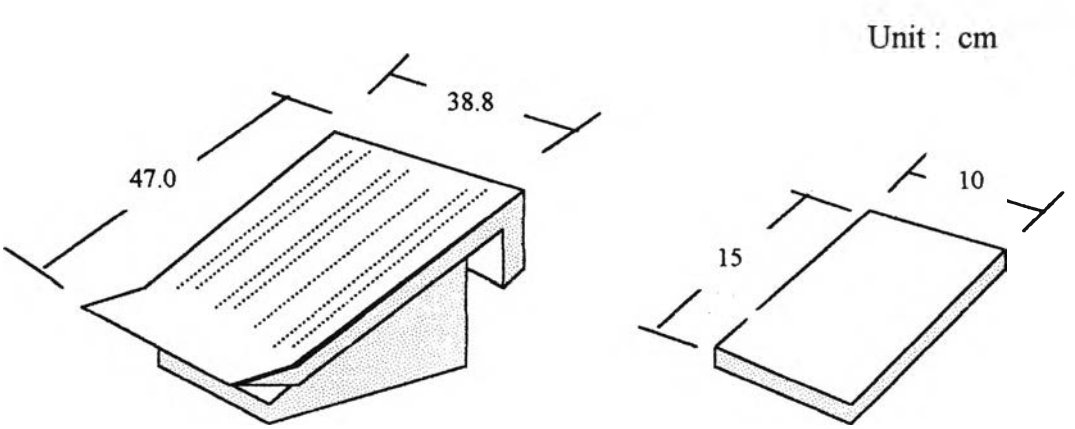
Chapter IV

Experimentation

The experimentation condition will be determined by the preliminary data from sampling factories. In order to correlate of some sand properties with the occurrence blowhole and pinhole defect.

Details of The Experimentation

Casting item of this work was designed following the problem of a real product in the factory. Since the CrMo40L (0.38-0.43%C, 0.30-0.60%Si, 0.70-0.90%Mn, 0.70-0.90%Cr, 0.18-0.22%Mo, < 0.05%P and < 0.05%S) part was a sampling product with pinholes on big thin surface, thus, the specimen was designed as 10 cm ×15 cm ×1 cm plate for investigation.



Real casting(CrMo40L) Simulated casting(thin plate)

Figure 4-1. Drawings of real casting(CrMo40L part) in the sampling factory and the simulated casting for the experimentation.

The defect type to be studied in this work is the pinhole since it is the most frequently occurred and should be taken care of first. Stereological technique was used to determine gas cavities by calculating the line fraction of cut surface and cavities on grid line. The method is shown in Figure 4-2.

Design of Experimentation

The objectives of the work are to study and identify the sand properties that influence pinhole and blowhole. The factors and their levels are set up from studying the preliminary data and literature survey, and compared with the theory in the previous chapter. By selection of some properties of sand, this work selected five factors, which influence pinhole and blowhole according to the explanation in the scope section. The five factors and two levels in the experiment are shown in Table 4-1.

Table 4-1. Factors and levels of the experimentation.

Factor	Level	
	1	2
A) Finess number (AFS)	49	46
B) Clay content	4.5 %	6.5 %
C) Starch content	0.5 %	1 %
D) Moisture content	2.5 %	4 %
E) Pouring temperature	1550 °C	1620 °C

By the design of experimentation (DOE), facing sand is varied as two levels in each factor, thus, the number of conditions are thirty-two runs. The thirty-two runs can be indicated by five-numbers code, which shown in Table 4-2.

Table 4-2. The five-numbers codes of each condition in the thirty-two runs.

	A	B	C	D	E
1	1	1	1	1	1
2	1	1	1	1	2
3	1	1	1	2	1
4	1	1	1	2	2
5	1	1	2	1	1
6	1	1	2	1	2
7	1	1	2	2	1
8	1	1	2	2	2
9	1	2	1	1	1
10	1	2	1	1	2
11	1	2	1	2	1
12	1	2	1	2	2
13	1	2	2	1	1
14	1	2	2	1	2
15	1	2	2	2	1
16	1	2	2	2	2

	A	B	C	D	E
17	2	1	1	1	1
18	2	1	1	1	2
19	2	1	1	2	1
20	2	1	1	2	2
21	2	1	2	1	1
22	2	1	2	1	2
23	2	1	2	2	1
24	2	1	2	2	2
25	2	2	1	1	1
26	2	2	1	1	2
27	2	2	1	2	1
28	2	2	1	2	2
29	2	2	2	1	1
30	2	2	2	1	2
31	2	2	2	2	1
32	2	2	2	2	2

Backing sand is used sand, because backing sand influence vaporization of moisture that will be gas, and permeability that influence gas escaping. Thus, permeability and moisture content of backing sand are needed to be controlled. Permeability of around 150-200 and 3.6 % moisture were controlled in this experiment.

Grain finess number of sand was controlled by screening dry sand before sand preparation. The 50 kilograms of dry sand was separated to be finer grain and coarser grain by sieve number 65. Then, each screened sand was mixed and divided into two groups sand. The first group is mixing of normal sand and coarser grain sand, the second group is mixing of normal sand and finer grain sand. After mixing, sand was test. The first group called "normal" grain size with grain finess number of about 45 and the other called "finer" grain size with grain finess number of about 49 (AFS standard).

Each run of 32 runs will provide 5 castings. So, total numbers of castings are 160 pieces.

Moisture content is selected because it influences pinhole by increasing of gas by vaporization of moisture. Clay and starch are the main additives of molding, which also influence pinhole. Clay is added to bond sands; therefore, clay might reduce the permeability of sand. Starch is added for increasing toughness of sand when lifting off the pattern, but starch will decompose and become gases. After sand mixing process, permeability, compressive strength and %loss on ignition were tested. After the foundry process, the castings were cut for gas cavity measurement.

Stereological Technique for Measuring the Fraction of Cavities

Since pinholes at the section have various sizes, the measurement of the amount of pinholes should be a method which can compare all area of gases on the cut surface. The chosen method is the stereological technique, which employs diagonal line on the cut surface. The length fraction of the line that pass pinhole's area and smooth area on the cut surface were measured. Figure 4-2 shows steps of the method.

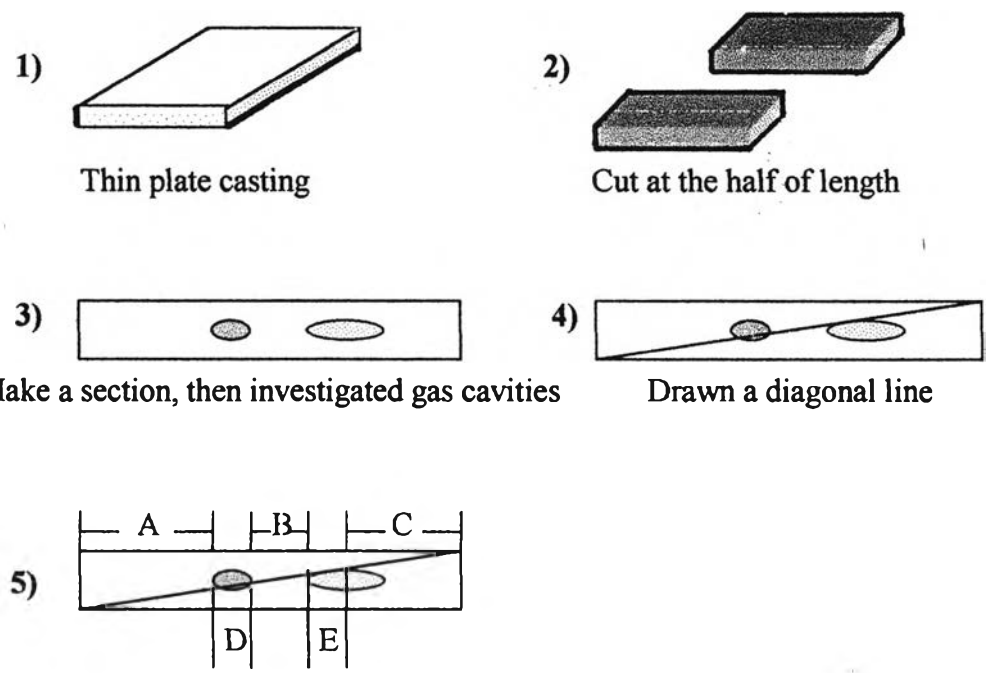


Figure 4-2. Diagram showing the steps employed to determine the area of cavities.

Experimental Procedure

From the explanation in the scope of work, the experimental procedures will be designed as follows:

1. Wood patterns were made with the size of 1 cm x10 cm x 15 cm plate.

2. Two different grain sizes of sand were prepared by screening dry sand (new chromite sand) and mix each screened sand into the new sand for classification sands as two groups; normal grain finess number sand and finer grain finess number sand.

3. Prepare the facing sand as 16 formulas (only first four factors) by calculation the weight ratio of sand mixing. Then, mill sand with all of prepared additives in the milling machine. During milling process, sampling mixed sand to test the moisture content. If the moisture content is less than the controlled level, add more water in the milling and mill again. The milling time were about 3 minutes. After milling, keep each formulas of facing sand in plastic bags to preserve moisture before using.

4. Prepare backing sand by milling used sand with controlling of the moisture content of around 3.6 % (between 3.4 % and 3.8 %). The milling time of backing sand were around 2 to 3 minutes.

5. After sand preparation, permeability, compressive strength and %loss on ignition of every formula of facing sand were tested and recorded.

6. In molding process, cover the pattern by facing sand around 2 cm thickness before putting in backing sand. Both facing and backing sand were

rammed by hand and made holes for gas venting around 15 holes per casting on the upper mold.

7. In metal preparation, charged CrMo40L (0.38-0.43%C, 0.30-0.60%Si, 0.70-0.90%Mn, 0.70-0.90%Cr, 0.18-0.22%Mo, < 0.05%P and < 0.05%S) scrap in the induction furnace (metal charge is around 27 kilograms per charge). After melting, flux was used for slag removing before tapping.

8. Strictly check pouring temperature by thermocouple for controlling pouring temperature in every tapping. Because the pouring temperature will be 10-15 °C lower than tapping temperature, thus temperature needed be checked again before pouring.

9. During tapping, put aluminum (deoxidizer) in the ladle for degas in metal during pouring(aluminum was used around 1.5 % by weight).

10. Run the thirty-two experiments with 5 castings per experiment (all are 160 castings). After the casting was rammed off, clean and cut off the gating system (fettling). Then, cut the casting and measured the fraction of cavities on cut surfaces. The results will be calculated by stereological technique.

11. Analyze the results by using statistical analysis (analysis of variance: ANOVA) for investigating significance level of each factor on sand test results and stereological results.

12. Conclude the analyzed result.

Flow Chart of Work Procedure

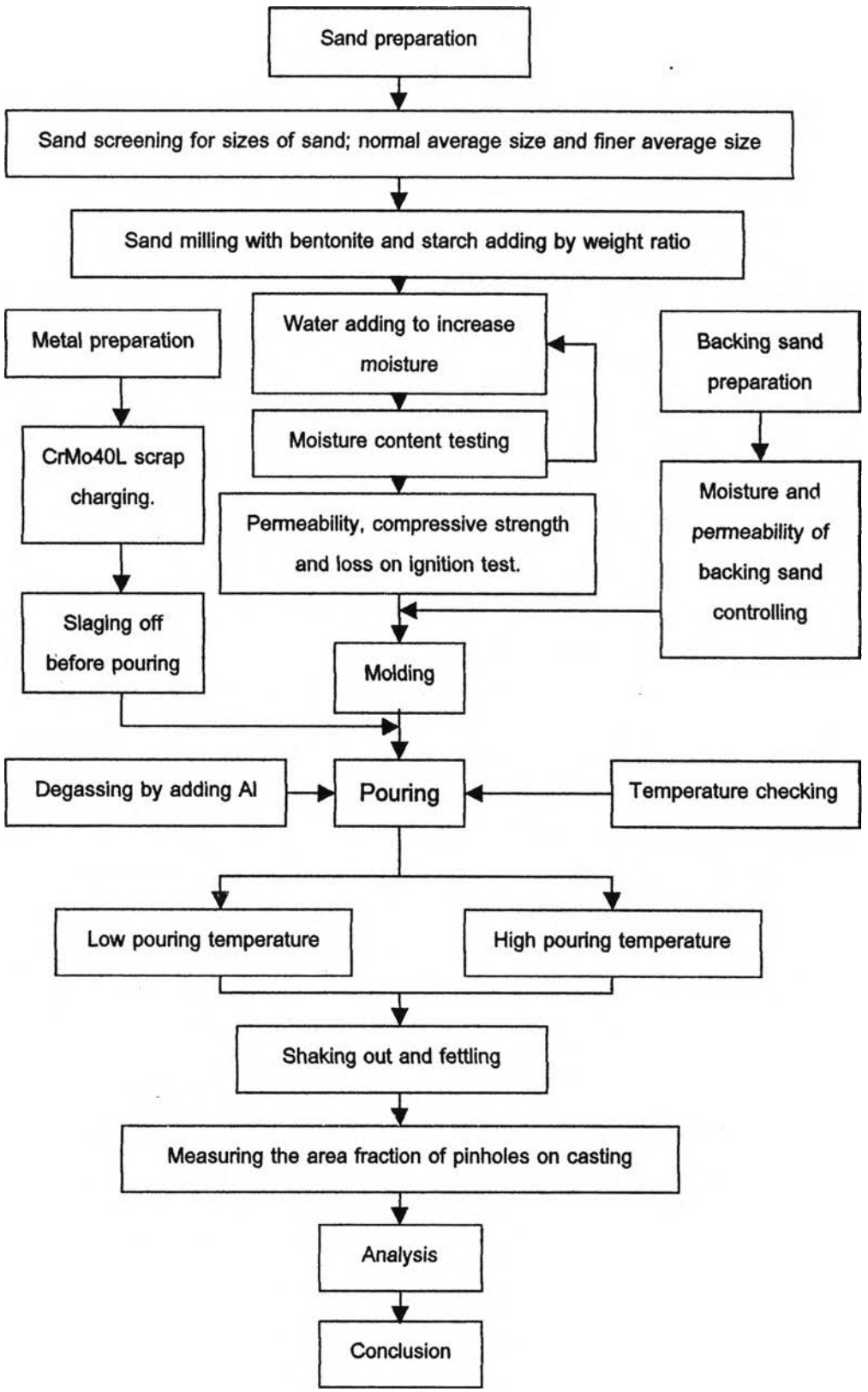


Figure 4-3. Flow chart of work procedure.