

# 加载频率对高强钢 GCr15 超高周疲劳行为的影响

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**摘要:** 近些年来, 超高周疲劳研究越来越受到国内外学者的重视, 而超声疲劳试验机的发展为研究材料的超高周疲劳带来了巨大的便利。与常规频率下的传统疲劳实验相比, 超声疲劳实验技术大大节约了实验时间, 已成为研究超高周疲劳不可或缺的一项实验技术。但与此同时, 超声频率也给疲劳研究带来了一些问题, 例如超声频率可能导致疲劳强度和寿命的提高、试样温度的升高等, 为便于研究, 将其统称为频率效应。

本文以高强钢 GCr15 为例, 分别在旋转弯曲疲劳试验机、高频疲劳试验机和超声疲劳试验机上进行了三种不同加载频率 (52.5 Hz、260 Hz、20 kHz) 下的超高周疲劳实验研究。从三种疲劳实验的 S-N 曲线上明显看出频率效应的存在。从本质上来说, 加载频率对疲劳性能的影响是改变了加载的应变率。本文还对 GCr15 在 MTS-810 材料试验机和 Hopkinson 压杆实验装置上做了三种应变率 ( $10^{-4}\text{s}^{-1}$ 、 $10^{-3}\text{s}^{-1}$ 、 $500\text{s}^{-1}$ ) 下的力学性能实验, 实验结果显示随着加载应变率的提高, 材料的拉伸强度和屈服强度逐渐增加。本文从加载频率、应变率、温度等多方面系统地研究了 GCr15 的频率效应, 揭示了相关机理并对工程应用具有重要意义。

**关键词:** GCr15, 频率效应, 超高周疲劳, 应变率, 温度

## EFFECTS OF LOADING FREQUENCY ON VERY-HIGH-CYCLE FATIGUE OF A HIGH STRENGTH STEEL GCr15

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**Abstract:** In recent years, the research of very-high-cycle fatigue (VHCF) attracts more and more attention of international scholars, and the development of ultrasonic fatigue testing machines provides great convenience to the VHCF research on materials. Compared with conventional frequencies under traditional fatigue tests, ultrasonic fatigue test technology greatly saves the experiment time, which has become an indispensable experimental technology. Meanwhile, ultrasonic frequency also brings some problems to fatigue study, such as the increase of ultrasonic fatigue strength and life, the rise of temperature on specimen, etc., which is referred to as frequency effects for convenience of study.

Based on a high strength steel GCr15 as an example, this paper respectively carries out VHCF experiments under three different loading frequencies (52.5 Hz, 260 Hz and 20 kHz) on rotating bending machine, high frequency machine and ultrasonic testing machine, and it is obvious that frequency effects can be seen from the three S-N curves. Essentially, the frequency effects are changing the loading strain rates. So this article conducts mechanical property tests of

GCr15 under three kinds of strain rate ( $10^{-4}\text{s}^{-1}$ ,  $10^{-3}\text{s}^{-1}$  and  $500\text{ s}^{-1}$ ) on MTS-810 material testing machine and split-Hopkinson pressure bar, which show that with the increase of loading strain rate, material tensile strength and yield strength increases gradually. This paper studies the frequency effects of GCr15 from the perspective of the loading frequency, strain rate, temperature, etc., which lead to the understanding of the related mechanism and is of significance for engineering applications.

**Key words:** GCr15, Frequency effects, Very-high-cycle fatigue, Strain rate, Temperature