論 文

Experiments for Pepset Mold Ductile Iron GCD300 Castings(1): A Benchmark Study

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Abstract

펩셑주형을 사용하여 한 주형내에 두께가 20, 26, 32 및 38 mm 인 4 종류의 T 형 시편을 배치시킨 후 구상흑연주철을 제조하였으며 이로부터 구상흑연립의 수, 페라이트의 함량, 브린넬경도 및 내부결함의 발생위치를 측정하였다. 시편의 상부를 절단한 후 8 위치에서 경도를 측정하였으며 역시 같은 위치에서 구상흑연립의 수 및 페라이트함량을 측정하였다. 압탕의 경우 응고후 급탕효과를 관찰하기위하여 X-선촬영을 하였는 바 시편의 두께가 20 mm 에서 38 mm 로 갈수록 압탕으로부터의 급탕이 원활하게 이루어졌음을 알 수 있었다. 또한 시편내부의 응고수축결함의 발생을 관찰하기 위하여 절단한 결과 20 및 26 mm 의 두께에는 응고수축결함이 T 형시편의 연결부에 발생한 반면 32 및 38 mm 에는 발생되지 않았다. 위에서 얻어진 실험적인 데이터는 구상흑연주철의 모델링을 검증하는 벤치마크의 연구로 유용하게 사용될 것이다.

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1. Introduction

The computer simulation models for casting processes have advanced tremendously in recent years. With the aid of them, the final properties of the casting such as dimension, surface quality, strength, fatigue life, porosity and inclusions can be predicted before production[1-9]. But, the casting models are useful only to the extent that they can match the real processes. As a way to validate these computer models, the details of the experimental condition must be recorded com-pletely, so that the models can later simulate the same experiment. Unfortunately, such fully-documented experiments are rare in the literature.

In this paper, the experiments have been con-ducted to quantify graphite nodule count, matrix structure, hardness and shrinkage during the pepset molded casting of four T-shaped ductile cast iron specimens at the Boo Kwang Cast Iron Co. in Korea. These experimental measurements should be of use in the validation of casting models in ductile cast iron.

2. Experimental Procedure

Heat produced in this study was prepared in a 1000 kg-capacity silica lined high frequency induction furnace. Charge constituents are presented in Table 1. The heat weighed 1000 kg and was prepared from a charge composed of clean pig iron and steel scrap. Steel and alloying elements, as necessary, were added to a slag free molten heel in the furnace so as to minimize oxidation and slag formation. The melt was heated to 1510°C when eutectometer samples were taken to obtain the base iron analysis. Minor additions to effect a constant base iron chemistry were made at this stage. The melt was subsequently heated to 1600°C and samples were taken for chemical analysis. Then, this base iron was transferred into a 300 kg-capacity ladle in which 4 kg of MgFeSi alloys were covered with clean steel scrap. After the spheroidizing reaction which lasted for 140s, the melt was slagged. The melt was then inoculated with 2.4 kg of FeSi(9 mm by down). After removal of any dross or slag, the melt was poured at 1400°C into pepset mold with four T-shaped castings of different dimensions and into a die to make a chill disk-shaped test piece of dimensions 25 × 4 mm. The dimensions and

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Table 1. Composition of charge materials.

Materials \ Composition	C(%)	Si(%)	Mn(%)	Other
Sorel Iron	4.35	0.18	0.009	0.025% P
Steel Scrap	0.20	0.10	0.40	
Ferro-Mn	6.79	0.57	75.18	
FeSi		75.0		0.95% Ca 1.21% Al
MgFeSi		46.24		5.06% Mg

arrangements of the four castings are shown in Fig. 1 and 2, respectively.

Brinell hardness tests were determined on the slice of the casting with thickness of 38mm. This test was conducted on a ground surface using standard procedures. Then, the specimens were prepared metallographically and examined both untched and etched(5% nital). The grid point intersection procedure was used to estimate the amount of matrix constituents. All the castings were radiographed to check on internal porosity. And, they were also sectioned to check the distribution and location of internal porosity in the castings.

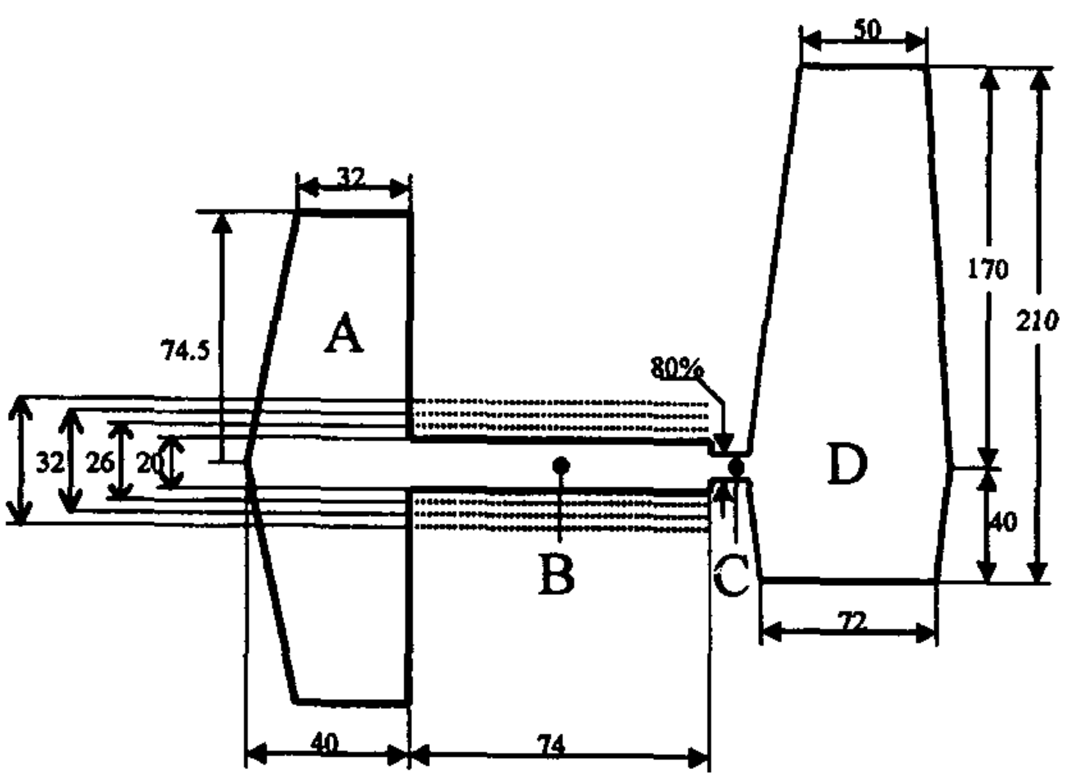


Fig. 1. Dimensions(unit: mm) of four T-shaped castings.

3. Experimental Results and Discussion

3.1 Chemical Analysis

The chemical analysis of the heat was 3.74%C-1.80%Si-0.31%Mn-0.047%Mg.

3.2 Hardness

The casting part on which Brinell hardnesses were measured is shown in Fig. 3. From the surface eight positions with 10 mm spacing were measured twice(A, B) and then averaged, as shown in Fig. 4. The relationship between hardness and distance from the surface is shown in Fig. 5, which shows that hardness decreases with the increase from the surface.

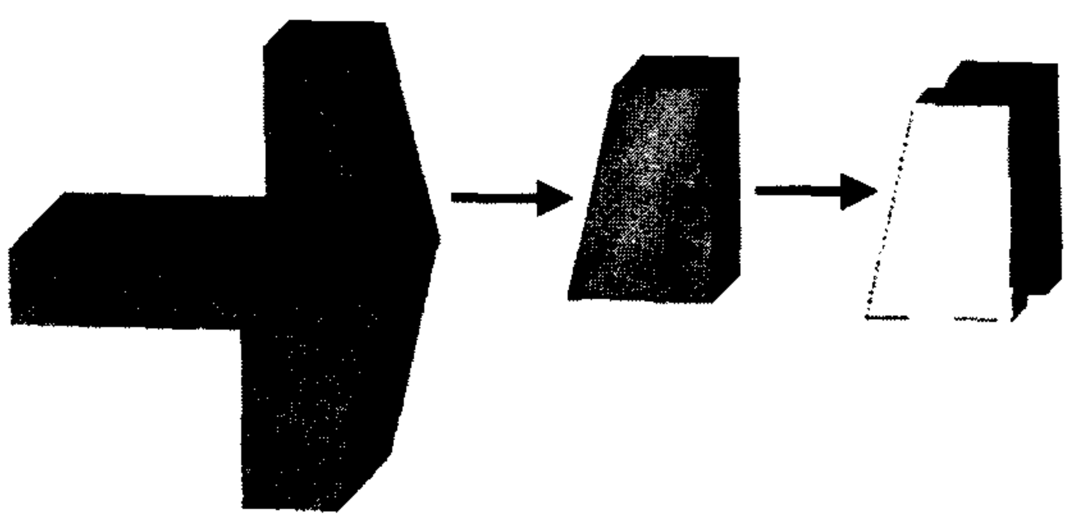
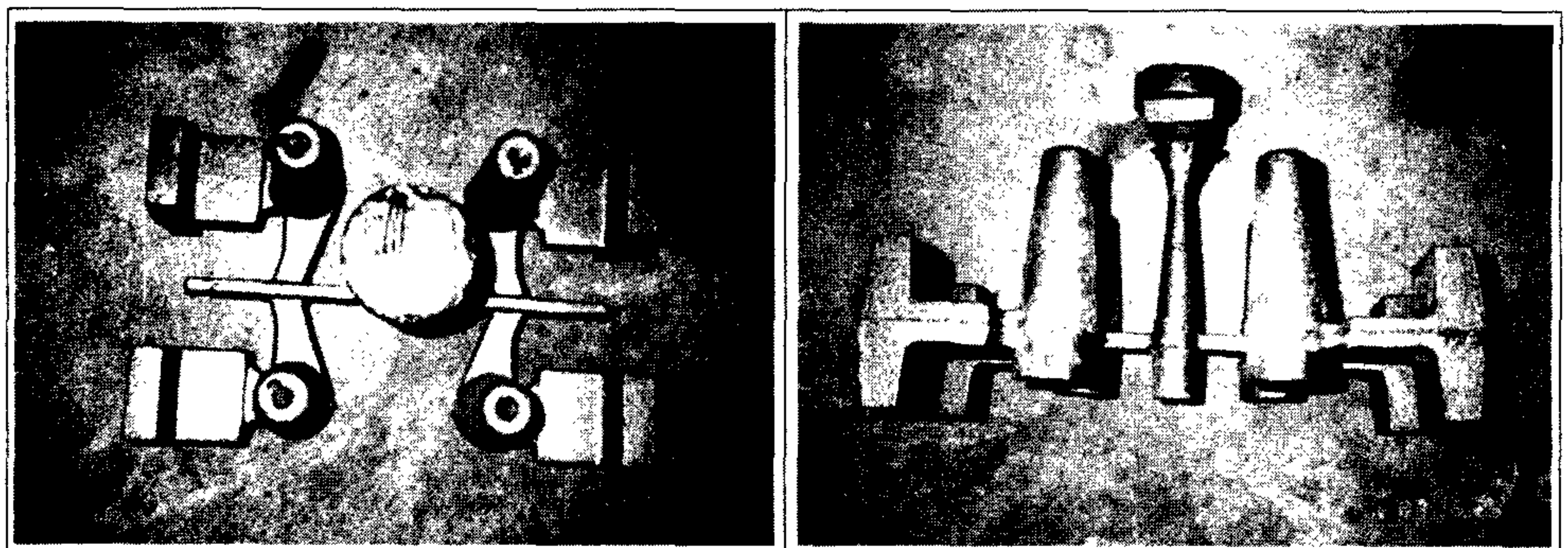


Fig. 3. Part of the casting on which Brinell hardnesses were measured.



(top view) (front view)

Fig. 2. Arrangement of four castings in the pepset mold.

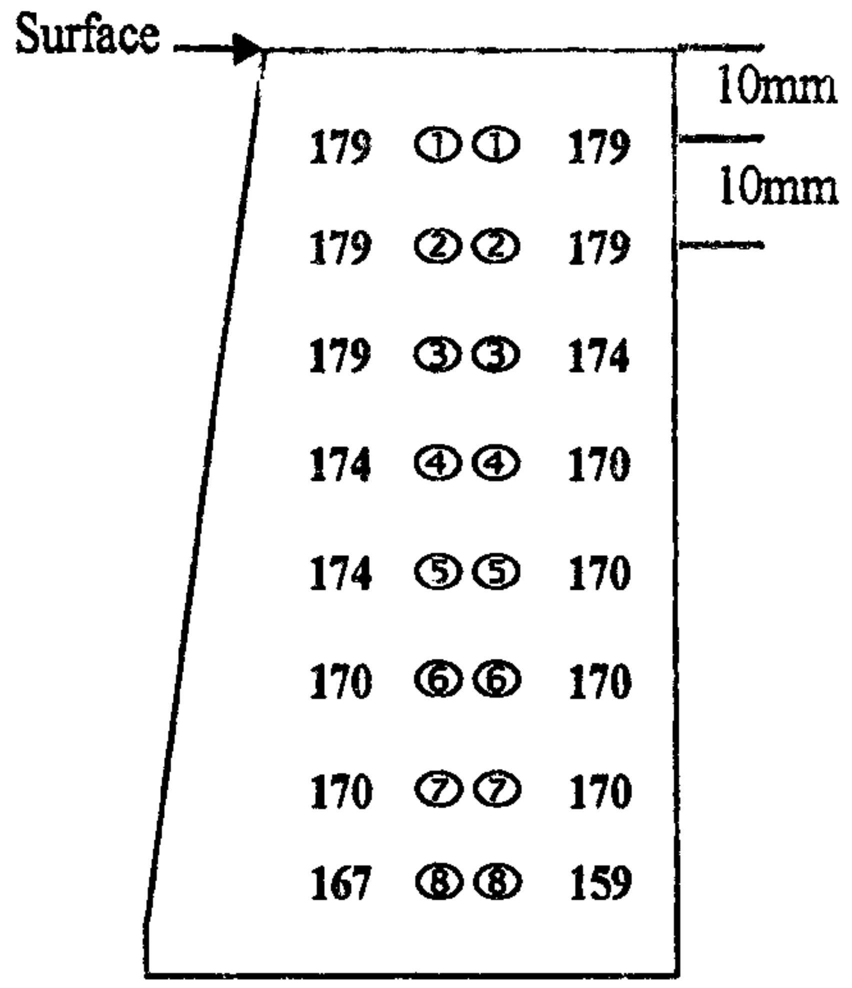


Fig. 4. Hardness(HB) distribution along the eight positions in the casting.

3.3 Nodule Count and Matrix Structure

The specimen for nodule count and metallographic examination was taken from the areas in the casting where the hardness measurements had been conducted. The examination included a measurement of the number of the nodular graphite precipitates and of the ferrite and pearlite contents. The nodule counts observed along the eight positions in Fig. 4 are shown in Fig. 6, indicating that the nodule counts decrease with the increase in distance from the surface and range from 126/mm^2 to 68/mm^2. The matrix structures of the casting were composed of pearlite and ferrite. The range of ferrite in the matrix was from 83.7% to 98.1%, depending upon the positions of the casting as

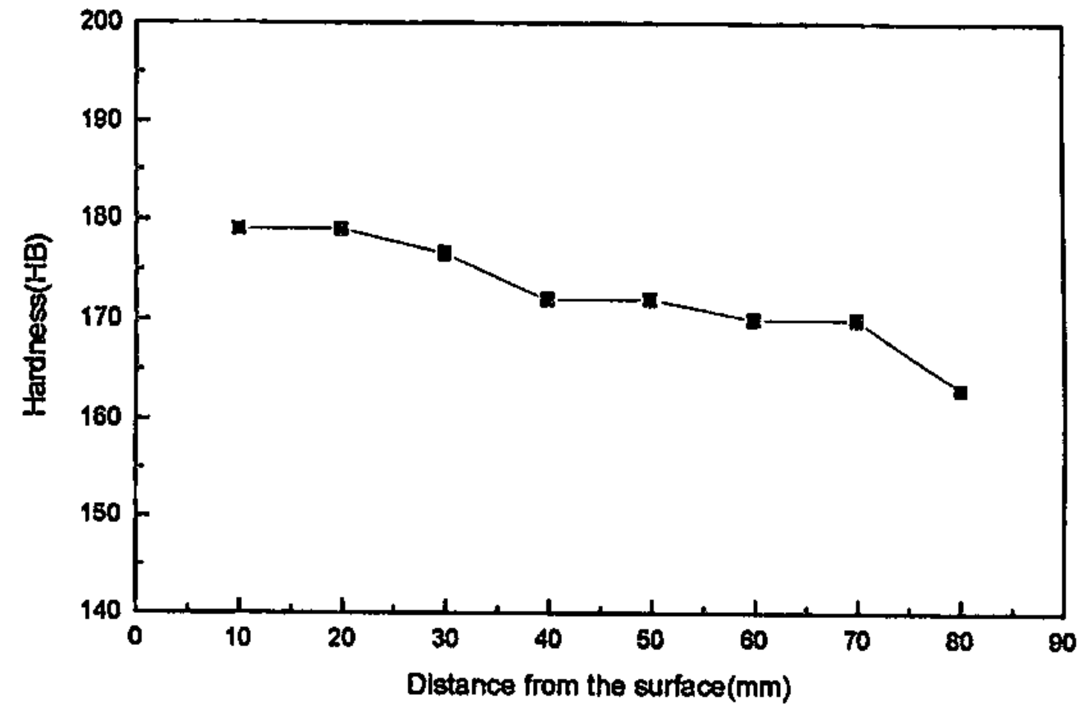


Fig. 5. Hardness distribution along the distance from the surface.

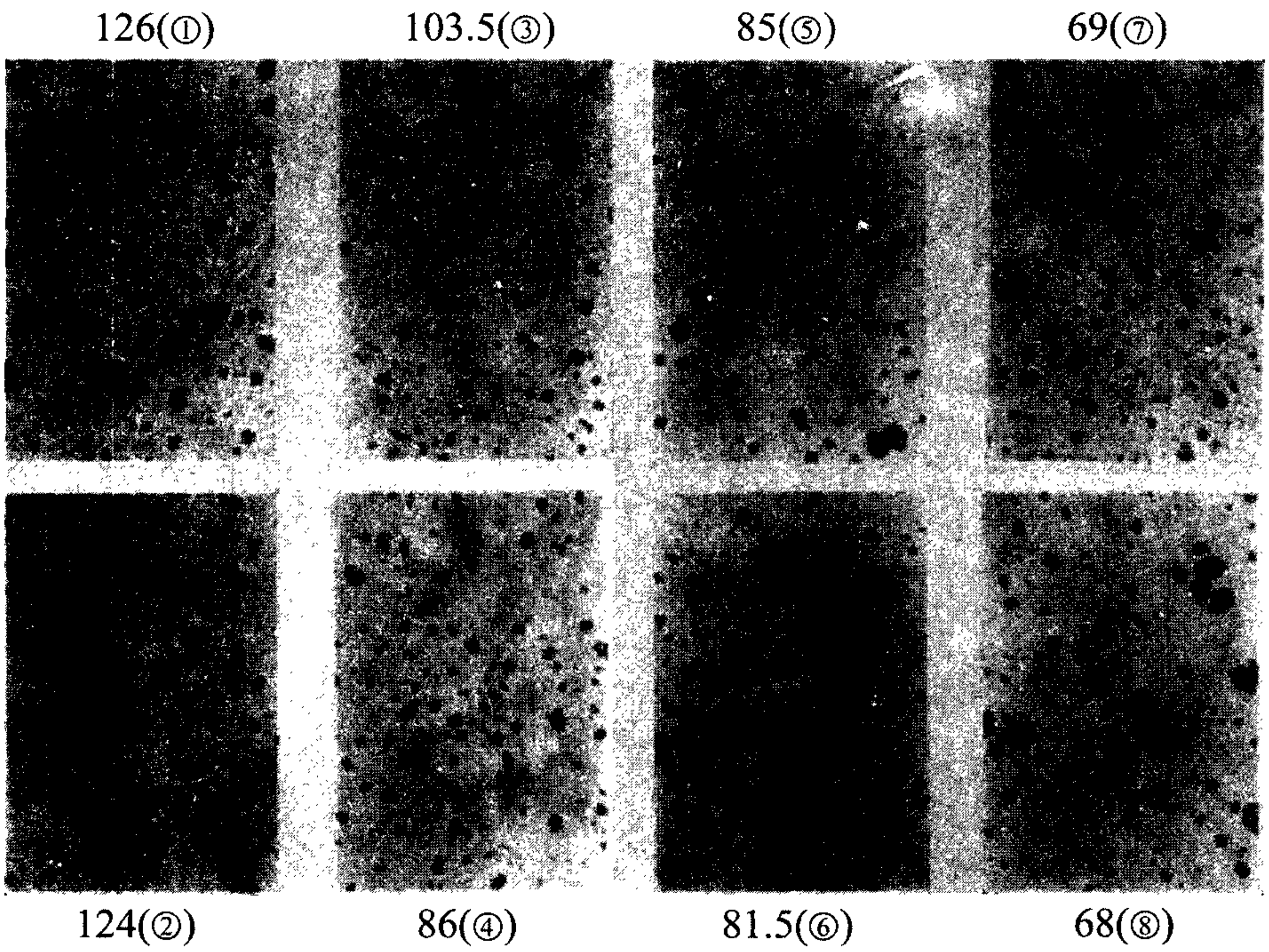


Fig. 6. The distribution of nodule counts along the eight different positions.

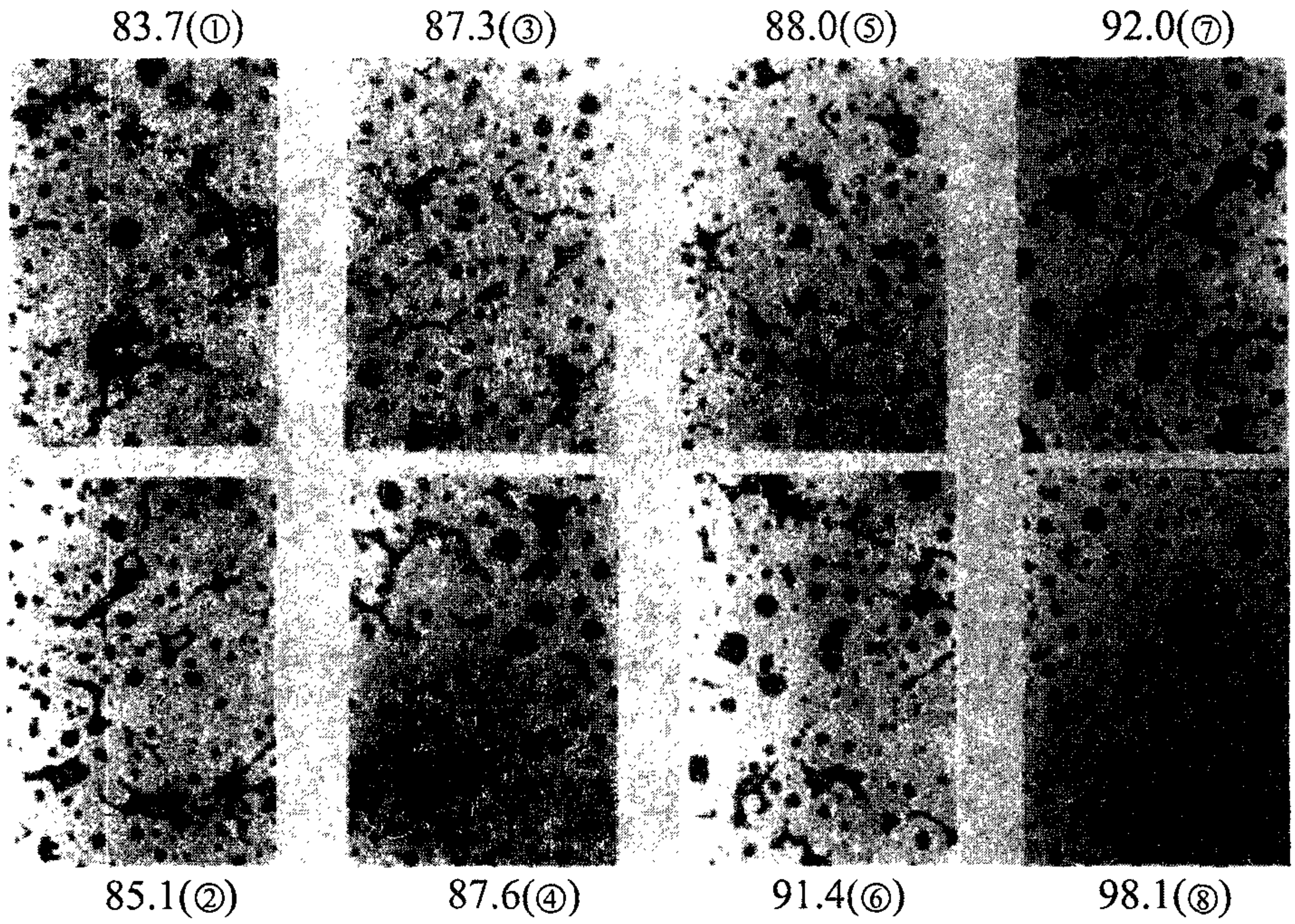


Fig. 7. The distribution of ferrite along the eight different positions.

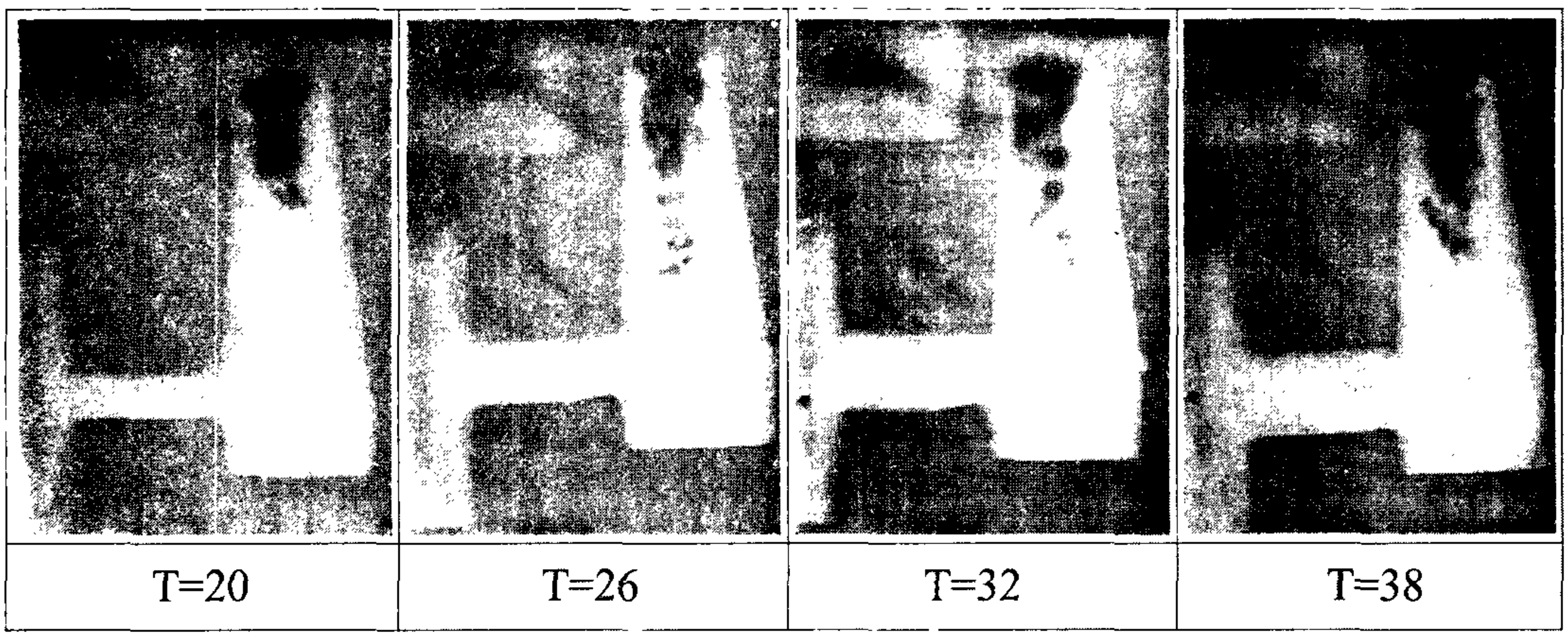


Fig. 8. The shape of four risers radiographed after solidification.

shown in Fig. 7.

3.4 Shrinkage

Four risers of the castings were radiographed in order to observe their feeding ability during solidification, which are shown in Fig. 8. It was observed that more sink down of the riser occurred with the thicker T, meaning that more volume of the riser had been fed to the casting with higher dimensions. The sectioned parts of the four castings are shown in Fig. 9, which reveals that the internal porosities are located in the junction of the specimens with thickness 20 and 26 mm.

4. Conclusion

Measurements have been made to quantify hardness, nodule count, matrix structure and shrinkage during the

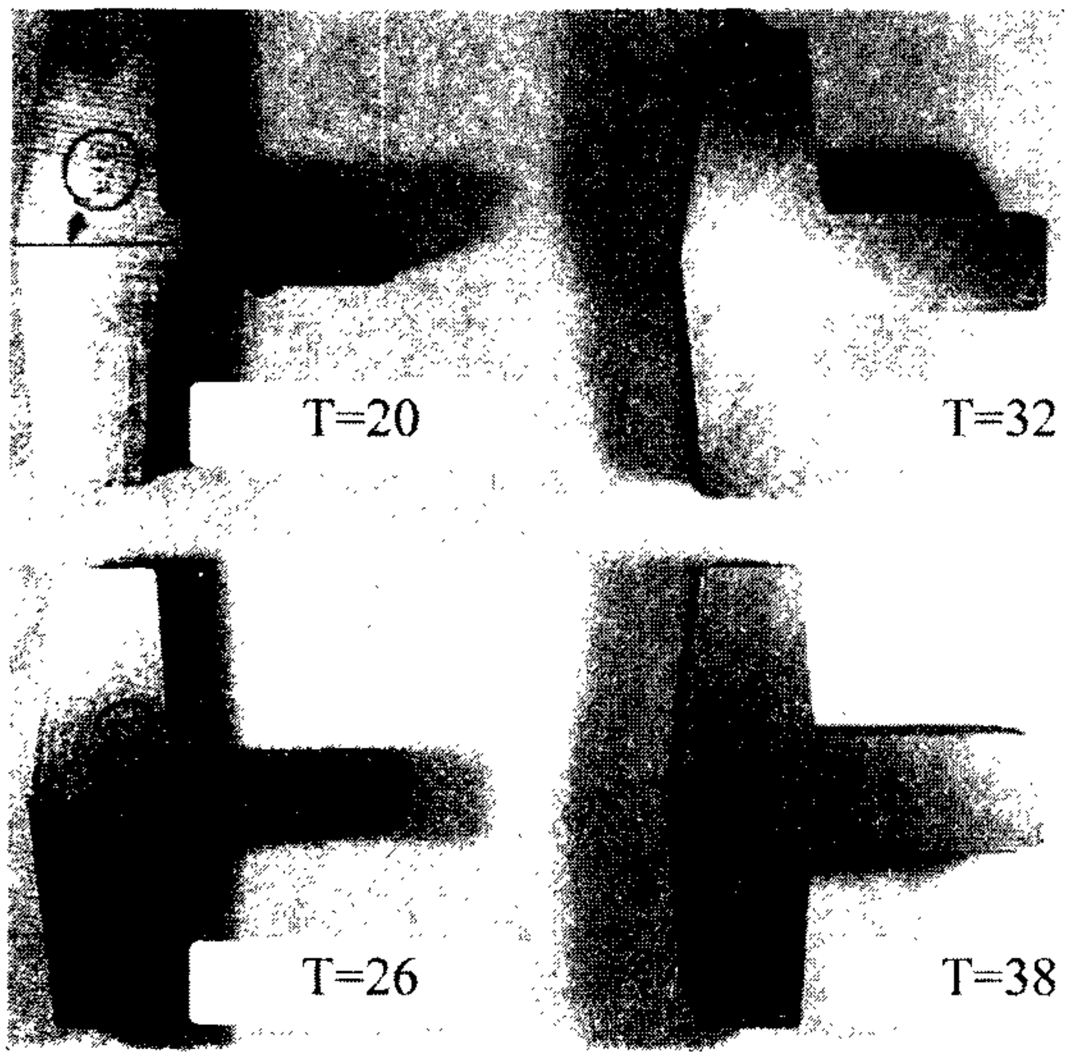


Fig. 9. Internal porosities shown in the sectioned castings.

pepset molded casting of T-shaped ductile cast iron. The experimental procedures, test conditions and final results could be used to validate a mathematical model for Brinell hardness, microstructure and shrinkage prediction of ductile cast iron.

Acknowledgments

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References

[1] M. Sussman and P. Smereka: J. of Fluid Mechanics, 341(1997)
[2] U. R. Kattner, J. of Metals: 49, 12(1997)
[3] E. Haug, A.Mo and H. Thevik: Int. J. Heat Mass Transfer, 38, 9(1995)
[4] C. A. Gandin and M. Rappaz: Acta Mater., 45(1997)
[5] M. Wessen and I. Svensson: Met. Trans A, 22A(1996)
[6] H. J. Diepers and I. Steinbach: in Proceedings 4th SP97, p 426, Sheffield(1997)
[7] C. M. Oldenburg and F. J. Spera: Numerical Heat Transfer, 21(1992)
[8] M. Bellet and I. Svensson: Met. Trans B, 27B(1996)
[9] V. K. Suri, H. huang and J. T. Berry: AFS Trans. 100(1992)