Aluminum Casting Laboratory

To Develop Competencies of Vocational High School Teacher Candidate

Tiwan, Arianto Leman S, Widarto, Aan Ardian

Universitas Negeri Yogyakarta

Yogyakarta, Indonesia

tiwan@uny.ac.id

Abstract—Aluminum casting laboratory model was developed in order to build competencies of Vocational High School (VHS) teacher candidates of mechanical engineering program. Research and development method was used to develop the model which consist steps of: need assessment, model design, preparing tools and equipment, application, evaluation and dissemination. The model verification involving respondent from metal casting industry, Manufacture Polytechnic of Bandung and VHS which is conduct casting program. The model of aluminum casting laboratory was designed integratedly with materials and processing laboratory. Equipment and tools should be prepared for melting process, pattern making, core and sand mold making, cutting and cleaning casting product, work and health safety also foundry and mold material. The crucible furnace developed to melt the aluminum is LPG-fueled one, having 20 kg capacity and using spiral finned crucible pot.

Keywords—aluminum; casting; laboratory

I. INTRODUCTION

Presently, majority of ASEAN nations faced to the unskilled worker problems [1]. This issues directly correspond to Technical and Vocational Education and Training (TVET) institution because it is their responsibility in accommodating teachers for VHS. TVET institution should follow the progress of VHS need through dynamic evolution. Since the teacher plays main role in achieving learning goal, TVET institution should make continuous transformation in learning media, learning model, learning method, systems, program and also facilities and laboratory. Those are needed to solve the problems regarding to the above issue.

Mechanical Engineering Education Department (MEED) of Yogyakarta State University (YSU) is a one of the TVET institution that has responsibility in developing professional teacher of mechanical engineering program of VHS. This is concerned with teacher commitment. Teachers' performance take main significant part in students' learning achievement [2]. So that, a teacher is the main core in the learning activity in order to develop students' competence [3]. The teacher existence is substantial and irreplaceable by other factors, moreover in multidimensional and multicultural society. Learning activities at VHS should be dynamic in order to comply with science and technology advancement as well as workers' skill requirements [3].

Presently, majority of ASEAN nations faced to the unskilled worker problems [1]. This issues directly correspond

to Technical and Vocational Education and Training (TVET) institution as it is their responsibility in accommodating teachers for VHS. TVET institution should be keep up the progress of VHS need through dynamic evolution. Since the teacher plays main role in achieving learning goal, TVET institution should make continuous transformation in learning media, learning model, learning method, systems, program also facilities and laboratory. Those are necessary to solve the problems regarding to issue above.

Casting is one of the important process in a product making. It is a basic process in product manufacture that should be possessed by VHS graduates. This have been noted in the decree of Director General of Middle Education of Indonesian Education and Culture Ministry number 4678/D/KEP/MK/2016 declared at 2 September 2016. According to the decree, a vocational teacher of mechanical engineering program should have competencies in casting process either theoretical and practice. In fact, almost all of VHS which conduct mechanical engineering program only give a theory of casting process without practice. This condition could be causes by the lack of competence of teacher or the absence of practice facilities.

The main facilities in casting process is a furnace to melt the metal. Crucible furnace is one of simplest furnace that has been used at small and middle industries, especially at home industries. The energy source of this furnace could be charcoal, oil, or gas [4, 5, 6, 7]. A crucible furnace to melt aluminum have been developed at several VHS around Yogyakarta and Magelang and at MEED YSU to support casting practice [8, 9, 10]. Green sand and equipment for sand mold making, foundry and casting, disassembly and cleaning castings product for supporting casting practice also been developed.

In 2009, aluminum casting practice was initiated at MEED YSU. At that time, the workshop is a part of laboratory of materials and processing. However, there is no a certain area to do those aluminum casting practice work. Up to now, there is no significant development to enhance the casting workshop. The development only focused on furnace as mentioned above. However, the competence in casting can be well developed if it is supported by integrated casting laboratory. It would give comprehensive experience to the undergraduate student that being prepared to be a mechanical engineering teacher of VHS. Surely, skill in casting process must be possessed. At this point of view, the presence of casting laboratory at MEED YSU is important to support

learning process so that the student will have direct experience to build their competence in casting field.

II. METHOD

An aluminum casting laboratory model was developed using research and development method. The development was conducted with steps as follows: (1) need assessment, (2) model design, (3) preparing tools and equipment, (4) application, (5) evaluation and (6) dissemination. The research was focused on design development of aluminum casting laboratory model.

The laboratory model was designed based on need assessment. This was implemented by field study approach and focusing discussion group with experts in casting. The model consists of layout design, tools and equipments which required for students practice activities. The feasibility of laboratory model was revealed using a verification instrument. It was then analyzed descriptively.

III. RESULT AND DISCUSSION

The model of aluminum casting laboratory was designed based on demand. This laboratory was designed as a workshop for practicing casting process especially for aluminum. The casting practice goal is to give casting competence to the students. Although it is in making simple product, but this is needed by student so they understand better about casting process. It is important for VHS teacher candidate of mechanical engineering program. The competence developed were sand preparing, sand testing, core and pattern making, mold making, material preparing for melting process, melting process, pouring process, mold disassembly, product cleaning and product investigation. The casting practice is conducted in one semester with time allocation of 12 hours lessons and 12 hours self-activities. In each practice session, maximum number of students is 20 that divided into 4 groups. The practice job include all of the competence that should be possessed by student which is start from sand preparing until product investigation. During practice work, students were supervised by a lecturer and a laboratory assistant.

The aluminum casting laboratory model is deliberately integrated with laboratory of materials and processing. This concept was built by reason that some facilities already exist can be used effectively and efficiently. Those facilities are tutorial room, hand tools equipment and testing equipment. The location of casting laboratory was planned at outer side of laboratory of materials and processing.

Operational cost to conduct aluminum casting practice designed with low cost fare. For this necessity, an economical crucible furnace was used to melt aluminum. It is liquid petroleum gas (LPG) fueled furnace which cheap and easy to made. The furnace capacity is 20 kg for each tapping and it is enough to fulfill 4 groups need in pouring process. The practice area was designed in form of semi open space so there is sufficient air circulation. The work area arranged with consideration of convenience mobilization for student and also easiness if any emergency situation happen during casting process. It is very substantial since in casting process student

work in high temperature that deal with high level of accident. The work area was roofed with suspended awning to protect student from sun exposure. Laboratory layout for casting practice area are shown in Figure 1.

Figure 1. Casting laboratory Layout of MEED YSU

The casting laboratory model have 8 work areas (Figure 1), that are: (1) Cleaning and observation area is the area for product cleaning after sand mold disassembled. The sand usually still stucked on product surface after disassembly. The gating system such as pouring basin, sprue, runner, riser and gate must be removed from the product. Visual observation then was conducted to examine the defect that could take place. (2) Sand casting area is the area for preparing the sand before it was used to make mold. This area is also for making and disassembling the sand mold. Proper placement must be controlled to obtain appropriate area utilization. This concept has been made to simplify area usage efficiently and effectively. This area in the shape of container that containing sand which equipped with lid that can be closed to maintain the sand when it is not in use. (3) Sand processing area is the zone where the sand was processed so it is ready to use to make sand mold. The sand processing comprises of enrichment and mixing the sand with binder such bentonite or clay and water. On the other hand, in this area the sand also reprocessing. (4) Pattern making area is the zone provided for pattern making. Pattern can be made from wood, polystyrene or epoxy resin. (5) Melting area is the area where aluminum melting activity is done. The crucible furnace and all of pouring tools is located at this place. The furnace is positioned in such a way to keep safety and easiness of access so the melting and pouring process of aluminum could done securely. A good melting and pouring process is important to obtain perfect product. (6) Material storage is an area where materials that used in casting process such as raw material of

aluminum, pattern and core making material also mixing material for sand are kept. Cabinets and storage racks are required. (7) Tools storage area is the place where all of tools and equipment for conducting casting practice are saved. Cabinets and storage racks are also required in this area. The tools and equipment separated and grouped by considering the tools and equipment types, pick up and storage easiness, also usage frequency. (8) Sand testing area. Sand quality should be maintain in order to guarantee the product quality. The quality of sand for casting should be guaranteed by sand testing. The testing of sand for casting were water content test, sand strength test, sand grain distribution and permeability.

Equipment and tools for casting practice comprises of equipment and tools for sand casting preparation, sand mold making, pattern and core making, foundry and pouring, disassembly and cleaning castings product. The equipment and tools designed for this casting laboratory model are shown in Table 1, 2, 3 and 4. Work health and safety equipment needed regarding to casting laboratory model is shown in table 5. It is important to ensure student safety during practice work. The materials needed to support casting practice activities is shown in Table 6.

TABLE 1. Equipment for melting process

Equipment	Specification	Quantity
Melting furnace	Crucible furnace	1 unit
Crucible pot	20 kg of capacity	2 unit
Gas burner	Gas burner with blower	1 unit
LPG	12 kg	2 unit
Thermometer	Infrared thermometer	1 unit
	Thermocouple	1 unit
LPG regulator	High pressure regulator	1 piece
LPG pressure gauge	10 Bar	1 piece

TABLE 2. Tools and equipment for pattern making

Equipment	Specification	Quantity
Sawing machine for wood	Saw length ± 55 cm 8 Tooth Per inch (TPI)	1 unit
Lathe machine	Medium size	2 unit
Planner machine	350 W	2 unit
Sandpaper machine	Orbital sander 220 V	1 unit
Hand drilling machine	350 W	2 unit
Wood file	12 inch	12 unit
Bevel edge chisel	15 mm	12 unit
Try square	12 inch	6 pieces
Divider	10 inch	6 pieces
Calipers	accuracy 0,05 mm	6 pieces
Bevel protactor	180°	4 pieces
Steel hammer	0.5 kg	6 pieces
Wood hammer		6 pieces
Pincers		6 pieces
Screwdriver		6 pieces
Work bench		6 pieces
Carpenter bench vice		6 pieces

TABLE 3. Tools and equipment for core and sand mold making

Equipment	Specification	Quantity
Sand mixer machine	Medium size	1 unit
Shovel		1 piece
Cope and drag flask	300 x 300 x 100 mm	8 set
Trowel		10 pieces
Scraper		10 pieces
Slick and oval spoon		10 pieces
Bench rammer	1 kg	6 pieces
Strike off bar		6 pieces
Camel's hair brush	2 inchi	6 pieces
Vent wire	Steel wire dia 3 mm	6 pieces
Gas CO sprayer	Standard	1 set
Compressor	Medium size	1 unit
Rapping bar and rapper		6 pieces
Sieve		4 pieces

TABLE 4. Tools and equipment disassembly and cleaning

Equipment	Specification	Quantity
Hack saw	12 inchi	6 pieces
Chisel	5 inchi	6 pieces
Rough flat file	12 inchi	6 pieces
Fine flat file	12 inchi	6 pieces
Hand grinder	Medium	3 unit
Hammer	0,5 kg	6 pieces
Half round file	12 inchi	6 pieces
Round file	12 inchi	6 pieces

TABLE 5. Occupational health and safety equipment

Equipment	Specification	Quantity
Safety helmet	SNI standard	4 pieces
Safety shoes	Toe steel protector	4 pairs
Masker	SNI standard	2 pack
Face shield	SNI standard	4 pieces
Eye protection	SNI standard	6 pieces
Apron	leather	4 pieces
safety glove	leather	8 pairs

TABLE 6. Materials for casting practice

Equipment	Specification	Quantity
Aluminum	Scrap	60 kg
Mold sand/silica sand	from Ceper, Klaten	2 m ³
Graphite		2 kg
Bentonit		2 kg
Limestone powder		2 kg
Water glass		2 kg
Wood for pattern	100 x 200 x 500 mm	1 piece
Polystyrene	10 x 1200 x 240 mm	1 piece
	20 x 1200 x 240 mm	1 piece
	40 x 1200 x 240 mm	1 piece
Glue	For wood and polystyrene	5 kg
Putty and hardener	Isamu 1 kg	3 piece
sandpaper	Number 150, 400, 600	60 sheet
LPG	12 kg	2 unit
CO ₂ gas	50 kf	1 tube

The crucible furnace developed for the casting laboratory model is a gas fueled crucible furnace (Figure 2). It is equipped with economizer to enhance its thermal efficiency [8]. A crucible pot made of steel is used to put the aluminum scrap that will melted. The pot with capacity of 20 kg is sufficient to serve 4 groups in casting practice. This crucible pot has a spiral fin so the heat produced by gas burner flowing around the pot. The heat will contact longer to the pot and aluminum in the pot melted quicker. Spiral fin with inclination of 10 degree gives optimum efficiency to the furnace (Figure 3). Although different, but it has same concept with the crucible furnace that has spiral guide way wall [11].

Figure 2. LPG fueled crucible furnace equipped with economizer [7].

Figure 3. Spiral finned crucible pot.

The feasibility of this casting laboratory model determined through discussion with experts in casting process. Verification questionnaire was used to quantify the laboratory properness. Verification was conducted by casting experts from casting industry, VHS which have casting program and Bandung State Manufacturing Polytechnic. Based on these verification result, the casting laboratory model feasibility are shown in table 7 and 8.

It can be seen from table 7 that overall the laboratory layout design have average score of 3.5 in score range 1 to 4. Likert scale was used as scoring criterion. The score of 1 mean unfeasible, 2 mean feasible enough, 3 is feasible and 4 is very feasible. Some aspects that have score below 3 should be improved to ensure practice runs well. Those aspects are practice comfort and security, mobility access, safety warranty and equipment layout.

TABLE 7. Assessment results of casting laboratory layout model

Layout Aspect	Score
Adequacy of work area	3.5
Provides safety and comfort to practice activity	2.75
Maximize equipment usage	3.5
Supervision easiness	3
Mobility easiness	2.75
Ensure in work safety	2.5
Providing enough space for maintenance	3.25
Maximizing natural lighting	3.75
Arrangement based on workflow and equipment type	3
Arrangement by type, size, and uniformity	2.75
The equipment is placed and arranged in a certain room	3.75
Laboratory location accessible by pickup truck	3.75
Free flood and safe from fire threat	3.25
Availability of supporting facilities such as: Electricity and water	3.5
Average score	3.21

TABLE 8. Feasibility of tool, equipment and material

Tools, equipment and material	Score
For melting the aluminum	3.43
For pattern making	3.66
For core and sand mold making	3.75
For cutting and cleaning casting product	3.75
For work health and safety	3.68
For foundry and mold material	3.75
Average score	3.21

The feasibility of casting laboratory model from the availability of tools and equipment for melting process, pattern making, core and sand mold making, cutting and cleaning casting product, work and health safety also foundry and mold material is shown in table 8. The equipment for melting process have score of 3.43 which is mean the tools and equipment designed in this model is feasible for casting practice. Same as that, the tools and equipment design for pattern making, core and sand mold making, cutting and cleaning casting product, work and health safety also foundry and mold material all are in feasible category. Overall assessment result of tools and equipment for the casting laboratory model developed in feasible category. Thus, this model could be implemented at MEED YSU.

IV. CONCLUSION

The casting laboratory model was developed interruptedly with the laboratory of materials and processing. Tools and equipment required in order to support casting practice are tools and equipment for melting process, pattern making, core and sand mold making, cutting and cleaning casting product, work and health safety also foundry and mold material. The crucible furnace developed to melt the aluminum is LPG-fueled, having 20 kg capacity and using spiral finned crucible pot.

REFERENCES

- [1] M. Grosch, "Developing A Competency Standard For TVET Teacher Education In ASEAN Countries", *Jurnal Pendidikan Teknologi dan Kejuruan*, Vol. 23, No. 3, 2017, pp. 279-287.
- [2] D. Junianto, "Pengaruh Kinerja Mengajar Guru, Keterlibatan Orang Tua, Aktualisasi Diri terhadap Motivasi Berprestasi", *Jurnal Pendidikan Teknologi dan Kejuruan*, Vol. 22, No. 3, 2015, Pp. 262-273
- [3] I.W. Djatmiko, "A Study on The Empowering Teachers' Professional Development And Quality Assurance to Increase Teachers' Effectiveness in Vocational Secondary Schools", *Jurnal Pendidikan Teknologi dan Kejuruan*, Vol. 23, No. 2, 2016. pp. 144-151.
- [4] M.V. Aditya Nag and R. R. Dareddy, "Performance Improvement Of An Oil Fired Furnace Through Oscillating Combustion Technology", *International Journal of Scientific & Engineering Research* Vol. 3, Issue 7, 2012, pp. 1-4.
- [5] R. Suresh and M. G. Nagarjun, "Construction and Performance analysis of Pit furnace by using Biodiesel", *Indian Journal of Science and Technology*, Vol 9, No.45, 2016, pp. 1-5.
- [6] A. A. Olalere1, O. A. Dahunsi, M. A. Akintunde, and M. O. Tanimola, "Development Of A Crucible Furnace Fired With Spent Engine Oil Using Locally Sourced Materials", *International Journal of Innovation and Applied Studies*, Vol. 13, No. 2., 2015, pp. 281-288.
- [7] O.A. Ighodalo, G. Akue, E. Enaboifo and J. Oyedoh, "Performance Evaluation of the Local Charcoal-Fired Furnace for Recycling Aluminium", *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)*, Vol. 2, No. 3., 2011, pp. 448-450.
- [8] A. L. Soemowidagdo, Tiwan, and Mujiyono. "Pengembangan Tungku Peleburan Aluminium untuk Mendukung Kompetensi Pengecoran Di SMK Program Studi Keahlian Teknik Mesin", *Inotek*, Vol. 18, No. 1, 2014, pp. 80-94.
- [9] A. L. Soemowidagdo, Tiwan, Sutopo and Nurdjito, "Sarana Praktik Pengecoran Aluminium untuk SMK Program Keahlian Teknik Mesin", *National Seminar of Vokational Education (SNPV) 2017*, FT UNY Yogyakarta, February 6th, 2017 pp. 277-284.
- [10] A L. Soemowidagdo, Tiwan and Mujiyono. "Tungku Krusibel dengan Economizer untuk Praktik Pengecoran di Jurusan Pendidikan Teknik Mesin FT UNY", *Jurnal Dinamika Vokasional Teknik Mesin*, Vol. 2, No. 1, 2016, pp. 21-27.
- [11] A. Tanaka, M.Tsuri, H. Ando, M. Kikura and M. Ueki, "High Efficiency Crucible Melting Furnace for Non-Ferrous Metals", 2001, accessed: August 10, 2017, from: <http://www.h-techno.com/en/seihin/asm.html>.