Reform
Materials forming and control engineering is an important part of advanced manufacturing discipline in University of Shanghai for Science and Technology. It was founded in 1952 and upgraded to undergraduate major in 1999. It was approved as a highland specialty of Shanghai undergraduate education in 2009. In recent ten years, aiming at the actual demand of material forming talents in Shanghai and the Yangtze River Delta region, the major has continuously optimized the professional training objectives, graduation requirements and curriculum system, and established a mechanism for graduates' quality tracking and improvement. Since 2009, the employment rate of graduates over the years has been maintained at 100%, ranking first in the whole university. On the basis of rapid development in the past ten years, it has successfully passed the China Engineering Education Certification in 2019, and has become the ‘first-class undergraduate’ major in Shanghai, and initially established a set of excellent engineering talent training mechanism.

With the implementation of Made in China 2025 strategy, intelligent manufacturing [1,2], additive manufacturing [3,4] and other emerging technologies are rising in Shanghai and Yangtze River Delta. In addition, the specialty of materials forming and control engineering will be brought into the specialty of new material engineering and manufacturing in Universities in Shanghai.

Intelligent manufacturing and additive manufacturing are one of the development areas clearly planned by Fudan Consensus of Ministry of Education, Tianda Action and Beijing Guide. Domestic well-known first-class colleges and universities have begun to promote the construction of related new engineering courses. Intelligent manufacturing and additive manufacturing have been incorporated into the teaching system of material engineering and mechanical engineering in well-known foreign universities, providing talent guarantee for the development of new technology and new economy.

As one of the top 100 universities in China, University of Shanghai for Science and Technology is vigorously promoting the construction of new engineering courses. Materials forming and control engineering specialty is the first characteristic brand specialty that has passed the engineering
education certification in the University. It is particularly necessary to seize the opportunity of this round of new engineering construction, integrate intelligent additive manufacturing into the professional development system and discipline construction, and realize the upgrading and transformation from specialty to new engineering.

The main reform objectives are: To study and analyze the new requirements of intelligent additive manufacturing technology for traditional Materials forming and control engineering talents training, update the curriculum system and teaching content, explore the ways and means of further informatization and digital transformation of traditional Materials forming and control engineering specialty, and explore the existing professional reform based on the new technology of artificial intelligence and additive manufacturing, create new directions and fields of upgrading and form a new curriculum system.

The main reform contents include: to formulate the training objectives and graduation requirements of Materials forming and control engineering specialty including intelligent additive manufacturing; to formulate the curriculum system of Materials forming and control engineering including intelligent additive manufacturing, and add the course modules of intelligent additive manufacturing; to compile a series of curriculum syllabus of intelligent additive manufacturing, select teaching materials, compile teaching courseware and teaching cases.

2. Reform Basis
From 2017 to 2018, the specialty introduced the international advanced additive manufacturing research team, established the additive manufacturing international laboratory, and configured various advanced additive manufacturing equipment, which provided sufficient experimental sites and equipment conditions for the teaching of additive manufacturing. The team has carried out various academic and scientific research cooperation with Monash University in Australia, the University of Birmingham in the UK and COMAC, providing an excellent support platform for professional upgrading, course teaching and student internship.

Other professional teaching and research teams have long been committed to teaching and scientific research in the fields of automobile forming manufacturing, intelligent manufacturing, micro nano manufacturing and medical industry, and their achievements can support the professional upgrading to intelligent manufacturing and other fields.

3. Reform Process
The whole reform process is divided into five stages: in April 2019, a seminar on the training scheme of professional backbone teachers was held to determine the direction and content of intelligent, additive, micro nano medical engineering cross manufacturing and other new engineering subjects in the training program since 2019. In May 2019, a seminar on the training plan for teachers and enterprise experts of the whole department was held to further refine the details of the training plan, and clarify the main framework of the training plan, curriculum system, curriculum outline and other documents. From May to July, 2019, we worked out the professional training program, curriculum system and curriculum outline. From September to October 2019, the responsible teacher completed the collection and preliminary production of course courseware and cases. In November 2019, the seminar on industrial enterprise expert training scheme was held again to collect and sort out the experts' opinions. The attending experts fully affirmed the fruitful results of the teaching reform, and put forward suggestions for further optimization of the reform, pointing out the direction for the continuous improvement of the specialty.

4. Concision of Training Objectives
After this round of reform, combined with the feedback of engineering certification, the training objectives of the major are summarized as: to cultivate advanced engineering technology and management talents in advanced forming, manufacturing and intelligent control industry with ‘engineering ability, innovation ability and international vision’ with comprehensive development of morality, intelligence, physique, beauty and labor; mastering solid professional knowledge and skills, having the ability to analyze, make decisions and solve professional complex engineering problems;
good English listening, speaking, reading and writing ability, professional communication ability in cross-cultural environment; innovative ability in design, development and application; lifelong learning and sustainable development ability, good humanistic and social literacy and team cooperation consciousness; certain knowledge of engineering management and economic decision-making, environmental protection knowledge and industry safety. With these abilities, graduates could become outstanding talents engaged in production design, research and development, quality control management and market operation in the field of advanced forming, manufacturing and intelligent control.

5. Optimization of Graduation Requirements
According to the determined training objectives, the graduation requirements are comprehensively optimized. The revised graduation requirements mainly include: be able to use mathematics, natural science, engineering foundation and professional knowledge to solve complex engineering problems in advanced forming, manufacturing and intelligent control field; be able to propose relevant system solutions; have the innovative consciousness of design and development; be able to comprehensively consider the factors of society, health, safety, law, culture and environment; be able to design experiments, analyze and interpret data, have the ability to get effective conclusions through information integration; be able to select, use and develop appropriate technologies, resources and tools to predict, simulate and optimize complex engineering problems; understand the background knowledge of standards, laws and regulations and safety management related to research, design, production, etc., and be able to comprehensively evaluate the impact of solutions on society, health, safety, etc. The graduates must have the awareness of environmental protection and sustainable development, have the humanities and social science literacy and social responsibility, understand and abide by engineering professional ethics and norms, and perform corresponding responsibilities; be able to communicate with peers in the industry and the public with clear expression ability; have foreign language ability and international vision, and be able to communicate under cross-cultural background; be able to master and apply engineering management and economic decision-making methods.

6. Improvement of Curriculum System
First, add three professional directions: (1) Advanced manufacturing, mainly for intelligent manufacturing, additive manufacturing, mold manufacturing and other fields. (2) Advanced molding, mainly for automobile panel forming, welding forming, rubber and plastic forming, composite material forming and other fields. (3) Process and quality control, mainly for molding quality control, mold surface control, material performance control, material failure control and other fields. Corresponding theory and practice courses are offered in all directions. Students can choose a certain direction according to their interests.

Second, add the course module of intelligent manufacturing. Additionally, courses such as ‘Intelligent control of molding manufacturing’, ‘Intelligent simulation of molding manufacturing’, ‘Practice of intelligent simulation of molding manufacturing’, and ‘Intelligent manufacturing technology’ are set up in the 5th and 6th short semesters, the 6th and 7th long semesters to strengthen the cultivation of intelligent molding manufacturing.

Third, add the course module of additive manufacturing. Add ‘Additive manufacturing technology’ and ‘Additive manufacturing project practice’ to cultivate students' professional skills in the field of additive manufacturing.

Fourth, add the course module of micro nano manufacturing. ‘Micro nano manufacturing technology’ and ‘Micro nano manufacturing project practice’ were added to cultivate students' professional skills in micro nano manufacturing and medical industry cross manufacturing fields.

Fifthly, according to the feedback of engineering certification, ‘Calculation method’ and ‘Thermal and fluid foundation’ are set as compulsory courses, and ‘Project management and decision-making’ are added as compulsory courses to cultivate students' management and decision-making skills.

At the same time, adjust the semester of some courses to balance the burden of each semester.
The revised training program has 168 credits, which is divided into four course modules, including 47.5 credits for general education course module, 60 credits for discipline basic course module, 56.5 credits for professional course module and 4 credits for optional course module.

7. Conclusion
After the above-mentioned teaching reform, the training program of Materials forming and control engineering is formed, which is oriented to intelligent additive manufacturing and meets the requirements of continuous improvement of engineering education certification. The scheme absorbs the opinions of engineering certification experts and enterprise experts, forms advanced manufacturing features such as intelligence and additive, and adapts to the development direction of new engineering. After the implementation of the training program, it will take the lead in realizing the new engineering characteristics of materials forming and control engineering oriented to intelligent and additive manufacturing in Shanghai and the Yangtze River Delta region, add highlights to the construction of first-class disciplines in University of Shanghai for Science and Technology, and cultivate outstanding engineering talents in intelligent manufacturing, additive manufacturing, large aircraft, automobile manufacturing and other industries in Shanghai and the Yangtze River Delta region, which has important reform significance and innovation value of popularization and application.

8. Acknowledgments
Great thanks to the teaching research projects (CFTD 193008, CFTD201011) supported by the Faculty Development Center, University of Shanghai for Science and Technology.

9. References
[1] Jingsha He, Prasad Yarlagadda and Shengzong Zhou 2020 *Int. J. of Computer Integrated Manufacturing (Special issue on the application of artificial intelligence in advanced manufacturing)* 33 10-11 pp 947-948
[2] Lihui Wang 2019 *Engineering (From Intelligence Science to Intelligent Manufacturing)* 5 4 pp 53-60
[3] Mercedes Pérez, Diego Carou, Eva María Rubio and Roberto Teti 2020 *Procedia CIRP (Current advances in additive manufacturing)* 88 pp 439-444
[4] Hague and Richard 2020 *Biomarkers and Genomic Medicine (Additive Manufacturing a mature technology?)* 300 7915 p 41