UNIVERSITI TEKNOLOGI MARA

# THE EFFECT OF COPPER ON HOT SHORTNESS OF LOW CARBON ALUMINIUM KILLED STEEL IN THIN SLAB CASTING

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## ABSTRACT

The surface hot shortness phenomenon causes cracks with high degree of difficulty to be eliminated during subsequent processing resulting surface defects especially in hot rolled coils and customer end products. In commercial practice the phenomenon contributes to customers dissatisfaction, product downgrading and coil rejections. The phenomenon is lead by the presence of copper which tends to be enriched at steel/scale interface by preferential oxidation of iron (Fe) causing liquid embrittlement at steel surface grain boundaries during hot working. The knowledge of Material Science Engineering on hot shortness dealing with the problems of surface cracking such as metal oxidation, diffusion and occlusion at high temperature deformation is the key factor of establishing a formula to solve the issue. The aim of this research is to investigate the effect of copper presence in thin slab casting in relation to casting speed through understanding of the mechanism of surface hot shortness and hot ductility. The objectives of the research are; to verify the oxidation behaviour and influence of grain size related to hot shortness, to characterize the surface cracks severity of the bend steel materials and the coil coarse edge severity index, and lastly to find the limits of copper contents in relation to casting speed. The limits of copper contents is influenced by the reduction percentage of final material thickness , the reduction of other crack inducing elements such as tin (Sn) and antinomy (As) and the addition of nickel (Ni) into copper (Cu) bearing steel. A specific case study with laboratory testing procedure using cold bending machine was conducted where cut samples of different copper contents taken from the hot rolled coils are bent to 180 degrees angle. The samples are grouped as steel model Group a with copper contents less than 0.10%Cu, Group B with 0.11%Cu to 0.12%Cu, Group C with 0.13%Cu to 0.14%Cu and Group D with 0.15%Cu to 0.18%Cu. Visible cracks are observed from the outer apex layers of the bend samples using the optical image analyzer and scanning electron microscope (SEM). In the laboratory testing, it is found that the degree of severity of the surface cracks of the bend samples varied with the amount of copper contents in the steel. The severity of the surface cracks are categorized based on the depth

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# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

The surface hot shortness and hot ductility phenomenon cause cracks with high degree of difficulty to be eliminated during subsequent processing resulting surface defects especially in hot rolled coils and customer end products. In commercial practice these phenomenon contribute to customers dissatisfaction, product downgrading and coil rejections. The hot shortness phenomenon is lead by the presence of copper which tends to be enriched at steel/scale interface by preferential oxidation of iron (Fe) causing liquid embrittlement at steel surface grain boundaries during hot working. Therefore it is important and beneficial to study ways to reduce the problems due to copper (Cu) by understanding the hot shortness mechanism from physical metallurgy point of view. The hot ductility phenomenon is caused by the precipitation of nitrides or carbides at the austenite grain boundaries when cast at critical temperature zone. The material will form voids that leads to cracking when the material is subjected to hot deformation such as casting followed by hot rolling. The severity of the edge cracks of a hot rolled coil is related by the combined effect from hot ductility and hot shortness and is closely influenced by the casting speed of the caster.

This thesis reports the research undertaken to study the phenomenon of surface hot ductility and hot shortness. Chapter 1 described the research background, the steel industry evolution that leads to the research problem, research aim and significance. The literature review is divided into three consecutive chapters each focusing on different reviews. Chapter 2 focused on the steel making process, Chapter 3 reviews on hot ductility and Chapter 4 focused on surface hot shortness. Chapter 5 elaborated the research methodology and the research method and then followed by Chapter 6 discussed