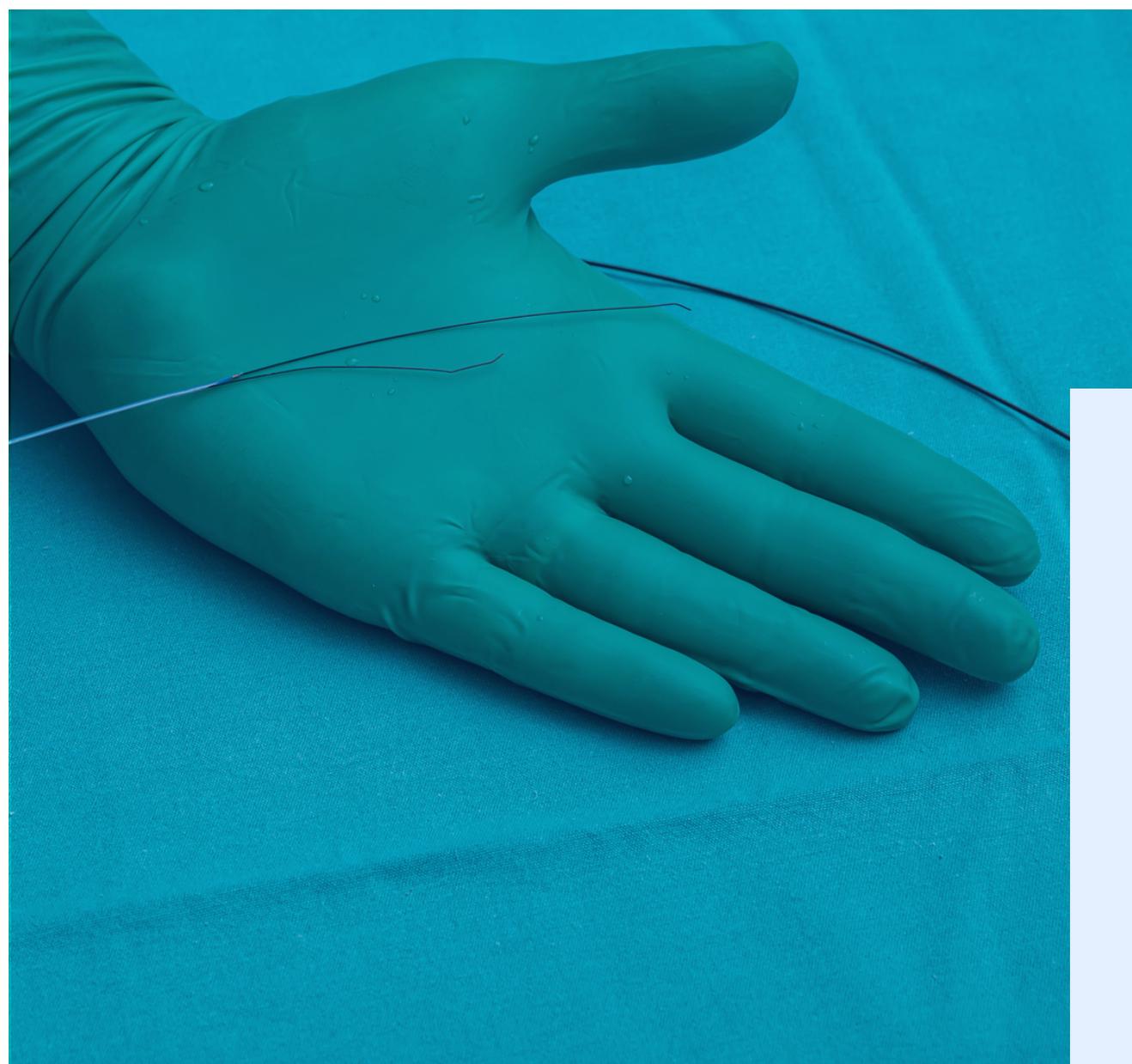


# WHITE PAPER

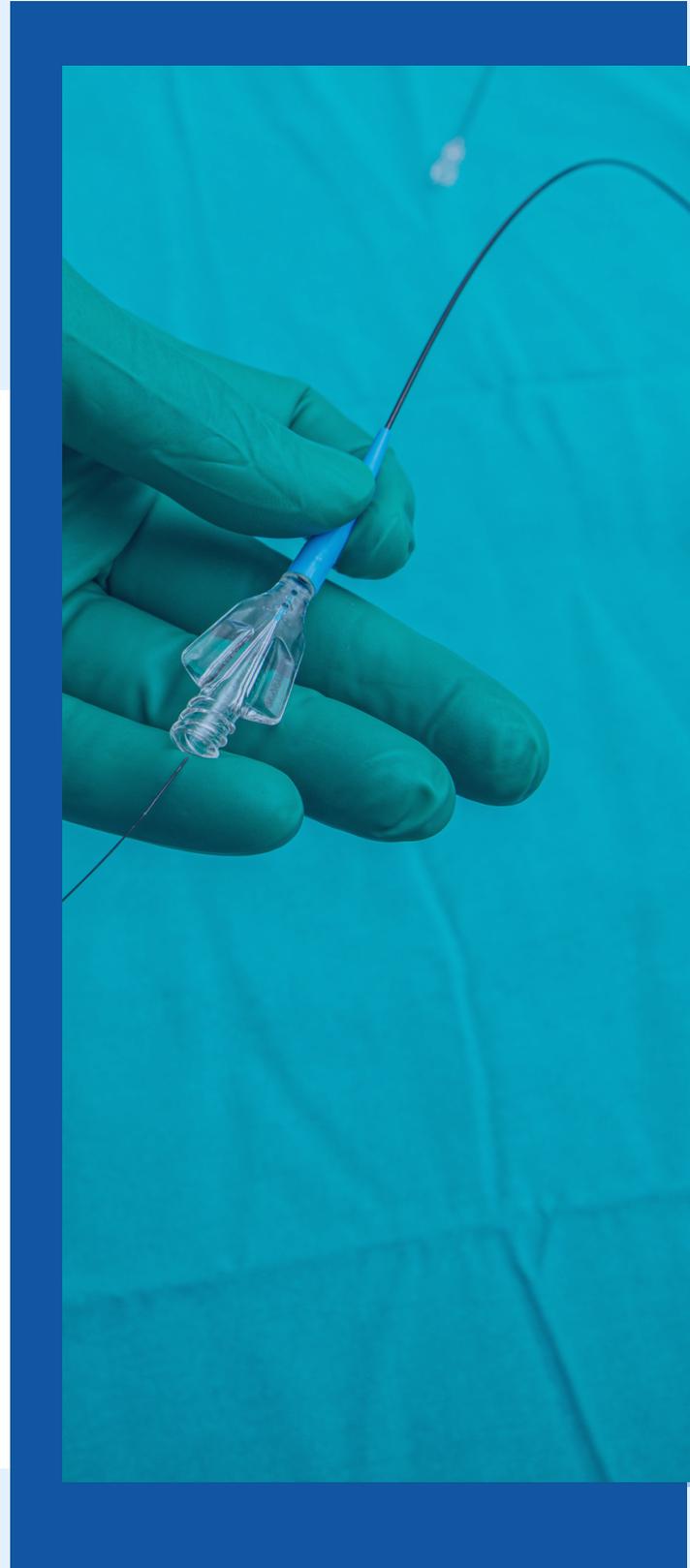
## HOW TO ELIMINATE THE “PIGTAIL EFFECT” IN STAINLESS STEEL GUIDEWIRE & COREWIRE GRINDING

This white paper delves into the “pigtail effect's” impact on stainless steel guidewire and corewire manufacturing, exploring its causes, implications, and mitigation strategies, including thermal treatment and material selection, to ensure cost-effective manufacturing solutions.



# Abstract

The "pigtail effect" presents a significant challenge in manufacturing stainless steel (SST) guidewires and corewires, resulting in unwanted helical distortion that impedes further material processing and compromises the integrity of the wire. This four-part white paper discusses the nature of the "pigtail effect" and its implications in SST guidewire and corewire manufacturing and outlines both conventional and innovative strategies for its mitigation. We explore thermal treatment, material selection, abrasives customization, grinding wheel formulations, and grinding technique optimization as critical methods to address this issue cost-effectively. Finally, we discuss the key operational pillars for efficient and cost-effective prevention of the "pigtail effect".



## What is the “Pigtail Effect?”

The "pigtail effect" refers to a deformation phenomenon predominantly observed in SST grinding. In this process, the material twists, forming a corkscrew or spiral shape akin to a pig's tail. This distortion is particularly problematic as it introduces unwanted flexibility and movement to the material, complicating further manufacturing processes. This effect is especially critical in producing SST guidewires and corewires, given their essential use in medical devices and the need for accuracy, precision, and reliability.

## Causes and Implications

When compounded by the combined thermal and mechanical impacts of the grinding process, inherent stresses within the wire are the primary contributors to the "pigtail effect". This process causes intense heat and mechanical force, exacerbating these stresses and leading to material deformation. The likelihood and severity of the "pigtail effect" depend on various factors, including the material's properties, the specific manufacturing processes employed, and the part's geometry and dimensions. The emergence of such distortions, especially at critical stress points, underscores the urgent need for integrated stress management strategies during SST guidewire and corewire grinding.



# Manufacturing Strategies to Mitigate the "Pigtail Effect"

## Thermal Treatment

Thermal treatment is a conventional method that relieves internal stresses within the SST wire, reducing the propensity for pigtailling. This process involves carefully controlled heating cycles that allow the material's atomic structure to relax. The primary objective is to alleviate internal stresses without compromising the wire's inherent mechanical properties, including tensile strength, hardness, and flexibility.

The efficacy of thermal treatment is fundamentally tied to the precision with which the temperature profile and cooling rates are managed. The aim is to achieve uniform stress relief across the entirety of the material, a task that demands meticulous control over the thermal process.

Strategic thermal treatment is a foundational approach to counteracting the tendencies towards pigtailling while preserving the material's functional characteristics. This balance between stress relief and maintaining physical properties is essential for producing high-performance, reliable SST guidewires and corewires.



## Sourcing of Stress-Resistant SST Material

The strategic sourcing of specialized SST alloys can also counter the "pigtail effect" in manufacturing stainless steel guidewires and corewires. A prime example of such a material is the Straight Linear Torque (SLT®) Type 4, engineered by Fort Wayne Metals. Characterized by its inherently low residual stresses and superior mechanical properties, SLT® Type 4 is ideally suited for high-precision applications, particularly in producing neurovascular guidewires. Known for its exceptional 1:1 torque response, this alloy is engineered to support extensive deep taper grinding, effectively minimizing the propensity for pigtailing and kinking.

However, there are limitations in the size range of these specialized alloys, confining their utility to specific wire dimensions. This underscores the critical need for continuous innovation and development in materials science to expand the versatility and scope of such stress-resistant materials. Advancing these alloys is crucial to extend their practical applications in the medtech industry, especially for producing SST guidewires and corewires that demand material integrity and performance.

## Abrasives Customizations

The interaction between the abrasive and the workpiece is critical in controlling the stress imparted during grinding. Customizing the abrasive type, grit size, bonding material, and wheel geometry can significantly influence the thermal and mechanical impact on the SST wire during the grinding process. The abrasive's hardness, friability, and thermal conductivity must be carefully balanced to optimize material removal while minimizing heat generation and mechanical stress. Developing abrasives with tailored properties, in conjunction with precise control over grinding parameters such as feed rate, speed, and coolant flow, allows for fine-tuning the grinding process to prevent the onset of pigtailing.

## Innovative Grinding Wheel Formulations

The composition and structure of the grinding wheel are fundamental in defining its performance and influence on the "pigtail effect". Through a meticulous formula development process, various components, such as abrasive grains, bonding agents, and porosity enhancers, are combined to create a wheel with specific characteristics. The "recipe" for this composition is refined through extensive testing and experimentation, where the impact of each variable on grinding efficiency and material integrity is assessed. Developing custom grinding wheel formulations involves a deep understanding of materials science and grinding dynamics, leading to solutions that offer the optimal balance between material removal rates and stress minimization.

## Grinding Technique Optimization

The grinding technique employed profoundly affects the stress state of the SST wire. The aggressive nature of centerless grinding, favored for its efficiency in material removal, tends to impart higher stress. In contrast, with its reduced contact area, outer diameter (OD) grinding offers a gentler approach that minimizes stress but at the cost of reduced efficiency. The art and science of grinding technique optimization lies in adjusting the parameters of this method, such as wheel speed, feed rate, and contact geometry, to achieve a cost-effective balance between productivity and material integrity. Innovations in grinding technology, such as adaptive control systems and precision tooling, enable the fine-tuning of the grinding process to specific material and product requirements, ensuring the highest quality outcome while addressing the challenge of the "pigtail effect".

# Key Operational Pillars for Effective “Pigtail Effect” Mitigation

## Structured Operator Competency Development

A well-defined grinder operator competency structure is vital for upholding stringent quality standards in SST guidewire and corewire grinding. By establishing specific advancement criteria, this performance-driven framework ensures that complex and critical projects are allocated to operators with proven skills and experience. Such an approach promotes ongoing professional growth and ensures that advanced tasks are executed with the highest level of precision and expertise. By assigning the most challenging projects to top-tier operators, the likelihood of errors is minimized, elevating the overall quality of the output. This strategic focus on skill enhancement and careful project distribution enhances operational efficiency and promotes continuous improvement and innovation.

## Proficiency in Abrasives and Wheel Composition

Understanding the complex interplay between the workpiece material and the grinding wheel is essential for guidewire grinders focused on high-precision tasks. Mastery over abrasive materials, wheel formulations, and their interactions with various metals is crucial for peak grinding performance. Such proficiency directly contributes to enhancing efficiency and mitigating the “pigtail effect”, ensuring the delivery of superior quality in grinding operations.

# Key Operational Pillars for Effective “Pigtail Effect” Mitigation Cont.

## Culture of Innovation

A culture deeply rooted in innovation, particularly in developing new abrasive compositions and grinding wheel formulations, fosters an environment ripe for grinding efficiency and precision breakthroughs. This culture is enhanced by relentless perseverance and strategic investments in exploring groundbreaking grinding solutions, allowing extensive testing and fine-tuning of custom solutions tailored to specific projects. The result is a notable operational efficiency enhancement, including significant throughput improvements stemming from these innovations. Embracing such a dynamic approach to innovation fosters the advancement of grinding technologies, ensuring cutting-edge solutions to industry-wide challenges.

## Cost-Efficient Grinding Practices

Achieving cost-efficiency while integrating innovative grinding practices is essential for producing economically viable components without sacrificing quality. This delicate equilibrium involves strategically applying advanced grinding techniques and materials to enhance the product's quality and cost-effectiveness. A proficient grinder deploys cutting-edge technologies and streamlines processes to boost operational efficiencies, minimize waste, and expedite production, effectively lowering costs while maintaining the integrity and performance of the parts produced. This approach optimizes the manufacturing process and ensures that the end products are high quality and competitively priced, enhancing the overall value.

# Key Operational Pillars for Effective “Pigtail Effect” Mitigation Cont.

## Robust Quality Assurance

Effective mitigation of the “pigtail effect” necessitates a robust quality assurance system with advanced metrology equipment for precise measurements, enhanced by meticulous human inspections. This combination ensures the highest standards of accuracy in grinding operations. Central to this pillar is a commitment to continuous quality improvement, driving persistent enhancements in process accuracy and product reliability. Such a focused approach to quality assurance is crucial for maintaining the integrity of high-precision guidewires and corewires.



# Summary

In summary, effectively mitigating the “pigtail effect” in SST guidewire and corewire manufacturing demands a holistic approach encompassing a range of strategic interventions. From the onset, it is imperative to understand the complex interplay of thermal and mechanical stresses that contribute to this deformation phenomenon. Addressing these challenges requires a multi-faceted strategy, including applying advanced thermal treatments to alleviate internal stresses, sourcing specialized stress-resistant materials, and customizing abrasives and grinding wheel formulations to optimize grinding processes.

Furthermore, proficiency in grinding technique optimization, underpinned by a robust operator competency structure, ensures that each grinding task is executed with precision and care, minimizing the introduction of additional stresses. The innovation culture within the manufacturing environment encourages continuous exploration and refinement of grinding solutions, contributing to significant advancements in operational efficiency and product quality.

Finally, a commitment to cost efficiency ensures that these technological and procedural advancements translate into high-quality, economically viable SST guidewire and corewire products. By integrating these strategies and aligning with the key operational pillars for effective pigtail mitigation outlined in this white paper, manufacturers can achieve a comprehensive solution to the “pigtail effect”, ensuring the production of superior SST guidewires and corewires that meet the stringent demands of medical applications.



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