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# Laser cleaning of dirty grease on steel sluice cables

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**Steel cables used to raise sluices require a layer of corrosion-resistant grease, which must be periodically replaced. It is time-consuming and laborious, and conventional manual cleaning, mechanical cleaning, and chemical cleaning methods have many drawbacks. In this paper, a nanosecond pulsed fiber laser is used to clean hardened surface grease from such cables. An experimental system was designed to study the effects of parameters such as the laser power, scanning speed, cleaning frequency, and defocusing amount. Macroscopic and microstructural observations were conducted on the surfaces of steel cables before and after cleaning using cameras, optical microscopy, scanning electron microscopy, and energy dispersive spectrometry. With the optimal parameters, laser cleaning can effectively remove hardened grease from steel cable surfaces without damaging the galvanized layer and the steel wire matrix. Ablation, gasification, and evaporation are the main mechanisms by which grease and dirt are removed. This study lays a foundation for optimizing the laser cleaning of steel sluice cables at work sites.** 

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## 1. INTRODUCTION

Sluices are hydraulic structures used to block and release water in rivers, reservoirs, and other places [1,2]. They are often operated using a steel cable covered in grease, which resists corrosion. After a certain period of operation, the grease hardens and fails, making it necessary to reapply it. Before reapplication, it is necessary to remove the old, hardened grease. Conventional methods for this include manual, mechanical, and chemical methods [3–5]. These have numerous shortcomings, including low efficiency, potential environmental contamination, risks to human health, and damage to the steel cable matrix. To solve these problems, there is an urgent need for a better method of old grease removal. Laser cleaning is a new technology with the advantages of requiring no contact, being environmentally friendly, and being able to be automated or controlled remotely. Hence, it has attracted attention from scholars and the industry [6–11]. With the development of laser cleaning technology, the cost of laser cleaning machines has significantly decreased. Currently, they are widely used in cultural relic restoration [12], mold cleaning [13], removal of aircraft skin [14], removal of pre-welding oxidation films on aluminum alloys [15], rust removal from steel surfaces [16], removal of concrete pouring template residue [17], removal of dirt from ceramic insulator surfaces [18], and many other applications. Cleanable substances include paint [19–22], coatings [23,24], oxide films [25], rust [26], graffiti [27], microparticles [13], and marine micro-organisms [28,29].

Currently, there is only a small amount of research literature on the laser cleaning of oil or grease. Mateo *et al*. [30] used a Q-switched Nd:YAG laser with a wavelength of 355 nm to clean contaminated tools and equipment, as well as to remove oil residues from rocky coasts and beaches. The effectiveness of laser cleaning of petroleum residues has been demonstrated through experiments, which has determined the effective laser energy density and rock damage threshold for petroleum fuel removal. Using numerical calculations and experimental methods, Ahn *et al*. [31] studied the cleaning processes and mechanisms of Nd:YAG and excimer lasers used to remove lubricating oil from metal surfaces such as carbon steel, stainless steel, and copper. To detect the carbon content and threshold for surface damage following the removal of oil film, researchers have employed advanced tools such as optical microscopy (OM), scanning electron microscopes (SEMs), and energy dispersive spectroscopy (EDS). For a carbon steel substrate, the removal threshold of mineral oil is $160 \pm 10\ \mathrm{mJ/cm^2}$, while the matrix damage threshold is $410 \pm 20\ \mathrm{mJ/cm^2}$. For a stainless-steel substrate, the removal and damage thresholds are $130 \pm 10\ \mathrm{mJ/cm^2}$ and $420 \pm 20\ \mathrm{mJ/cm^2}$, respectively. For a copper substrate, the removal and damage thresholds are $1500 \pm 100\ \mathrm{mJ/cm^2}$ and $3200 \pm 200\ \mathrm{mJ/cm^2}$, respectively. Ye *et al*. [32] used a $CO_2$