INTRODUCTION

Thermal analysis is based on the principle that each phase of metal transformation in a sample causes a thermal event on its cooling or heating curve. In fact, the cooling curve (CC) represents the history of solidification of such sample. Thus it is feasible to obtain comparable information on cast iron by comparing the cooling curves of different graphite types. By means of the first and the second derivatives of the cooling curves, characteristic points correlated to cooling curves of different graphite types can be achieved and compared. An important tool to investigate the solidification process is thermal analysis in which the temperature during solidification is monitored. Any change in the solidification process causes an alternation in the slope of the curve. In a hypoeutectic and eutectic cast iron, the solidification starts with formation of the primary austenite dendrites (TLiq). While decreasing the temperature, the dendrites grow and the melt is enriched with carbon. At TEs, the graphite and austenite is formed. Finally at Tsol point, the eutectic reaction ends and the melt is completely solidified. If the melt is treated with magnesium, vermicular and nodular cast iron will be formed. No addition of magnesium will lead to the grey iron.

CORRELATION BETWEEN SOLIDIFICATION BEHAVIOUR AND THERMAL ANALYSIS PARAMETERS

The hexagonal graphite growth in cast iron have been investigated by many researchers leading to the conclusion that a screw dislocation mechanism exists along A or C axis. The eutectic cell growth in cast iron begins from a nucleus. In a grey iron, the graphite is in contact with the liquid during the solidification phase. The growth starts on a low number of nuclei, but because the growth condition in the liquid is fast, it begins when the temperature goes below the equilibrium temperature, with very low undercooling and Recalescence. So, for a grey iron, the growth is mostly in ‘A’ direction. For a compacted graphite iron, the growth condition is unfavorable. It means that it shows a delay in start of eutectic solidification compared to normal grey iron. Because of that and low number of nuclei, a higher undercooling is required to proceed the solidification. Then the growth will proceed in preferential direction C axis.

The graphite will grow in contact with the melt in the early stages of solidification. Then it grows rapidly and releases a lot of latent heat and resulting Tmax (Maximum Temperature of Eutectic) or the Recalescence R is considerably high. The growth condition in nodular cast iron is also unfavorable, but because of a high number of nuclei the growth starts sooner and it does not need very low TEMin (Minimum Temperature of Eutectic) like a compacted graphite iron. Then it proceeds rather slowly with low TEMax since the graphite particles lose their contact with the liquid at the early stages of solidification phase. But the minimum temperature of eutectic (TEmin) is the lowest one which is because of unfavorable nucleation condition in compacted graphite iron. Another important parameter for comparison of different graphite types is maximum Recalescence rate. It is considerably higher for Compacted graphite iron, lower for grey iron and much lower for nodular iron.

The latent heat can also be measured by multiplying the area under the first derivative with the specific heat of cast iron. It means that the area is proportional to the value of heat released during Recalescence.

CORRELATION BETWEEN THERMAL ANALYSIS PARAMETERS AND CHEMICAL COMPOSITION

The liquidus temperature TLiq is closely related to carbon equivalent Ceq. Low values of TLiq are primarily the indication of high carbon contents. The combination of high carbon contents (i.e. high Ceq) and slow cooling rates (as a thick section) results in flotation and formation of non-spheroidal graphite forms. The increasing in C contents may results in the increase of nodule count.

Silicon is the most influencing element in the solidification behavior after carbon. In fact, its amount influences the position of the lowest eutectic temperature (TEmin) given the metastable (white) eutectic temperature. If TTest, TEMax and TSol are above the metastable temperature, the solidification and the final structure are gray, (with graphite phase). But if these characteristic points are below the metastable line, the iron structure will end as white iron, without graphite phase. In fact, the stable temperature depends on silicon by the relationship Tst = 1153 + 6.7 (Si3), while the metastable eutectic temperature is function of silicon content by Tst = 1147-12 (Si3).

CORRELATION BETWEEN THERMAL ANALYSIS PARAMETERS AND CASTING DEFECTS

The difference between the eutectic temperature in the stable system (Ts) and the lowest eutectic temperature (T Emin) is referred to as degree of eutectic undercooling (ATm). For good inoculated ductile iron, Temin must be greater than Tst. The efficiency of inoculants is measured by its ability to decrease ATm. Uninoculated iron is characterized by low Temin and T maximum temperatures. Inoculants influence can be measured by the increase in these parameters value from the uninoculated iron.

Highest eutectic temperature (Temax) is attained as a result of increase in temperature because of the release of the inherent heat called latent heat. This increase in temperature is called Recalescence (R). The recalcescence will depicts high efficiency of inoculants and the risk for micro shrinkage and porosity will be reduced. If the recaselence degree is too high, it may indicate undesirable, low nodule count, early graphite expansion effects and primary shrinkage. Also, early graphite expansion may reduce the available carbon for later graphite expansion. At the end of solidification and thus increase the risk for microshrinkage porosity formation. Too high recallescence might be harmful especially in green sand mould as the volume expansion is high and might increase the size of the mould cavity.