

SUSTAINABLE MANUFACTURING PRACTICES IN THE MACHINE BUILDING INDUSTRY

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Machine tool consist of various elements like spindles, drives, and guideways. A machine tool may have a cutting portion with ultra-hard materials like diamond or boron nitride, enhancing its durability and performance. Machine tools are essential in various industries for achieving accurate and consistent machining results while improving productivity and quality [1]. These findings underscore the significance of embracing innovative approaches and technologies to achieve sustainability goals in manufacturing. Manufacturing practices in the machine building industry encompass various processes like casting, forging, welding, extrusion, spinning, and power metallurgy. Forging, in particular, has been highlighted for its efficiency in reducing material waste during production compared to machining, with significant reductions in material loss observed when forging crankshafts from different materials. Standards play a crucial role in ensuring quality and competitiveness in mechanical production, with the application of norms and technical documentation being essential for meeting consumer demands and competing in both domestic and international markets. Additionally, the adoption of digital technologies, such as CNC applications and online monitoring [2], is transforming the industry by enabling real-time equipment diagnostics and comparison with set standards, ultimately reducing machine downtime and enhancing efficiency. The integration of digital servitization in the machine tool industry is also emerging as a key enabler for delivering value through services, leveraging data capture and connectivity to optimize decision-making and enhance overall production systems.

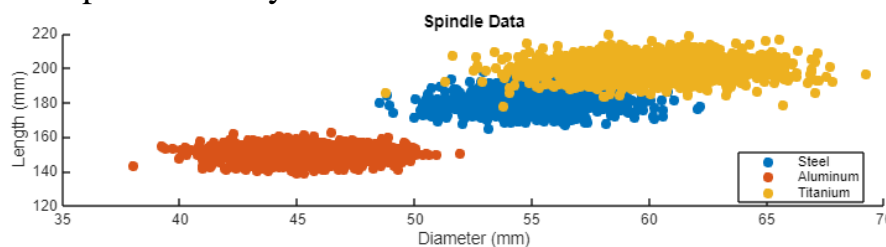


Figure 1. Spindle Component.

Figure 1 depicts the spindle is a critical component in machine tools responsible for rotating cutting tools. Its dimensions, such as diameter and length, significantly influence machining performance. The material choice also affects properties like strength and thermal conductivity, impacting machining accuracy and tool life. We simulate spindle data using normal distributions based on mean diameter and length values specific to each material type (steel, aluminum,

titanium). The mean values represent typical dimensions, while standard deviations introduce variability to mimic real-world manufacturing tolerances.

The drive system provides power to the spindle, controlling rotational speed and torque during machining operations. Parameters such as power rating and rotational speed determine the machine's cutting capabilities and efficiency. Drive data is generated with statistical distributions reflecting typical power and speed ranges for different machine applications. Normal distributions are used to model variations in power and speed within the manufacturing environment. Guideways provide linear motion support for machine tool components, ensuring precision and stability during machining processes.

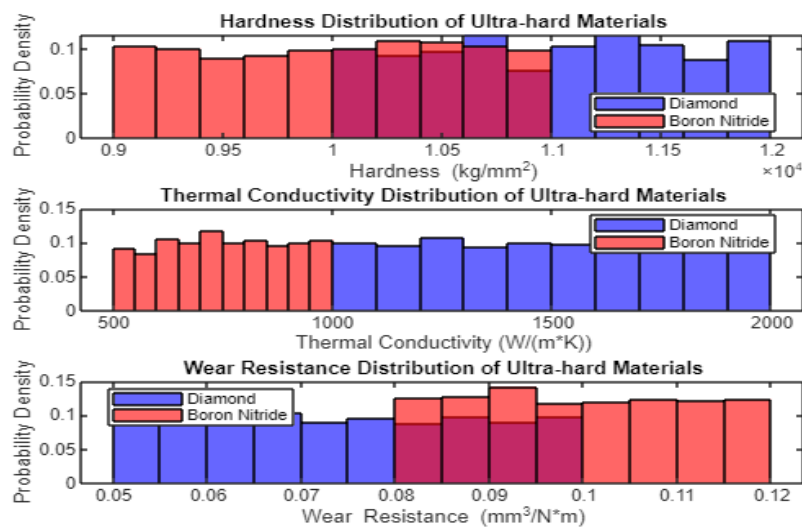


Figure 2. Hardness.

Length and width dimensions of guideways influence machine size and rigidity, impacting machining accuracy and surface finish. Guideway data [3] is simulated using statistical distributions based on common length and width specifications observed in machine tools. Variability in length and width dimensions is introduced through normal distributions to capture manufacturing variations and design considerations.

Hardness is a fundamental material property representing its resistance to deformation, particularly in response to indentation or scratching. In the context of machine tools, the hardness of cutting tool materials like diamond or boron nitride is crucial as it influences their ability to withstand high cutting forces and maintain sharp cutting edges during machining operations. Higher hardness values indicate greater resistance to wear and longer tool life, contributing to enhanced machining efficiency and productivity [4].

Thermal conductivity measures a material's ability to conduct heat, influencing its temperature distribution and heat dissipation characteristics during machining. In machine tools, especially during high-speed cutting operations, efficient heat dissipation is vital to prevent tool overheating, material deformation, and premature tool failure. Materials with high thermal conductivity, such as



diamond or boron nitride, facilitate effective heat transfer away from the cutting zone, thereby improving machining performance, dimensional accuracy and surface finish.

References

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