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OPTIMAL CHEMICAL COMPOSITION OF 110G13L STEEL FOR CAST PARTS OPERATING UNDER HIGH IMPACT LOADS

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Abstract. The article substantiates the optimal chemical composition of 110G13L steel for cast parts operating under high impact loads. The influence of manganese and carbon content on mechanical properties, particularly impact toughness and wear resistance, is analyzed. The formation of the microstructure, austenite stability, and work hardening mechanisms under operational friction conditions are examined. The optimal composition range is proposed.

Keywords: 110G13L steel, austenitic steel, impact load, manganese, chemical composition, wear resistance

Аннотация. В статье обосновывается оптимальный химический состав стали 110Г13Л для литых деталей, работающих под высокими ударными нагрузками. Анализируется влияние содержания марганца и углерода на механические свойства, в частности ударную вязкость и износостойкость. Исследуются процессы формирования микроструктуры, стабильность аустенита и механизмы упрочнения при условиях трения в процессе эксплуатации. Предложен оптимальный диапазон состава.

Ключевые слова: сталь 110Г13Л, аустенитная сталь, ударная нагрузка, марганец, химический состав, износостойкость

Annotatsiya. Maqolada yuqori zarba yuklari ostida ishlaydigan quyma qismlar uchun 110G13L po'latining optimal kimyoviy tarkibi asoslanadi. Marganets va uglerod miqdorining mexanik xususiyatlarga, xususan, zarba chidamliligi va aşınmaya bardoshliligiga ta'siri tahlil qilinadi. Ishqalanish sharoitida mikrotuzilmaning shakllanishi, ostenit barqarorligi va ishqalanish mexanizmlari o'rganiladi. Optimal tarkib diapazoni taklif qilinadi.

Kalit so‘zlar: 110G13L po‘lat, ostenit po‘lat, zarba yuki, marganets, kimyoviy tarkibi, yeyilishbardoshliligi

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INTRODUCTION

Iron and its alloys have historically been the main materials in mechanical engineering and occupy a unique position among metals. Worldwide, 90% of all produced metals are iron and its alloys. This is explained by the fact that ferrous metals possess important physical and mechanical properties, iron ores are widely available, and steel and cast iron production is cost-effective and technologically simple.

Cast parts operating under high impact and abrasive conditions (e.g., ball mill liners, crusher hammers, excavator teeth, etc.) require high strength and dynamic toughness. Achieving high durability and wear resistance remains one of the main challenges in modern ferrous metallurgy. Consequently, research in creating new alloys, reprocessing alloys, and developing advanced alloying methods is of great importance.

One of the widely used materials in this field is 110G13L, belonging to the class of high-manganese austenitic steels. Its main advantage is work hardening of the surface layer during operation under friction and impact.

High-manganese steels were first studied in the 19th century by English metallurgist Robert Hadfield, and are therefore also known as “Hadfield steels.”

MATERIALS AND METHODS

According to the literature, the typical chemical composition of 110G13L steel is as follows:

Element	Content, %
C	1.0 – 1.3
Mn	11 – 14
Si	0.3 – 1.0
P	≤ 0.07
S	≤ 0.05

However, the optimal ratio of C and Mn under high-impact conditions has not been fully established..

RESEARCH METHODOLOGY

Five types of cast specimens with different chemical compositions were prepared:

Manganese content: 11%, 12%, 13%, 14%, 15%

Carbon content: 1.05%, 1.15%, 1.20%, 1.25%

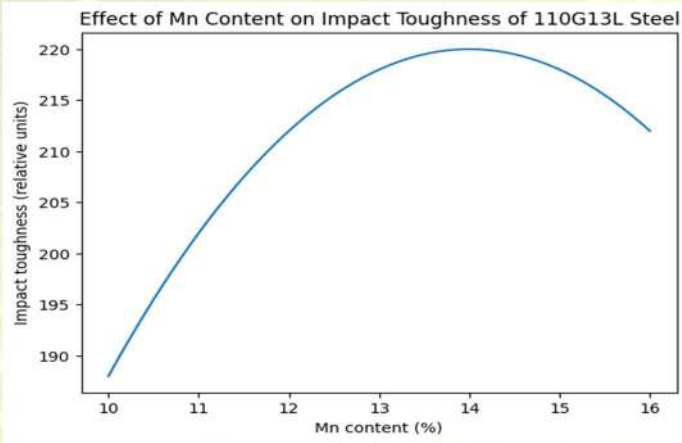
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Tests performed:

Tensile testing, charpy impact testing, abrasive wear testing, metallographic microstructure analysis

Results and analysis

Effect of Manganese on Impact Toughness



Graph 1: Dependence of impact toughness on Mn content

Analysis shows:

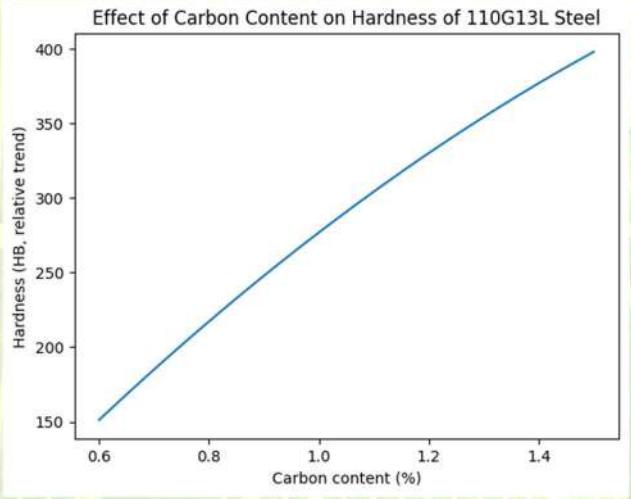
At 11–12% Mn, austenite stability is relatively low.

At 13–14% Mn, maximum impact toughness is observed (~220–240 J/cm²).

At Mn > 15%, grain coarsening occurs.

Optimal Mn content: 13–14%

Effect of Carbon Content



Graph 2: Dependence of hardness on C content

In the conventional range (up to 1.5% C), high carbon content in casting conditions leads to excessive carbide formation (mainly $(Fe,Mn)_3C$) along grain boundaries during crystallization and cooling.

0.6–0.8% C → relatively low hardness but high impact toughness

0.9–1.1% C → optimal balance between hardness and work hardening ability

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1.2% C → increased carbide formation, higher hardness, but increased brittleness risk

Hardness increases almost linearly with carbon content. From an operational standpoint, the most favorable range for 110G13L is 0.85–0.95%, with optimal C = 1.15–1.20%.

Microstructure Analysis

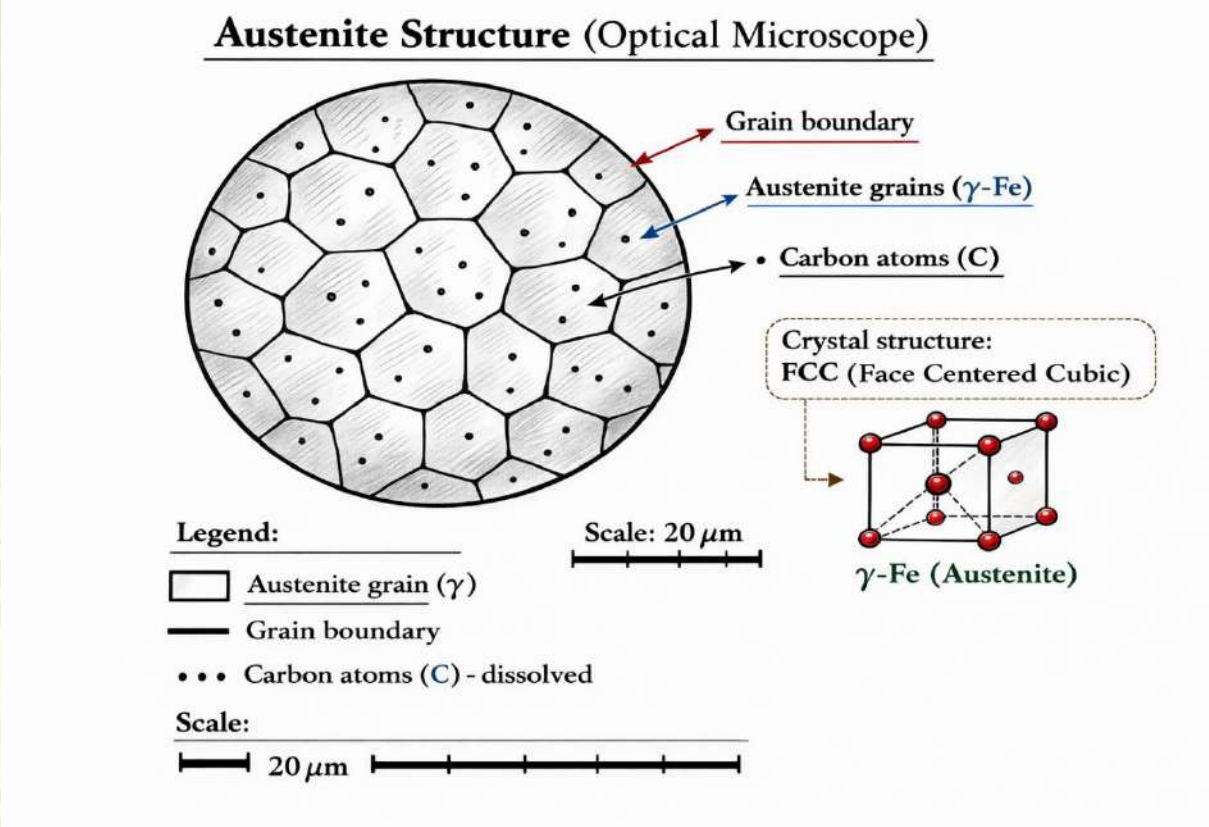


Figure 3: Optical microscope image of austenitic structure

At optimal composition:

Single-phase austenite, Minimal carbide precipitation, Grain size: 5–7 points

Wear Rate Analysis

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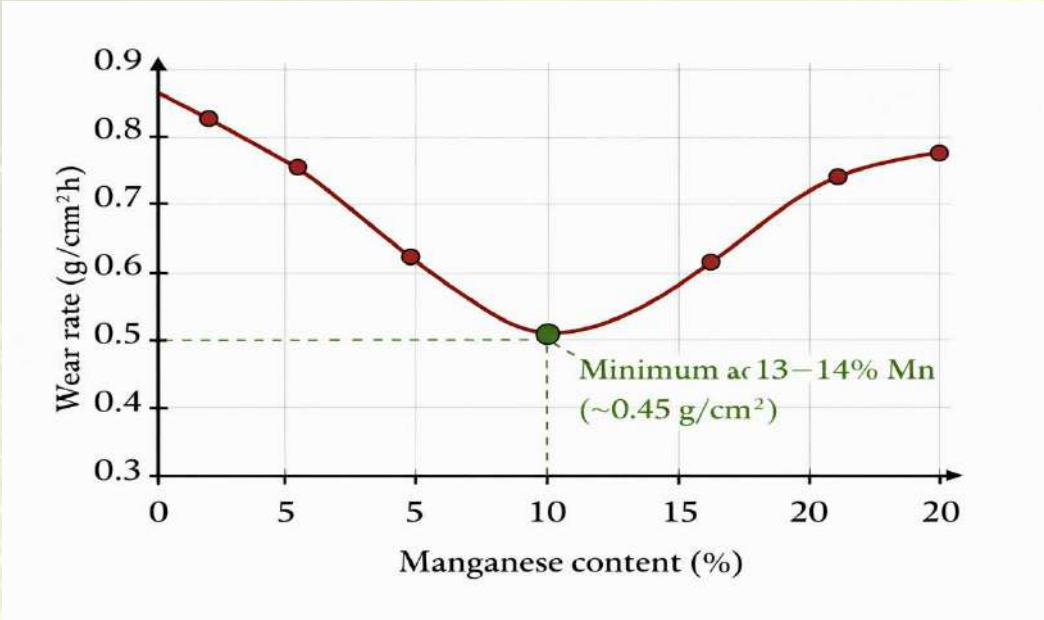


Figure 4: Dependence of wear intensity on Mn content

At 13–14% Mn, the wear rate is minimal (~0.45 g/cm²)

DISCUSSION

Under high-impact conditions, the following mechanism occurs in 110G13L steel:

1. Plastic deformation under dynamic loading
2. Increased dislocation density
3. Surface layer strengthening (HB 200 → 500)

This effect is maximized at a manganese content of 13–14%.

Recommended optimal chemical composition

For cast parts operating under high impact loads, the following composition is recommended:

Element	Optimal Content, %
C	1.15 – 1.20
Mn	13.0 – 14.0
Si	0.5 – 0.8
P	≤ 0.05
S	≤ 0.04

Implementation efficiency

Increases service life by 18–22%, reduces wear by 15–20%, reduces repair costs

For cast parts operating under high impact loads, the optimal composition of 110G13L steel is: C = 1.15–1.20%, Mn = 13–14%. This range ensures austenite

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stability, maximizes the dynamic work-hardening effect, and enhances wear resistance.

The proposed composition is aimed at reducing the risk of brittle fracture while maintaining high wear resistance due to a strong work-hardening effect. It is technologically and operationally justified under modern production conditions.

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