ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research, volume 455
Proceedings of the 2020 International Conference on Social Science, Economics and Education Research (SSEER 2020)

Explore and Research on Flipped Class in Brazing Experimental Teaching

Duo Liu, Jingbo Yu*, Xingyi Li, Bin Chen
School of Materials Science and Engineering
Harbin Institute of Technology, Weihai
Weihai, China
*Corresponding Author

***Abstract*—According to the characteristics of brazing experimental teaching, such as unitary equipment, low engagement of students, inferior learning initiative and tardy experiment content update, flipped class and micro-video were introduced to brazing experimental teaching successfully. The interaction between teachers and students is carried out in a pioneering way. The student-centered supervision mechanism is developed to help students choose the time, place and method to preview the experimental report and watch the micro-video of experimental teaching in the best condition. Experimental teaching model was optimized, and the learning interest and engagement of students were improved significantly, contributing to the enhancement of integrative competence containing manipulative ability and consciousness of innovation. Therefore, scientific literacy and comprehensive abilities of the students can be improved.**

Keywords—Brazing; Experimental Teaching; Flipped Class; Micro-video

I. INTRODUCTION

OBE is the abbreviation of Outcome-Based Education, proposed by Spady in 1981, which received extensive attention and application at an amazing speed [1-3]. In June 2013, China was admitted as a member of the Washington Accord. Results-oriented education refers to the teaching process in which all activities are centred on the expected learning outcomes realized by students [4]. Engineering education emphasizes student-centered, and the following four questions are emphasized in in brazing experimental teaching: (1) what are the learning results we want students to achieve? (2) Why should we let students achieve such learning results? (3) How can we effectively help students achieve these learning outcomes? (4) How do we know that students have achieved these learning outcomes? It is of practical significance to introduce the idea of achievement result-oriented education into the teaching reform of brazing experiment.

Brazing is one of the three main components of modern welding technology [5]. With the rapid development of aviation, aerospace, ship and automobile manufacturing technology, brazing teaching is receiving more and more attention. Brazing is a major course of welding technology and engineering, which is composed of brazing theory and experimental teaching, and it's an important part of basic welding experimental teaching. The purpose of this part is to improve students' understanding of the basic principles of brazing, the operation of equipment and the improvement of comprehensive ability. Because the experimental equipment is a large-scale instrument, so for the traditional brazing experimental teaching process, the experimental teacher's operation demonstration is adopted, the students watch it nearby, which leads to the less enthusiasm and participation of students in the teaching process, inhibit the improvement of practical and innovation ability. So, the necessity of combine the requirements of OBE education concept and integrate the graduation requirements of students into the brazing experimental teaching is obviously.

Supported by Education Reform Project of Harbin Institute of Technology (Weihai):BKJY201921

II. THE NECESSITY OF THE BRAZING EXPERIMENTAL TEACHING REFORMATION

A. Analysis of Traditional Brazing Experimental Teaching

Brazing experimental teaching is a major course of basic welding experiment, which plays an important auxiliary role in the teaching of brazing theory. Through the study of this experiment course, students can deepen their understanding of the basic principles of brazing, be familiar with the operation of equipment and welding process. At present, the large-scale brazing experimental teaching equipment with a unit price of more than 400000, and experiment takes several hours. Therefore, it is impossible for each student to complete the experiment operation independently. So, the traditional experimental teaching mode adopts the students to preview the experiment content before the experiment, the experimental teachers explain the experiment content during the class congregated, and demonstrate the operation process of the experimental equipment, and students complete the experiment report after class. However, due to the limitations of the number of students and laboratory space, the students had to be divided into several groups before the experiment, which will increase the number of repeated explanations and the workload of the experimental teachers. At the same time, experimental explanation takes up a lot of class time, so the students cannot carry out the teaching content in time, which affects the effective combination of brazing experimental and theoretical teaching.

B. *The Sluggishly Update of Brazing Experimental Teaching Content, and the Inadequate Investment of Experimental Equipment*

With the rapid development of science and technology, the content of brazing theory teaching is updated quickly, but the content of experimental teaching is obsolete. Due to the newly revised undergraduate syllabus, the teaching hours of experiment are further compressed, but the content of experimental teaching are still complicated. The insufficient time for theoretical teaching makes students hard to grasp and understand the teaching content. Therefore, the experimental teaching is turned into a means to verify and deepen the understanding of the theoretical teaching content. In addition, the laboratory teaching investment is insufficient, and the number of experimental equipment sets is small, all above inhibit the training of experimental teachers.

C. *Simple Assessment Method of Experimental Teaching is not Conducive to the Assessment of Comprehensive Experimental Results*

At present, the experiment report is the mainly teaching method of brazing experiment, which is evaluated according to the students' attendance rate and the result of experiment report which cannot represent their comprehensive quality. Due to this single method in the process of experimental teaching, students cannot experiment personally, and their comprehensive abilities such as practical and innovation ability cannot be evaluated. The traditional experiment report is mainly composed of experiment purpose, principle, procedure, result analysis and experience. Students only need to copy the purpose, principle and procedure according to the experiment instruction, which cannot reflect the technical content. However, the most critical parts such as microstructure, analysis of brazed joint materials and experience can't be completed personally, so that both their subjective initiative and enthusiasm and practical, innovation ability can't be reflected. Consequently, there are similarities and even plagiarism. Therefore, the traditional experimental assessment method can only partially represent students' mastery of experiments, but not their innovation awareness, the ability of practical and the use of knowledge comprehensively.

III. Reform of Brazing Experimental Teaching Based on the Concept of Engineering Education

The development of mobile computing technology has led to the change of education concept and learning mode. With the popularity of smart phones and the rapid development of wireless networks, college students are more and more accustomed to using mobile phones for mobile learning, while micro video has the advantages of flexibility, autonomy, repeatability, openness and so on [6]. By introducing the micro-video into the brazing experimental teaching, we can transform the boring experiment content into the short and concise, standardize the brazing experimental teaching, and improve the effect of the experimental teaching. At the same time, flipped class has the advantages of flexibility, repeatability, brevity, highlighted theme, strong interaction and so on [7]. Brazing experimental teaching realizes the flipping of time and place of experimental teaching, and enriches the teaching methods and forms of experimental teachers, making the experimental teaching hours from the original limited 45 minutes to unlimited hours, and students are no longer subject to the laboratory space. In the past, energetic students will actively stand beside the teacher and listen to the experimental operation procedures, operation essentials and experimental precautions carefully, while those students who are not active in their learning attitude will stand behind as "Bow head clan", which results in some students' high learning efficiency, while some students are completely "invisible" and "inaudible". The previous experimental teaching was a low-efficiency repeated drill. Now "invisible" and "inaudible" students can repeatedly learn the experimental operation procedures, essentials and precautions through micro video, until they acquaint.

According to the advantages of flipped class, the layout of brazing experimental teaching system is designed, as shown in Fig. 1. Before the class, the experimental teacher sends the experimental instruction and teaching micro video to the students through the Management Front-End, and the students choose the time, place and way to preview the experimental report and watch the experimental teaching micro video independently, so they can preview the experiment efficiently under the best condition. According to the advantages of the repeatability of the flipped class, they can repeatedly watch the safety operation micro video and the experimental teaching video, be familiar with the experimental equipment and safety operation rules, so as to reduce the burden of teachers' explanation and improve the teaching effect.

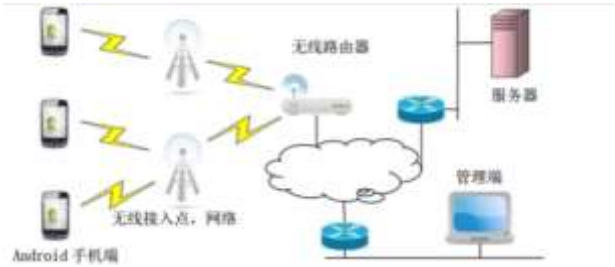

Fig. 1. Lay out of system

In addition, due to the single experimental equipment and 6-8 hours demand for a complete experiment, while the experimental teaching class hours are only 2. In order to solve the problem of teaching time conflict, the experimental teaching and graduation design, the first-grade project and comprehensive innovation experiment are combined. At the same time, the laboratory adopts the open management mode, breaks the traditional experimental teaching unified teaching mode, and takes students as the main body. Using the experiment appointment system, students can arrange the experiment time and place more flexibly, provide students with a loose learning environment, fully mobilize students' interest in active learning, and promote students' comprehensive ability.

A. *Reform the Traditional Experimental Teaching Mode with the Goal of Application Ability Training*

The traditional brazing experimental teaching adopts demonstrative experiment. The experimental teacher mainly explains and demonstrates the safety operation rules of the

equipment and the setting of the parameters. However, there is no adequate time for the subsequent test piece processing and analysis to demonstrate, inhibit the improvement of the experimental teaching effect and analysis ability of students. For this problem, the micro-video composed of safety operation procedures of equipment, setting of parameters, post-processing video of samples (such as sample preparation, grinding, microstructure analysis, etc.), combining with the micro-video playing, the whole experiment process is mainly explained, and the experiment process is divided into several stages for detailed introduction, which is beneficial for improving the experimental teaching effect and practical ability and innovation ability of students. In order to ensure that every student can be proficient in the experimental teaching content, a network experimental teaching platform is established, which mainly consists of the experiment instruction, the operation video module of equipment, SEM, the 3D animation module of brazing welding method, the metallographic preparation module and the communication module between teachers and students. The construction of the platform has changed the traditional brazing experimental teaching mode. The traditional laboratory teaching location can be changed into classrooms, dormitories, parks and other places to facilitate students to watch and learn the experimental teaching content anytime and anywhere efficiently. The traditional fixed experimental teaching time has been changed into students' efficient learning at their own time which help to improve students' learning efficiency. In this way, the time and space of the traditional experimental teaching mode is enlarged infinitely, which is beneficial to guarantee the opening of laboratory resources to each student. In addition, through the interactive communication module between teachers and students, the students send the preview assignments to the teachers, so that they can grasp the learning situation of each student's experimental content through the their answers to the preview experimental assignments, and then grasp the differences of students' learning, which helpful for the arrangement of specific experimental teaching activities orderly and effectively.

B. Innovative Experimental Teaching Based on the Concept of CDIO Engineering Education

The concept of CDIO (Conceive/ Design/ Implement/ Operate) engineering education [8-10] is a joint effort by four universities including MIT to form new achievements in the reform of international engineering education. The CDIO emphasizes "learning by doing", which is to use comprehensive design projects that are close to the actual project as possible to teach students and cultivate their enthusiasm for learning. In the brazing experimental teaching, the Ni-based filler metal was used to braze SiO2 ceramics and TC4 alloy in the vacuum diffusion bonding equipment (brazing temperature: 1000 ℃, brazing holding time: 10 minutes), as shown in Fig. 2(a). In order to improve the teaching effect, the teacher would make the experimental sample into a standard sample, and instruct the students to observe it with the field emission electron microscope, as shown in Fig. 2(b). The scanning electron microscope (SEM) is used to observe and analyze the surface composition, morphology and structure of the sample by the signals generated by the interaction of the focused electron beam emitted by the electron gun on the sample [11]. Characteristics of the surface of the sample were analyzed by scanning electron microscopy (SEM) mainly through the signal of secondary electron, backscattered electron and characteristic X ray. In addition, SEM plays an important role in brazing experiment teaching with its advantages of high resolution, good depth of field and simple operation.

Fig. 2. (a) Vacuum diffusion bonding equipment; (b) SEM analysis.

Fig. 3(a). showed the morphology and backscattering microstructure of the joint near the side of TC4 matrix taken by the student whit SEM during the experimental teaching. The interface of the joint mainly composed of dark needle-like structure (Region I). The joining of ceramic and filler was well, and no obvious cracks, micropores or inclusions existed. In order to fully exercise the students, the experimental teachers would lead the students to analyze the following layers.

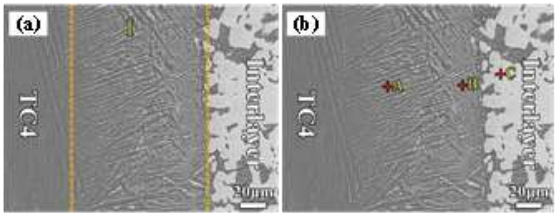

Fig. 3. (a) SiO2 ceramic / Ni / TC4 joint at 1000 ºC; (b) EDS analysis area

In order to better distinguish the interface products and the element distribution in each area, Considering the complex products, the Energy Dispersive Spectrometer analysis was performed. The analysis area of the joint at 1000 °C shown in Fig. 3(b). Point A and B were dark needle-like structure of area I; Point C was in filler region. In order to better confirm the composition of each area of the joint, the average chemical composition of the joint was listed, as shown in Table I.

TABLE I. ENERGY SPECTRUM ANALYSIS OF SIO2 / NI / TC4 JOINT AT 1000 ºC

	Ti	*Al*	*Ni*	*Possible phases*
A	78.56	10.05	7.92	α-Ti
B	80.45	8.19	8.95	α-Ti
C	60.40	5.26	32.97	TiNi +Ti_2Ni

The joint microstructure of Ni-based filler metal was analyzed in Table 1, the dark needle-like of Area I between Point A and Point B was basically confirmed as α-Ti. This structure is also known as Widmannstetter Structure, which is a common structure in the brazing process of Ti alloys. Ni in the filler metal diffused into TC4, resulting in a lower β-phase transition temperature. Therefore, it is understood that the equiaxed α-phases containing Ni are transformed into β-phases during brazing; after cooling, these β-phases are transformed into needle-like α-phases. From Table 1, it was found that the

Ni content at Point C in brazing filler region was greater than the Ni content at Points A and B. According to the phase diagram of Ti-Ni binary eutectic as shown in Fig. 4, it been seen that a hypoeutectic reaction (L → TiNi + Ti2Ni) occurred at Point C.

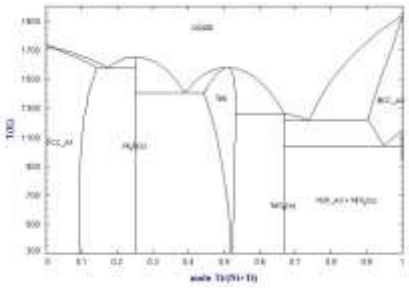

Fig. 4. Phase diagram of Ti-Ni binary eutectic

Through the completion of the above analysis experiments, students deepened their understanding of brazing and welding, firmly mastered the skills of brazing and field emission electron microscope operations. Their analytical and testing capabilities, hands-on capabilities and innovative awareness improved.

C. Experimental Teaching Quality Supervision and Improvement Mechanism

Teaching evaluation based on OBE attaches importance to the judgment of the degree of achievement of learning results, which is the key to continuous improvement of brazing experiment teaching [12]. When the final experimental scores and results of the students meet the requirements of the predetermined learning outcomes, they can prove the correctness of the previous teaching design, teaching methods and teaching models. At the same time, the welding technology and engineering specialty established a teaching supervision group composed of teaching leaders, full-time professors of theoretical courses, person in charge of experimental courses and senior engineers with rich experience in teaching supervise the teaching effect of experimental teaching and score the teaching process and results. The supervision group will initiate a questionnaire survey on students to evaluate the experimental teaching. The experimental teacher will re-examine the rationality and standardization of each link in the experimental teaching according to the results of the supervision team and student evaluation, and promptly correct the problems in the experimental teaching process in order to improve the teaching design, teaching methods, teaching methods and teaching content in the brazing experiment teaching.

IV. CONCLUSION

According to the OBE engineering education concept, the brazing experiment teaching focuses on guiding students to deepen students' understanding of the basic principles of brazing, proficiency in the operation of brazing equipment and brazing processes, the analysis and testing methods of brazing joints. Based on the reform of experimental teaching mode, open laboratory and network experimental teaching platform, innovative experimental teaching under CDIO mode is built. In addition, the experimental teaching design of teacher-student interaction is creatively carried out, and the student-centered supervision mechanism of experimental teaching quality was established. Therefore, students have greatly improved their comprehensive abilities such as hands-on ability, innovation ability, analysis and testing, which has laid a solid foundation for the graduation design of the senior year.

ACKNOWLEDGMENT

This project is supported by Education Reform Project of Harbin Institute of Technology (Weihai) (Project Number: BKJY201921)

First author: Duo Liu (1982-), female, Weihai, Shandong, Ph.D., associate professor, doctoral supervisor, the main research direction about brazing and diffusion welding, email: liuduo@hitwh.edu.cn.

Corresponding author: Jingbo Yu (1978-), male, Harbin, Heilongjiang, master, senior engineer, director of the Experimental Teaching Center, the main research direction about flash butt welding and bonding process for dissimilar metal brazing, email: hityjb328@163.com

REFERENCES

[1] Songdong Yao, Zhigang Fang, Lin Chen, et al. Application of Virtual Simulation in OBE Practice Teaching and Innovation and Entrepreneurship [J]. Experimental Technology and Management, 2019, 36 (6): 229-233. (*In Chinese*).

[2] Jiaojiao Deng, Yuanyuan Guo, Shaoyan Wu. OBE mode workshop teaching practice and exploration [J]. Research and Exploration in Laboratory, 2018, 37 (11): 242-246. (*In Chinese*).

[3] Peihua Gu, Wenlong Hu, Peng Lin, et al. Engineering Education Model Based on "Outcome-Based Education" (OBE) -Practice and Exploration of Shantou University [J]. Research in Higher Education of Engineering, 2014 (1): 27-37. (*In Chinese*).

[4] Ke Zhang, Binguo Zheng, Jiehu Cui, et al. Exploration on the construction of virtual simulation experiment center for environmental engineering based on OBE mode [J]. Experimental Technology and Management, 2019, 36 (01): 278-281. (*In Chinese*).

[5] Xi Zou. Brazing. [M]. Beijing: Machinery Industry Press, 1997. (*In Chinese*).

[6] Guilan Xie. Analysis of the five relationships between MOOC, Flipped classroom, Micro-course online video and Micro-video [J] Education Science, 2015 (31): 43-46. (*In Chinese*).

[7] Yongfen Wu, Weiwei Chen, Zhigang Li, et al. C Programming Language experiment teaching reform for the cultivation of innovative practical ability [J]. Computer Education, 2014 (3): 88-96. (*In Chinese*).

[8] Zhixing Guo, Guang Xian, Ji Xiong. Composite material experiment teaching method based on CDIO model [J]. Research and Exploration in Laboratory, 2019, 38 (6): 202-205. (*In Chinese*).

[9] Xixiang Yang. The application of CDIO model in the guidance of innovative practice projects in aerospace disciplines [J]. Experimental Technology and Management, 2016, 33 (8): 18-20, 40. (*In Chinese*).

[10] Xin Yang. Preliminary exploration of basic experimental teaching reform based on CDIO concept [J]. Laboratory Science, 2018, 21 (4): 85-88. (*In Chinese*).

[11] Lingzhu Yu, Jian Lu. Basic principles and applications of scanning electron microscopy [J]. Experiment Science and Technology, 2018 (7). (*In Chinese*).

[12] Guangyuan Shi. Teaching reform and practice of optional course "Brazing" [J]. Journal of Zhengzhou Polytechnic College, 2004 (6): 61-62. (*In Chinese*).