Chapter II

Literature Survey

Gas in Metals

Pinhole and blowhole defects in casting production are mainly found from the following cases.

1. Gas can be generated when melting dirty and rusty scrap metal. Good iron cleaning can help minimizing the defect problem[3]. Sufficient amount of deoxidizer needs to be added in the melting operation after slag removing.

2. Controlling problem in the pouring condition and pouring time[4]. Gas in the air can be absorbed into the metal stream during tapping.

3. The volatile additive in sand mold, which cannot be stable in high temperature condition of pouring metal. Volatile and ignitable materials will become gases and blow into the molten metal during solidifying process.

A good design of gas vent in mold can reduce problem of gas defect, but it is not a total improvement. The controlling of sand properties in molding process is an effective measure for pinhole problems. Some limited factors of sand properties cannot be adjusted independently. They are related to other factors and also are correlated. Thus, the study of molding sand is an advantage for approaching and improving the pinhole defect.

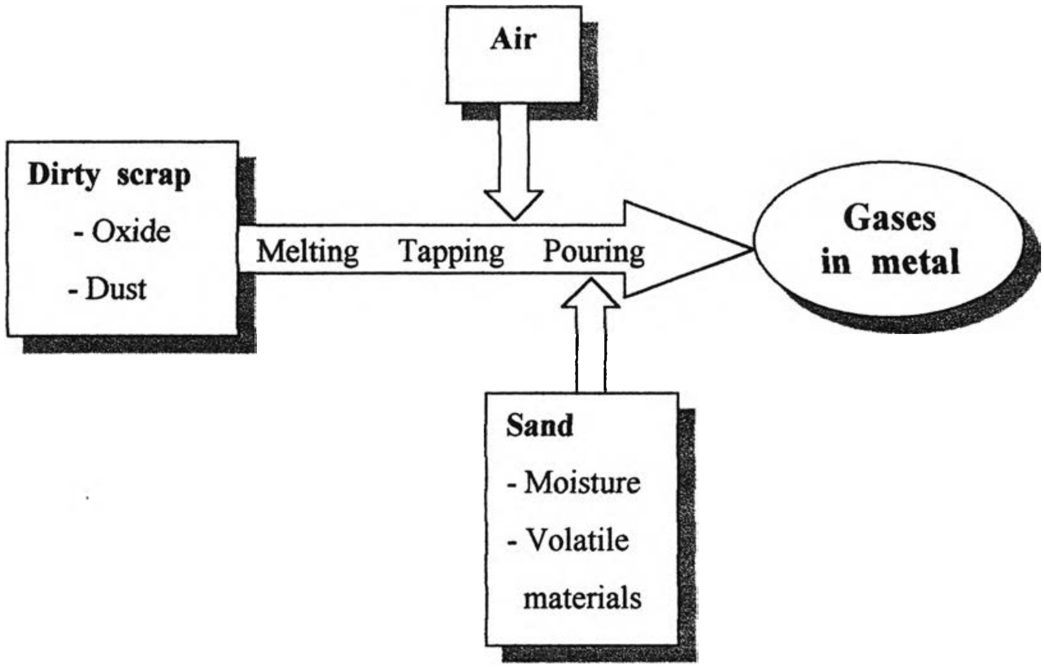


Figure 2-1. Sources of gases in a metal.

Sands

Silica sand is normally used as molding sand in iron casting. But, in steel casting with higher pouring temperature, high refractory sand is used as facing sand. For example, olivine sand is used for the production of austenitic manganese steel casting[5] and chromite sand for chromium cast steel and nickle-chromium cast steel. As chromite sand possesses good refractoriness, it is p.omoted for using in very high pouring temperature casting. The low thermal expansion of olivine sand and chromite sand are effective for controlling mold dimensions[6] and resisting to expansion defect[7]. Since olivine and chromite sand have basic chemical composition, they are used for low reactivity with metallic oxides.

Sand is sometimes referred to as natural or synthetic[8]. Synthetic sands have been washed to remove clay and other impurities, carefully screened and classified to give a desired size distribution, and then reblended with clays and other materials to produce an optimized sand for the casting being produced. Because of the demands of modern high-pressure molding machines and the necessity to exercise close control over every aspect of casting production, most foundries use only synthetic sand. The properties of sand for core are the same as materials used with molding sand.

Other types of sand such as zircon and alumino-silicate still have not been widely used because of their relative high prices and commercial unavailability in Thailand.

Sand Additives

Additives of sands, which can influence sand properties and pinhole in steel casting, are as follows:

1. Effective clay: effective clay in sand mixes to bonds sand grain together. If clay content is too much, permeability will be reduced. A 4 to 5% bentonite addition is commonly used in the steel foundry[5].

2. Cereal addition: adding cereal will increase toughness of sand, making it resisting to cracking by thermal expansion during pouring. Cereal is decomposed at pouring temperature; thus, more cereal will yield more gas. A 0.5% to 1% cereal addition is commonly used in the steel foundry[5]

3. Moisture: adding water in sand mix will make up bonding of clay. If moisture content in molding sand is too much, green compressive strength will be reduced.

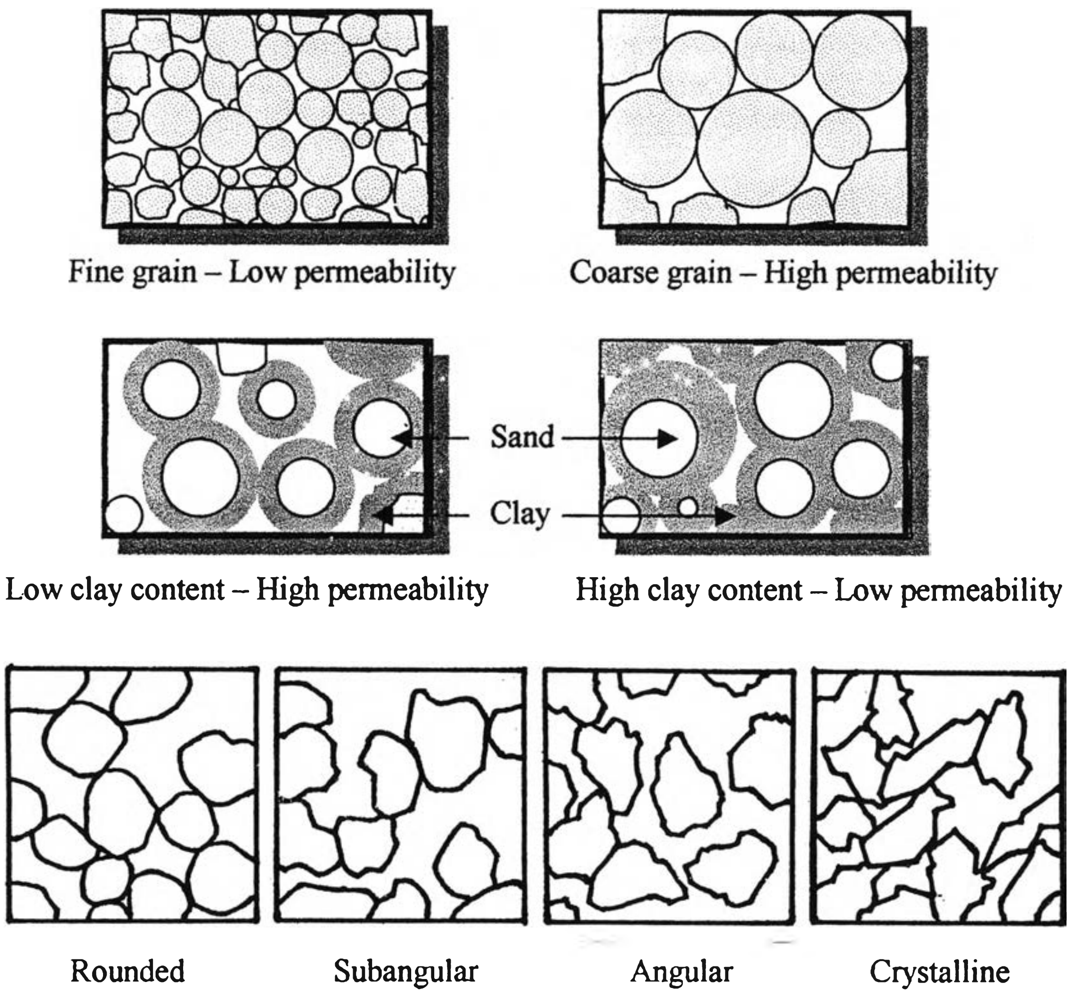


Figure 2-2. Effects of grain size, clay content and grain shape on permeability of molding sand.

Figure 2-2 show effect of grain size and clay content on permeability. The coarser grain size will have greater porosity than finer grain size. But, if sand mix have both fine grain and coarse grain, fine grains will close in the vacancies between coarse grain, and causes lower permeability. Increasing clay content and absorbing water of clay may reduce permeability.

Shape of sand has strong influences with permeability, in Fig 2-2, shapes of molding sand are classified as four types, i.e. rounded, subangular, angular and crystalline[2]. Good molding sand should be rounded shape, because it can be bonded with less binder. The rounded shape is widely used because the good permeability and smooth mold surface for flowability of molten metal. The crystalline shape sand is not commonly used in foundry because the crystalline shape can be broken easily in milling, which causes low refractoriness, low permeability and need much binder.

Normally, molding sand is composed of various grain size, but the good molding sand should not has much various grain size. The summary weight of the three highest grain sizes from grain distribution should equal or more than 2/3 ratio by weight of molding sand, if not, too much distribution will causes low permeability.

Molding

In molding process, moisture and additive contents are factors that can be adjusted. The level of adjustment depends on the working condition in each factory. The quality of the casting product is critically depends on the process parameters[10]. The research of Sweeting, Thorpe and Peittit[9] showed that increasing the amount of blister, a type of gas defect, relate to lower permeability and higher loss on ignition. This relation is shown in Figure 2-3.

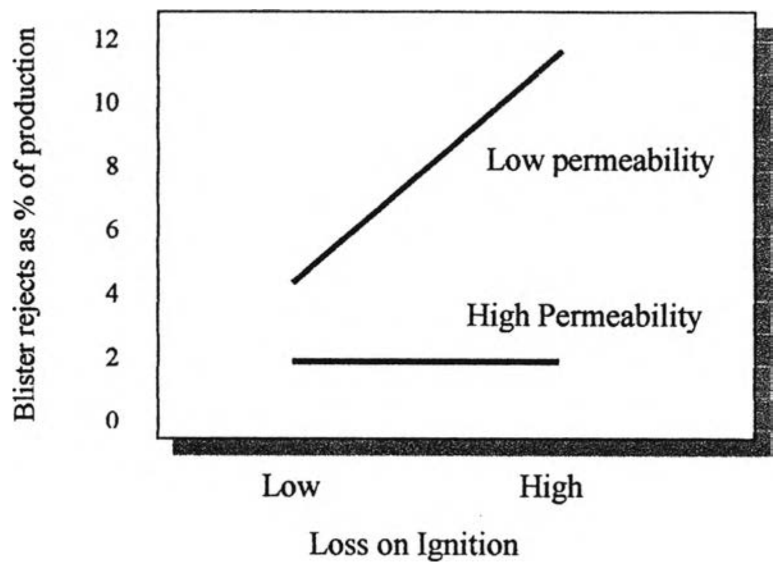


Figure 2-3. Plot of interactions between permeability and loss on ignition[9]

Pouring

Solidification is directly related to all types of porosity defects, since solid surfaces of molten metal that solidify first will be barrier of venting gas. Bubbles of gases[11] cannot escape and retain in solid metal. Thus, short time of solidification in mold encourage supports to retained gas in the solid metal. The relation of this case is shown in research of Sweeting et al.[4], which shows the effect of pouring time and mold sequence of pouring. The result is shown in Figure 2-4, which shows a distribution of the proportion of molds that were poured within a particular time, that is 9 second, 10 second, etc. It can be seen that blister rejects appear to correlate strongly with pouring time, i.e. the slower mold filling giving more blisters.

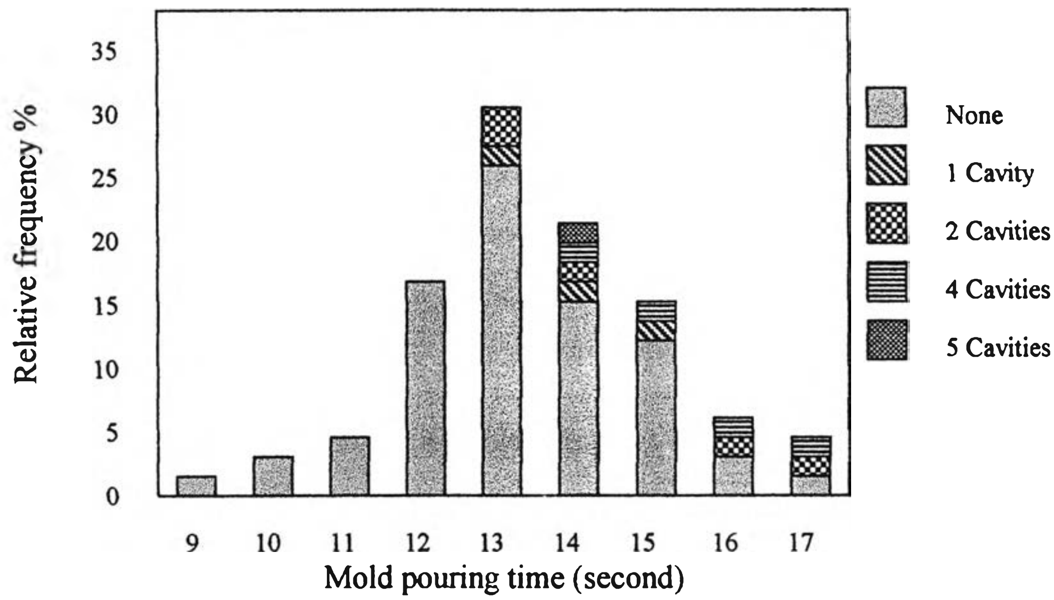
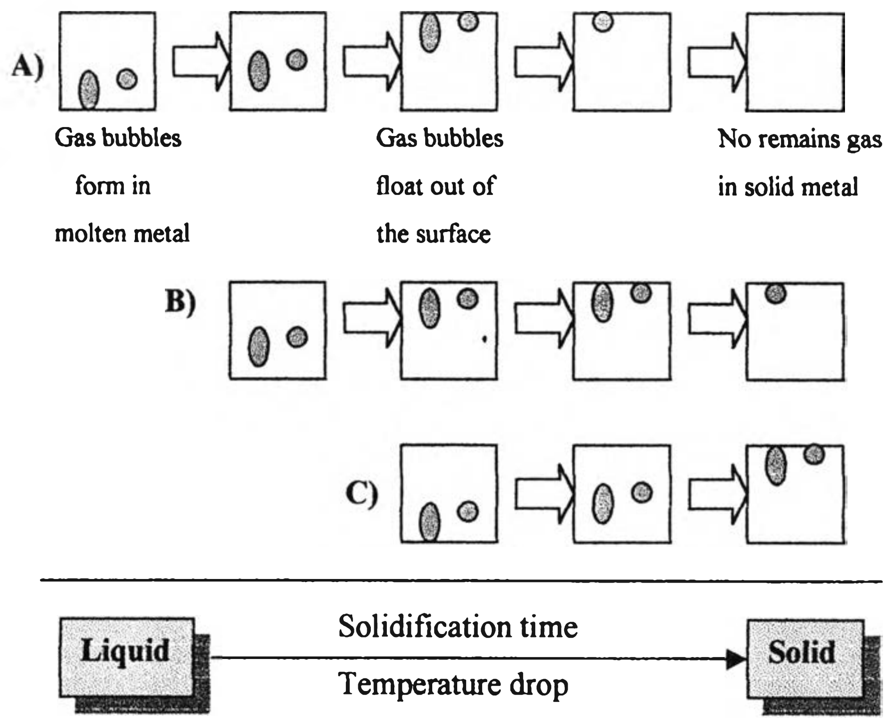


Figure 2-4. Blister(a type of gas defects) rejects by mold pouring time.[4]

In this case, the rejects level can be explained by Figure 2-5, which shows that the variation of solidification time and pouring temperature depend on mold sequence of one ladle. On the other hand, if one ladle is to pour to many molds, the first mold may sometimes be poured at a vary high temperature. Too high pouring temperature may cause sand burn on casting surface, increase moisture vaporization in mold[12] and increase volatile gas from decomposable additive and shrinkage.



Pouring temperature : A > B > C , Solidification time : A > B > C

Mold sequence : A , B , C , Severity of gas defect : C > B > A

Figure 2-5. Influence of mold sequence and pouring temperature on gas ventilation during solidification

The literature survey discussed steel casting process. However, to solve blowhole problem, the condition of experimentation has to be determined by the actual data collected in the real conditions, which have blowhole problems in the sampling factories.