Technical Review of S7 Tool Steel Hardness Characteristics

Introduction

S7 tool steel is an air-hardening, shock-resisting grade renowned for its exceptional impact strength and toughness. Its versatile property profile makes it a suitable material for a range of applications, including medium cold-work tools and dies, shear blades, medium hot-work dies, and various component parts. This document outlines the key hardness characteristics of S7 tool steel based on established technical data.

Hardness Profile of S7 Tool Steel

Annealed Hardness

In its annealed state, S7 tool steel typically exhibits a Brinell hardness (HB) ranging from 192 to 223. Some data sources indicate an annealed hardnessمكانية of up to 230 BHN. This condition is achieved through a specific annealing heat treatment process designed to soften the material for improved machinability prior to hardening.

As-Quenched Hardness

Following austenitizing and subsequent air quenching from the recommended hardening temperature, the as-quenched surface hardness for S7 tool steel is typically in the range of 59–60 HRC (Rockwell C Hardness). The maximum attainable as-quenched hardness is generally cited as 60 HRC.

Recommended Working Hardness

The optimal working hardness for S7 tool steel, balancing toughness and strength, is generally recommended to be between 56–58 HRC. Some technical literature suggests a broader usual working hardness of 50-56 HRC. This targeted hardness is typically achieved by tempering the as-quenched steel at temperatures between 400–450°F (204–232°C). It is widely noted that tempering to achieve a hardness of 58 HRC provides the best combination of toughness and strength for most S7 applications.

Influence of Hardness Level on Toughness

It is critical to note that increasing the hardness of S7 tool steel through lower tempering temperatures or alternative heat treatments will result in a corresponding decrease in its toughness. For instance, hardening and tempering S7 to achieve 60–61 HRC can significantly reduce its impact strength, potentially leading to premature failure or cracking in service, especially in shock-loading applications.

Case Hardening

S7 tool steel can undergo case hardening procedures, such as nitriding or carburizing under controlled atmospheric conditions, subsequent to its primary air hardening and tempering treatment. This can further increase the surface hardness, potentially up to 64 HRC. However, such surface treatments typically result in a reduction of the steel's inherent shock resistance and core toughness.

Through-Hardening Capability

S7 is classified as a deep-hardening steel within the S-group of tool steels. It is capable of achieving full through-hardening (uniform hardness from surface to core) in cross-sectional sizes up to approximately 2.5 inches (63.5 mm) when air quenched. For sections exceeding 2.5 inches (63.5 mm) in thickness or diameter, complete through-hardening may not be achieved with standard air cooling, potentially resulting in a hardness gradient from the surface to the center of the component.

Hot Hardness and Resistance to Softening

The chemical composition of S7 tool steel, particularly its molybdenum content, imparts good hot hardness and resistance to softening at elevated temperatures. This characteristic allows S7 to be effectively utilized in medium hot-work applications. It can withstand service temperatures up to approximately 1000°F (540°C) with only minimal loss of hardness. For example, tempering at 1100°F (595°C) typically results in a hardness of approximately 46 HRC. In hot working scenarios, S7 offers an excellent combination of shock resistance and heat resistance.

Summary

S7 tool steel can achieve an as-quenched hardness of approximately 60 HRC. However, for applications demanding its characteristic high shock resistance and toughness, a working hardness in the range of 56–58 HRC, achieved by tempering between 400–450°F (204–232°C), is generally optimal. The through-hardening capability of S7 is excellent for sections up to 2.5 inches (63.5 mm); for larger sections, potential hardness gradients must be considered in design and application. Its notable hot hardness also makes it suitable for certain elevated temperature tooling.

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