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SELECTION OF TOOLS AND MACHINING PARAMETERS FOR PIPE WALLS

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Abstract

This review paper examines the techniques and factors involved in pipe wall processing, with a focus on the essential technologies utilized in this field. The study revealed crucial elements, such as ASTM A350-LF2 Class 1 carbon steel, renowned for its exceptional mechanical qualities and ability to withstand low temperatures. An exhaustive analysis has been conducted on the chemical makeup of this steel to comprehend its capacity to adjust and endure in various operational environments. The study focused on examining several particle separation processes, including as turning, milling, drilling, and grinding, in order to determine the exact equipment and criteria needed for each technique. The cooling and lubricating process received particular emphasis, with thorough investigation of several agents, including CASTROL HYSOL T15, and their impact on surface quality and tool longevity. The utilization of these compounds has been discovered to substantially decrease tool temperature and enhance machining quality. Upon closer examination of the processing techniques specified in section A-A of the tube wall, it was determined that advanced procedures such as floating plug drawing and micro-sized spiral tube hydroforming were discovered. These techniques allow the attainment of superior surface quality and precise dimensions, which are crucial for guaranteeing the structural integrity of the pipe. Cutting tools, processing equipment, and coolants and lubricants are essential components in the manufacturing of pipe walls. Nanoparticulate cooling and lubrication systems, which are advanced technologies, have demonstrated their effectiveness in minimizing friction and heat during machining. As a result, these systems enhance productivity and prolong the lifespan of tools. According to the article, the essential components for attaining high-quality manufacture of pipe walls are cutting tools, processing equipment, and coolants and lubricants. Additional study is advised to enhance processing parameters, create eco-friendly coolants and lubricants, and utilize artificial intelligence for predictive modeling and optimization of processing. This establishes the groundwork for future research and innovation in the pipe wall production business, with the objective of attaining enhanced efficiency and sustainability in production processes.

Keywords:

Pipe wall treatment, carbon steel ASTM A350-LF2 Class 1, particle separation techniques, cooling and lubrication, advanced processing technologies

1 INTRODUCTION

Pipe walls are key elements in industries such as oil, gas, chemical and shipbuilding. Their production requires the application of various material processing technologies in order to achieve high precision, strength and durability. This paper analyzes the tools and processing parameters used in the production of pipe walls, with special emphasis on particle separation, drilling and milling. Materials such as carbon steels, especially ASTM A350-LF2 Class 1, play a key role due to their mechanical properties and resistance to low temperatures. The processing of these materials involves particle separation techniques, such as turning, milling, drilling and grinding, which have specific requirements. Cooling and lubrication are also important to reduce tool temperature and improve surface quality. Although individual machining processes have been well studied, a comprehensive review integrating the various processes and tools in the context of pipe wall manufacturing is lacking. The objective of this review is to provide an overview of best practices and recent developments in tool selection and processing parameters, to improve production efficiency and quality, and to suggest directions for future research and industry application.

The next chapter takes a closer look at the materials used in the production of pipe walls, which is a key element in understanding the overall production process.

2 MATERIAL ANALYSIS

The materials used to make pipe walls are key to their durability, resistance and functionality. One of the commonly used materials is ASTM A350-LF2 Class 1, a carbon steel known for its outstanding mechanical properties and adaptability to different working conditions. In the analysis, relevant scientific papers, industrial reports and technical specifications were used for the identification

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and assessment of tools and processing parameters in the production of pipe walls. Data were collected from databases such as ScienceDirect, IEEE Xplore and Google Scholar. The methodology includes a comparative analysis of different material processing technologies, with an emphasis on particle separation, drilling and milling. The impact of cooling and lubricating agents on the environment and workers' health was analyzed in detail. Special attention is paid to the toxicity, biodegradability and recyclability of the materials used, as well as potential risks to the health of workers and protection measures against harmful chemicals.

2.1 Mechanical properties of carbon steel (ASTM A350-LF2 CLASS 1)

The mechanical properties of ASTM A350-LF2 Class 1 carbon steel are critical in evaluating its suitability for various applications, particularly in pipe wall construction where durability and resistance are of utmost importance. This steel is designed for optimal performance at low temperatures, providing excellent mechanical properties that make it a reliable choice in demanding conditions [1]. Its adaptability and mechanical properties ensure the longevity and reliability of the system [2].

ASTM A350-LF2 Class 1 is often used in components that do not need to withstand high stress levels, such as mechanical parts and structural elements [3]. Its ability to withstand low temperatures without loss of integrity ensures the longevity of the system, making it the preferred choice in industries where high performance is required [4]. Because of this, this material has found wide application in industries where high resistance and reliability are required in difficult operating conditions [5].

The tensile strength and yield strength make ASTM A350-LF2 Class 1 a reliable material for components that must withstand severe operating conditions, while ensuring longevity and system efficiency [6]. These characteristics make it a flexible and highly valued material in various sectors. Thanks to strictly defined standards and specific procedures, ASTM A350-LF2 Class 1 meets all the necessary mechanical requirements for key applications, ensuring reliability and durability in various industrial applications [7].

2.2 Chemical composition of carbon steel (ASTM A350-LF2 CLASS 1)

The chemical composition of ASTM A350-LF2 Class 1 materials is shown in the table and includes carbon, manganese, phosphorus, sulfur, silicon, nickel, chromium, molybdenum, copper, niobium, and vanadium.

Tab. 1: Chemical composition of material [%]

Element	Min	Max
C	-	0.30
Mn	0.60	1.35
P	-	0.035
S	-	0.040
Si	-	0.30
Ni	-	0.40
Cr	-	0.30
Mo	-	0.12
Cu	-	0.40
Cb	-	0.02
V	-	0.05

Carbon, which is present up to 0.30%, is crucial for the hardness and strength of steel. Manganese, ranging from 0.60% to 1.35%, improves strength and impact resistance. Phosphorus and sulfur are present in minimal amounts because they can negatively affect the ductility and weldability of the material. Other elements, such as silicon, nickel, chromium, molybdenum, copper, niobium and vanadium, are present in smaller amounts, but significantly contribute to the properties of steel, such as corrosion resistance, hardness and stability at different temperature conditions.

ASTM A350-LF2 Class 1 material has specific thermal properties that are essential for its use in various sectors. The yield strength at a temperature of 20°C is approximately 250 MPa, and as the temperature increases, the yield strength decreases. This happens because the material becomes more ductile and less resistant to deformation. For example, the yield strength at 100°C is 238 MPa, while at 300°C it drops to 171 MPa. These data show that ASTM A350-LF2 Class 1 retains considerable strength even at high temperatures, making it suitable for applications where resistance to temperature variations is required without compromising structural integrity.

Cooling and lubricating agents such as CASTROL HYSOL T15, which is a chlorine-free semi-synthetic agent with advanced additives, were used in this research. CASTROL HYSOL T15 provides protection against corrosion, has a low foaming tendency and is compatible with different water hardnesses. Its applications include grinding, turning and milling, and it is recommended for steel and cast iron. In addition, agents such as this reduce exposure to harmful chemicals and the risks of bacterial and fungal infections, providing environmental and health benefits.

Given the importance of the material, the next key step in the production of pipe walls is the analysis of the particle separation process, which will be discussed below.

3 PARTICLE SEPARATION PROCESSES

Particle separation techniques are crucial in production because they enable the removal of excess material and the achievement of exact dimensions and desired surface properties. Operations such as turning, milling, drilling and abrasive processing ensure precise results and high product quality [8]. The choice of technique depends on economy, precision and surface quality, and includes mechanical, electrochemical and chemical methods [8].

Advanced methods, such as microfluidics and dielectrophoresis, enable efficient separation of particles in various applications [9]. Computational fluid dynamics (CFD) helps to optimize particle separation in hydrocyclones, improving the accuracy and efficiency of the process [10]. Hybrid abrasive techniques are being researched to increase production efficiency, while abrasive waterjet cutting brings progress in the processing of metal materials [11, 12]. Electrostatic separation and particle simulations also contribute to improving recycling and processing [13, 14].

Particle separation techniques enable precise manufacturing and quality surfaces, which is crucial for industrial applications. The next step in the production of pipe walls is the discussion of drilling and reaming.

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4 PROCESSES IN PIPE WALL MANUFACTURING (COUNTERSINKING AND REAMING)

Countersink cutting tools are specialized tools used to machine the entrance or exit of round holes. This operation, known as countersinking, is essential for creating precise hole shapes and enlarging their entrances or exits. Countersinks, similar to drills, have multiple cutting edges and are essential for precisely shaping flat or inclined surfaces. Liu et al [16] carried out research aimed at optimizing the design to predict and correct embedment depth errors in CFRP/Al layers. Their study demonstrates the effectiveness of the developed approach in ensuring accurate penetration depth, highlighting the importance of precision in penetration procedures.

Fig. 1: Milling [22]

Plunge cutting tools are an essential part of machining operations, as they fulfill many vital roles necessary to achieve accurate and high-quality results. These tools are mainly used to widen holes, ensuring precise measurements and adequate preparation for future machining procedures [17]. This process is crucial for creating holes of the precise dimensions required for various components in the manufacturing industry. In addition, countersinking tools are used to create countersunk holes for screw heads, allowing for precise placement of screws on the surface of the workpiece [17]. This function is essential to ensure the structural strength and stability of the assembled components. Furthermore, countersinks play a key role in processing the inclined edges of holes, improving the visual appeal and overall performance of the end product [17]. This element is especially important in industries where accuracy and aesthetics are of utmost importance, such as the aerospace and automotive industries. Countersink cutting tools are also used to level the raised parts of the workpiece, which is necessary to achieve flat surfaces and precise joints [17]. This function is essential to ensure the overall quality and functionality of the processed components.

Fig. 2: Countersinking cutter [23]

Researches emphasize the importance of using symmetrical milling cutters to improve machining results in grooving procedures [18]. Symmetric milling cutters are a type of tool that can improve the precision and efficiency of machining operations. Furthermore, research points to the advantages of corrugated milling cutters compared to ordinary ones, showing lower specific energy consumption, increased wear resistance and less surface hardening [18]. This shows that the choice of cutter design has a significant impact on machining performance and tool life, highlighting the importance of proper tool selection for specific applications. Analyzing milling as a special type of processing, research points out that the processed layer varies depending on the angle of the cutting blade [15]. This observation sheds light on the complex dynamics that occur during milling operations and the importance of cutter shape in material removal. Additional information on the interrelationship and influence of angles in the design and milling process provides insight into the complex and precise nature of tool design required to achieve maximum performance [20]. Comparative studies on tool wear and performance show that diamond-coated milling cutters have particular advantages in terms of tool life and cutting force [21]. This research highlights the importance of considering tool coatings and materials to improve tool life and performance during machining operations. Choosing the right router is crucial to achieving the desired machining results. The efficiency, precision and quality of the machining process largely depend on the design, geometry and coating of the milling cutter. Manufacturers can improve their machining processes to meet the stringent requirements of modern industry by understanding the capabilities and advantages of different types of milling cutters.

Fig. 3: Reaming [24]

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Reaming is a precise machining process that is of critical importance in industries such as automotive, aerospace and machinery manufacturing, where maintaining high quality standards is of utmost importance [13]. This technique involves using a reamer to remove a thin layer of material from the inside wall of the hole, improving dimensional accuracy and surface quality. During the reaming process, the tool works at a slow pace and gradually enters the hole in a straight line. The front conical part of the reamer primarily processes the surface, while the cylindrical part serves as a guide to achieve a smoother surface [13]. The length of the conical part of the reamer depends on the material being processed; a longer conical part ensures better polishing and a better quality processed surface [13].

The effectiveness of a reamer depends on several factors, including its design, build quality, and usage technique. Ideal working conditions and processing settings are crucial for optimal operation of the reamer. There are several types of reamers that differ in tooth structure, material composition, method of use, hole shape and attachment method. These variations make it possible to adapt to specific processing needs and achieve the best possible results [13]. Taper reamers require unique cutting conditions that include three stages of machining - rough, fine and finest - to ensure a surface that is smooth and precise [13].

Research has shown the importance of reaming in achieving precise and high-quality hole processing, which is essential for meeting strict construction standards in modern industry [14]. The quality of the reaming process is evaluated according to parameters such as surface roughness, diameter and roundness, which emphasizes the importance of precision in this machining process [15]. Reaming is key to achieving precise dimensions and also has a significant impact on improving surface integrity and geometry, as proven by research specifically examining materials such as martensitic stainless steel 15-5PH [16].

Reaming is widely used in the automotive industry, especially given the increasing use of lightweight materials such as aluminum-silicon alloys in engine blocks [17]. Analytical procedures were performed to understand the forces involved in cutting and hole precision in the reaming process, especially with regard to materials such as Al–Si–Mg alloy. These studies emphasize the importance of ease of material processing and the need for precise processing in industrial conditions [17].

Additionally, the research examined how Laser Powder Bed Fusion (LPBF) parameters and methods affect the machining accuracy of pre-drilled holes, highlighting the importance of process modeling in determining optimal machining conditions for reaming, depending on strain rates [18]. The adaptability of reaming techniques has also been shown in medical applications, where it is used for reaming pig bones and replacement bones [16]. Furthermore, research on the precision of reaming holes in medium carbon steel using ultrasonic vibration techniques highlights the continuous investigation of new approaches to improve the precision and efficiency of reaming procedures [19].

Studies have also investigated surgical procedures such as glenoid reaming, highlighting the complex nature of the procedure and the importance of sensory input in achieving favorable results [20]. Reaming is a key machining technique required to achieve precise and high quality standards in various sectors. The precise and careful nature of reaming, along with its ability to affect dimensional accuracy, surface quality and material integrity, as well as its versatility in working with different materials and applications, underscores its critical importance in modern manufacturing processes. Through continued research and implementation of innovative techniques, the efficiency and effectiveness of reaming processes can be improved to better meet the changing needs of precision engineering. After describing the drilling and reaming processes, the role of cooling and lubricating agents in these processes is discussed below.

5 COOLANTS AND LUBRICANTS

Coolants and lubricants play a key role in the tribomechanical system during cutting operations and have been used since the early stages of metalworking history. The main purpose of these substances is to dissipate the heat produced during cutting operations, thus cooling both the workpiece and the cutter of the tool. Cooling not only improves surface quality, but also extends tool life by reducing friction on its contacting surfaces [21]. During deep drilling, coolants and lubricants are forcefully injected through special channels in the tool to remove chips from the hole. The pressure used for these operations can exceed 300 MPa, which enables faster cutting speeds and increased productivity [21].

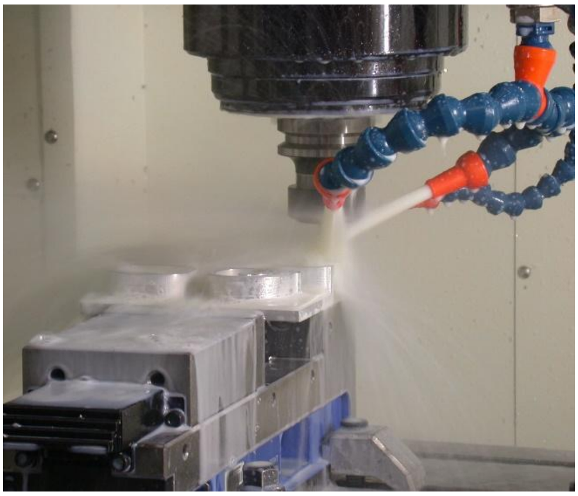

Fig. 4: Example of applying cooling and lubrication during drilling [25]

Research has shown that the inclusion of lubricants and coolants as additional measures can significantly extend tool life and improve surface quality in machining operations [21]. The use of cooling systems in cutting processes has a positive effect on surface quality, which highlights the importance of these chemicals in improving processing efficiency [21]. Also, empirical tests have shown that cooling and lubrication play a key role in machining operations by reducing tool temperatures, forces and wear, while at the same time improving the quality of the workpiece and extending tool life [21].

Research has also shown that the traditional function of coolants in processing goes beyond just cooling; they also

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provide lubrication, prevent corrosion and help remove chips. This highlights the various advantages of these substances in industrial processes [21]. The introduction of cooling techniques, such as minimum lubrication (MQL), aims to improve surface smoothness, reduce costs, mitigate environmental impacts and reduce the amount of metal cutting fluids used [21]. This highlights the continuous development and advancement in the field of coolants and lubricants to solve various processing challenges and improve overall operational efficiency.

Extensive research has shown that coolant conditions, such as cutting speed and coolant pressure, significantly affect the machining processes of materials such as Inconel 718. The best results in achieving high-quality machined surfaces are achieved at a cutting speed of 140 m/min and a coolant pressure of 150 up to 200 bar, which emphasizes the importance of optimal parameters for effective cooling and lubrication [20]. Also, the application of cutting fluids enriched with nanoparticles extends the tool life and improves the characteristics of the processed material, which indicates the potential of new lubrication approaches [21]. Research using computational fluid dynamics (CFD) in cryogenic milling has shown that effective cooling reduces tool wear and improves the quality of the machined surface [21]. Thermal modeling studies have shown that coolant pressure significantly affects tool temperature distribution, and high-pressure jets are effective in cooling and lubricating the contact between the tool and the workpiece [21]. These results highlight the critical importance of coolant pressure for effective heat removal and lubrication during machining. Coolants and lubricants are necessary in machining processes, because in addition to cooling, they reduce friction and extend tool life, and ongoing research in this area seeks to optimize machining processes, improve surface quality, and increase productivity.

Once the importance of coolants and lubricants is understood, the focus shifts to detailing the technology along the A-A pipe wall section.

6 TECHNOLOGY FOR PROCESSING DETAILS ACCORDING TO SECTION A-A ON A TUBE WALL

The technology of processing details along the A-A section of the pipe wall is a key element of manufacturing processes that require precision and compliance with design specifications to ensure the structural strength and functionality of the pipe, while meeting dimensional and surface criteria. This procedure uses a number of sophisticated methods and tools that are selected according to the characteristics of the material and the desired results [21].

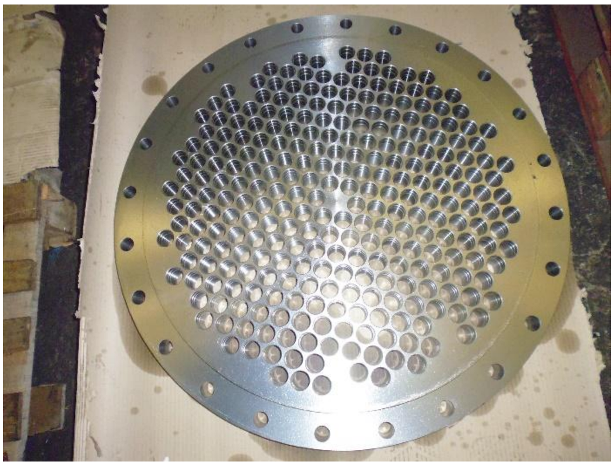

Fig. 5: Finished tube sheet [26]

Fig. 6: Grooves on the tube sheet [27]

The floating plug drawing (FPD) technique is an advanced technology for the production of seamless thin-walled pipes with high surface quality, which highlights the importance of innovative approaches in this field [13]. A study on the hydroforming of micro spiral tubes with uniform wall thickness highlights the importance of selecting appropriate tube dimensions to meet specific requirements [16]. Research on the material properties of DC04 welded pipe in hydroforming indicates the wide application of this technology in the automotive and aviation industries, highlighting the importance of precise processing techniques [16]. In order to understand the effect of combined tensile-torsional loading on thin-walled circular pipes, it is important to consider different stress and strain conditions to preserve the mechanical properties of the pipe [16]. The automatic system for welding the protective layer on the walls of boiler tubes emphasizes the need for protection against high temperatures and corrosion, which shows the importance of precise processing [17]. Advanced methods such as electromagnetic tube drawing and ultrasonic vibration for the production of ultra-fine brass electrodes indicate continuous progress in processing technologies, with priority given to dimensional accuracy and surface quality [17, 18]. Research on improving the performance of multi-cell thin-walled tubes under three-point loading emphasizes the application of sophisticated methods to identify optimal designs [19].

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In the technological production process, a GRM 16450 machine and a DCN 190-095-25A-5D drill bit with an ICP 190-2M IC908 crown are used for the drilling operation. The procedure includes several steps: clamping the workpiece, measuring the dimensions, drilling a hole with a diameter of 19 mm, final inspection and releasing the workpiece. Machining modes for drilling include rotational speed (n) of 1490 rpm, feed (s) of 390 mm/min, cutting speed (Vc) of 88.9 m/min and depth of cut (ap) of 9.5 mm [19].

A GRM 16450 machine and an E45 D16-W25 milling cutter with a TPMT 160304 IC825 plate are used for the boring procedure. The procedure includes the following steps: clamping the workpiece, measuring the dimensions, plunging at an angle of 45°, final inspection and releasing the workpiece. Machining modes for plunging include rotational speed (n) of 2500 rpm, feed (s) of 500 mm/min, cutting speed (Vc) of 281.8 m/min and depth of cut (ap) of 0.5 mm [19].

For the reaming process, the GRM 16450 machine and the RM-BN7-19.0300LA-337-908 reaming tool are used. The procedure includes the following steps: clamping the workpiece, measuring the dimensions, reaming the hole to a diameter of 19.3 mm with a tolerance of +0.05/-0.1 mm, final inspection and releasing the workpiece. Machining modes for reaming include rotational speed (n) of 495 rpm, feed (s) of 247 mm/min, cutting speed (Vc) of 31.08 m/min and depth of cut (ap) of 0.15 mm [20].

For the milling process, a GRM 16450 machine and a KGEM 1905R3 WN20M milling cutter with a KGIP0125H0189 6D KC045 insert are used. The process includes the following steps: clamping the workpiece, measuring the dimensions, milling the slot, final inspection and releasing the workpiece. Machining modes for milling include rotational speed (n) of 1625 rpm, feed (s) of 200 mm/min, cutting speed (Vc) of 96.28 m/min and depth of cut (ap) of 0.4 mm [20].

Research on natural bulging of thin-walled metal pipes during liquid impact forming presents new technologies that improve traditional pipe hydroforming methods [19]. A study on increasing coil temperature and processing efficiency in electromagnetic forming emphasizes the need to understand the thermal elements of processing to improve efficiency and quality [19]. The process of joining composite plates with tubes shows the complexity of integrating different materials and forming methods to achieve the desired structural properties [19]. Research on an innovative robotic tube bending process provides insight into the factors that influence the deformation of the tube section, emphasizing the need for precise control of processing variables [19]. Advances in continuous extrusion of thin-walled magnesium alloy tubes improve production efficiency, accuracy and material utilization, which indicates the continuous development of tube processing technologies [20].

Technologies for processing parts along the A-A section of the pipe wall include sophisticated procedures to ensure precise measurements, dimensional accuracy and high surface quality. These advanced processing methods are key to achieving the desired structural integrity and functionality of pipes in various industries, such as automotive, aerospace and construction. Continuous research and development in processing technologies are necessary to meet the ever-increasing demands for high-performance pipes with complex shapes and strict quality standards.

The next chapter will cover in detail the cutting tools, machining equipment, and coolants and lubricants that are critical to achieving high-quality production.

7 CUTTING TOOLS, MACHINING EQUIPMENT, AND COOLING AND LUBRICATION AGENTS

Key elements in the manufacturing industry include cutting tools, processing equipment, and coolants and lubricants. These elements play a key role in ensuring efficient and high-quality production processes. The emergence of intelligent cutting tools and processing procedures, which include innovations such as plug-and-produce design, intelligent algorithms for managing and monitoring critical cutting temperatures in real time, has revolutionized this field [18]. These advances not only improve precision, but also extend tool life and improve the overall quality of machined surfaces.

Fig. 7: Selected machine Four star Taiwan FD3242 [28]

The use of nanoparticle-based systems in cooling and lubrication has significantly improved the sustainability of machining processes by reducing heat and friction during operations [14]. By integrating additives into cooling and lubrication systems, the tribological elements of processing are improved, resulting in smoother operation and longer tool life. Furthermore, the use of surface response optimization methods plays a key role in the evaluation of tool wear in turning operations, highlighting the importance of effective lubrication strategies in reducing wear and optimizing tool longevity [19].

Understanding the effect of machining parameters on cutting forces is critical to improving machining operations. Research has shown that the evaluation and analysis of cutting forces provide key insights into several aspects of machining, such as tool wear, machining precision, energy efficiency, and surface quality [20]. Manufacturers can increase the productivity and quality of surface treatment by adjusting cutting parameters and tool geometry, which allows them to control cutting forces and vibrations [21].

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Fig. 8: Application of coolants and lubricants in the process of tube sheet production [29]

Researchers have explored environmentally friendly cutting fluids and minimal lubrication approaches to reduce environmental impact and preserve machining efficiency in pursuit of sustainable manufacturing practices [14]. Manufacturers can strike a balance between efficiency and sustainability by using environmentally friendly cutting fluids and improving lubrication operations. Furthermore, the application of machine learning-based modeling has been implemented to predict cutting forces and improve cooling and lubrication techniques for proactive maintenance in manufacturing systems [11]. The machinability characteristics of the material are directly influenced by the cooling and lubrication procedures. Research has shown that the application of cryogenic jets and minimal lubrication techniques can effectively improve machining properties by reducing cutting temperatures, specific cutting energy and tool wear [20]. Manufacturers can optimize the efficiency and effectiveness of machining processes by carefully selecting appropriate cooling and lubrication techniques.

Fig. 17: Drill bit [30]

Selection of appropriate cutting fluids is critical in machining operations. The use of solid lubricants and nano-fluids has been shown to be useful in reducing friction and heat in the cutting zone [14]. Advances in lubrication and cooling technology have resulted in increased productivity and better machining performance. Furthermore, the application of machine learning methods in predictive modeling has enabled manufacturers to improve their turning operations for sustainable manufacturing practices by considering different cooling and lubrication conditions [11]. Modern manufacturing processes are heavily dependent on cutting tools, machining equipment, and cooling and lubricating chemicals. Manufacturers can improve their operational efficiency, precision and quality by using intelligent cutting tools, sophisticated machining methods and advanced cooling and lubrication systems. Continuous progress and integration of the latest technologies in various fields are essential to promote progress and ensure long-term sustainability in the industrial sector.

Key findings and recommendations for future research and industry application are summarized below.

8 CONCLUSION

This review study examines the essential technologies and materials employed in manufacturing pipe walls. It also identifies the primary obstacles encountered in this process and proposes corresponding solutions. ASTM A350-LF2 Class 1 carbon steel is widely recognized as a crucial material for manufacturing pipe walls because of its exceptional mechanical qualities and ability to withstand low temperatures.

Particle separation processes, such as turning, milling, drilling, and grinding, are essential for achieving the correct dimensions and surface quality. Utilizing dedicated tools for each technique and implementing cooling and lubrication with substances like CASTROL HYSOL T15 have demonstrated a notable decrease in tool temperature and enhancement in processing quality.

Additional examination of sophisticated techniques such as floating plug drawing and micro-sized spiral tube hydroforming has revealed that these technologies enable the achievement of superior surface quality and precise dimensions. This is crucial in guaranteeing the structural integrity of the tube.

The significance of cutting tools, processing equipment, and coolants and lubricants in the manufacturing of pipe walls is well acknowledged. Nanoparticulate cooling and lubrication systems, among other advanced technologies, have demonstrated their efficacy in minimizing friction and heat during machining processes. This leads to enhanced productivity and prolonged tool lifespan.

Additional investigation is advised to focus on refining processing parameters and incorporating cutting-edge materials and technologies to attain higher levels of efficiency and production quality. It is important to prioritize the advancement of cooling and lubricating agents that are environmentally benign, as well as the utilization of artificial intelligence in predictive modeling and optimization of processes.

This serves as the foundation for future research and innovation in the pipe wall manufacturing business, with the objective of attaining enhanced performance, increased efficiency, and sustainable production methods.

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