National University of Science and Technology POLITEHNICA Bucharest

Doctoral School of Industrial Engineering and Robotics

DOCTORAL THESIS SUMMARY

MSc. Eng. Marian – Florentin F. GHENA

INNOVATION AND TECHNOLOGY TRANSFER METHODS FOR ACHIEVING COMPETITIVE ADVANTAGE IN THE POWER TOOL INDUSTRY

DOCTORAL COMMISSION

Prof. PhD. Eng. Nicolae IONESCU National University of Science and Technology POLITEHNICA Bucharest	Committee Chairman
Prof. PhD. Eng. Liviu – Daniel GHICULESCU National University of Science and Technology POLITEHNICA Bucharest	PhD Supervisor
Prof. PhD. Eng. Oana DODUN-DES_PERRIERES Gheorghe Asachi Technical University of Iași	Reviewer
Prof. PhD. Eng. Viorel PĂUNOIU Dunărea de Jos University of Galați	Reviewer
Prof. PhD. Eng. Eduard Laurențiu NIȚU National University of Science and Technology POLITEHNICA Bucharest, University Center of Pitești	Reviewer

BUCHAREST 2025

CUPRINS

INTRODUCTION

The power tool industry is a dynamic and innovative field at the intersection of advanced technology and the practical needs of users. It not only reflects technological progress but also drives it, constantly adapting to market demands and anticipating future trends. An analysis of this sector reveals profound transformations that define it, from the diversity of products to the influence of global factors and essential strategies such as sustainability and technology transfer.

The power tool market is highly diversified, varying by applications and geographic regions. In mature markets such as North America and Europe, innovation and quality are key priorities, and products are focused on performance and durability. In contrast, emerging markets in Asia-Pacific and Latin America are experiencing rapid growth, where diversification and affordability play central roles. These differences shape company strategies, which must tailor their products and marketing methods to the specific characteristics of each region.

Technology is a major driver in the transformation of power tools. One of the most significant developments has been the shift from corded to cordless tools powered by Li-Ion batteries, improving both mobility and performance. Moreover, the integration of smart technologies, such as IoT connectivity, advanced sensors, and real-time feedback functions, has transformed power tools from simple instruments into sophisticated devices capable of meeting the specific requirements of Industry 4.0. These advancements have increased efficiency, safety, and precision, redefining user experience.

Sustainability is becoming increasingly important in this sector. Companies are driven not only by stringent environmental regulations but also by the growing demand for eco-friendly products. Initiatives include the use of recyclable materials, energy-efficient consumption, and the adoption of less polluting manufacturing processes. Thus, sustainability is not just an obligation but also an opportunity to stand out in a competitive global market that is increasingly sensitive to environmental issues, aligning with the vision of Industry 5.0.

Global disruptive factors, such as the COVID-19 pandemic and the war between Ukraine and Russia, have significantly impacted the industry. Supply chains were disrupted, and market demand experienced major fluctuations. However, these crises accelerated certain trends, such as process digitalization and the rethinking of logistics strategies. BRICS countries were deeply affected by these events but demonstrated adaptability by investing in advanced technologies and diversifying supply sources.

Makita, Bosch, and DeWalt are established leaders in the power tool industry, each employing unique strategies to maintain competitiveness. A comparative analysis of these companies highlights strengths such as diverse product portfolios, consistent investment in research and development, and adaptation to local markets, including in Romania. However, these companies also face specific risks, such as market fluctuations and supply chain pressures, requiring them to continuously adjust their strategies.

Another crucial aspect is technology transfer, which facilitates the adoption of innovations and their introduction to the market. Project management methodologies such as Waterfall and Agile are analyzed and combined into a hybrid approach to meet the specific needs of the industry. This methodology ensures a balance between rigorous planning and flexibility, accelerating development processes and maximizing operational efficiency.

The process of developing innovative products is detailed through stages such as identifying user needs, conducting SWOT analysis, and market segmentation. Product design considers essential aspects such as ergonomics, durability, and recyclability.

CHAPTER 1. CONTEXT AND GENERAL STRUCTURE OF THE DOCTORAL THESIS

This chapter aims to provide a general overview of the doctoral thesis, highlighting the current context and emphasizing the importance and relevance of the proposed research topic. It also presents key contemporary topics that will be analyzed and developed throughout the work. The power tool industry is rapidly evolving under the influence of digital transformations, sustainability demands, and the growing need for innovation. The transition to Industry 5.0 introduces new challenges, such as the integration of emerging technologies, energy efficiency, connectivity, and supply chain resilience, issues accentuated by global events like the COVID-19 pandemic and geopolitical conflicts. Developing innovative methods for technology transfer and product development in the power tool industry ensures sustainable competitive advantage through the integration of advanced technologies, process optimization, and alignment with Industry 4.0 and 5.0 trends.

Specific Objectives (SO):

- **SO1:** Develop a hybrid project management model based on Agile and Waterfall methodologies, tailored to the power tool industry.
- **SO2:** Create an efficient technology transfer process between headquarters and subsidiaries to support innovation and global product implementation.
- **SO3:** Evaluate the organizational growth and crises of market leaders (Makita, Bosch, DeWalt) using the Greiner model and propose customized solutions for competitiveness.
- **SO4:** Analyze the impact of the COVID-19 pandemic and the Ukraine-Russia conflict on the power tool industry and develop adaptation strategies.
- **SO5:** Develop innovative products focused on ergonomics and safety in accordance with Industry 4.0 requirements.
- **SO6:** Integrate digital technologies and connectivity into power tools to enhance their performance and utility.
- **SO7:** Create renewable energy-powered solutions supporting the sustainability goals of the industry.

Specific Activities and Results Obtained:

Activities carried out for each objective and associated results

SO1: Development of a Hybrid Project Management Model

Activities performed:

- Comparative study of Agile and Waterfall methodologies.
- Analysis of performance indicators (efficiency, flexibility, costs) in projects within the power tool industry.
- Consultations with industry experts for model validation.

Results obtained:

- Proposal of a hybrid model combining Agile adaptability with the rigorous structure of Waterfall.
- Creation of a customized governance framework for implementing innovative projects.

SO2: Creation of an Efficient Technology Transfer Process

Activities performed:

- Identification of technology transfer flows between headquarters and subsidiaries.
- Analysis of constraints in current processes.

• Proposal of a transfer model based on bidirectional collaboration between headquarters and subsidiaries.

Results obtained:

• An optimized process enabling faster implementation of innovative products.
• Improved global collaboration efficiency within organizations.

SO3: Evaluation of Organizational Growth Using the Greiner Model
Activities performed:

• Analysis of case studies for Makita, Bosch, and DeWalt.
• Application of the Greiner model to anticipate organizational crises.

Results obtained:

• Customized recommendations for each analyzed company.
• Proposals to adapt organizational processes to the demands of Industry 5.0.

SO4: Analysis of Geopolitical and Pandemic Impacts on the Industry
Activities performed:

• Study of the pandemic's and geopolitical conflicts' effects on BRICS economies.
• Analysis of supply chain disruptions and changes in global demand.

Results obtained:

• Economic recovery strategies and adaptation plans for similar future crises.
• Identification of opportunities to diversify supply sources.

SO5: Development of Ergonomic and Safe Products
Activities performed:

• Market needs assessment through usage studies and user feedback.
• Use of the TRIZ method and customer matrix for identifying product features.

Results obtained (Development of concepts such as**):**

• Housing with an integrated support handle.
• Protection against flying debris.
• Optical sensor for monitoring thermal expansion.
• Solar-powered rechargeable battery.
• Smart storage case.
• User guidance device.

SO6: Integration of Digital Technologies
Activities performed:

• Development of an interface for monitoring operating parameters.
• Integration of wireless connectivity and mobile device control.

Results obtained:

• Smart power tools connected to digital platforms for monitoring and diagnostics.

SO7: Creation of Renewable Power Solutions
Activities performed:

• Research into solar batteries and sustainable materials.
• Development of a solar-powered rechargeable battery.

Results obtained:

• Functional solar-powered battery for power tools.

CHAPTER 2. ANALYSIS OF THE GLOBAL POWER TOOLS MARKET: APPLICATIONS, TYPES, AND TRENDS

Power tools are essential across diverse sectors such as civil construction, manufacturing, and material processing, significantly improving work processes and saving valuable time. Due to their versatility, these tools are indispensable in many industries.

2.1. The Global Power Tools Market by Applications, Types, Operating Modes, and Regions

The power tools market is experiencing continuous expansion, with a compound annual growth rate (CAGR) exceeding 6.4% between 2023 and 2032. This growth is driven by factors such as the demands of various industries and the rise of the "Do It Yourself" (DIY) phenomenon. Many consumers choose to undertake home improvement projects, leading to increased demand for high-performance and user-friendly power tools for interior and exterior renovations and the installation of new structures.

In 2021, a study by the Home Improvement Research Institute revealed that approximately 50% of DIY enthusiasts focused on outdoor home improvement projects. This trend underscores homeowners' desire to tackle more complex tasks, requiring higher-performance power tools. The growing demand for these tools is driving market expansion, encompassing both products for DIY enthusiasts and professional tools used in industry.

Market Segments

Industrial Segment representing nearly 72% of the market, this segment includes applications in industries such as automotive, construction, aerospace, and logistics. The growth of technological innovations and their integration into industrial processes supports this segment's expansion. Requirements for efficiency, precision, and safety continue to drive demand for high-performance power tools. **Residential Segment** is diven by the DIY phenomenon, more consumers are choosing to improve their homes using power tools. This trend increases demand for affordable, high-quality tools, enabling efficient and precise renovation and maintenance projects.

- **Product Types:** Saws are essential in construction, and their demand will continue to grow due to the expansion of the construction sector. Drilling machines are experiencing rapid growth due to their versatility in both industrial and residential applications.
- **Operating Modes:** The market is segmented into three types: electric tools, pneumatic tools, and others. Electric tools dominate the market with a 64.9% share. These tools are valued for their ease of use, durability, and affordability, with technological advancements improving performance, including more powerful batteries and cordless designs.
- **Geographic Regions:** North America leads the market with a 34.7% share. Infrastructure growth and industrial sector expansion contribute to the demand for power tools, while interest in DIY supports the residential market's development. The United States plays a key role in this growth due to its strong construction and manufacturing sectors.

2.2. Research and Development Trends

In the power tools sector, current trends are focused on significant improvements that include advanced technologies and sustainable solutions. Key development directions include:

- **Cordless Tools and Li-Ion Batteries:** These are crucial for enhancing the performance and durability of power tools. Advances in battery technology are being studied to improve their capacity and support use in various applications.

- **Smart Tools:** Equipped with Bluetooth connectivity and compatibility with smartphone applications, these tools are gaining popularity. Nanotechnology development is a key factor in this trend, enabling advanced functionalities such as real-time performance monitoring and settings adjustments via mobile apps.
- **Smart Storage and Transport:** Innovative storage solutions, such as smart boxes with remote location tracking and alarms for unauthorized movement or forced opening, enhance security and efficiency. Modular storage systems also provide flexibility in organizing and transporting tools.
- **Improvement of Existing Products:** Brushless motor technology brings significant improvements, such as reduced friction and longer service life. Manufacturers are investing in creating safer, lighter, and more comfortable tools with noticeable enhancements in ergonomics and maneuverability.
- **Nanotechnology:** Nanotechnologies are being used to improve the performance of power tools, from more efficient batteries to nanosensors monitoring critical parameters. These technologies enhance safety and efficiency, enabling sustainable use of power tools even in remote locations, supported by advanced photovoltaic panels.
- **The Gig Economy:** The growth of the gig sector is driving higher demand for high-performance power tools used by independent workers. Rental platforms are becoming an important option, providing access to professional equipment without high acquisition costs. Collaboration between power tool suppliers and digital platforms will support the needs of this evolving sector.

2.3. Conclusions from the Analysis of the Global Power Tools Market

The analysis of the power tools market and emerging trends concludes that this sector is undergoing continuous expansion, driven by the demands of diverse industries and the growth of the DIY phenomenon. The rapid market growth stems from the need for higher-performance power tools, both for professional users and DIY enthusiasts. This highlights an important trend: the versatility and accessibility of power tools are becoming essential as market demands diversify.

Technological innovations will continue to play a key role in this expansion, particularly through advancements in batteries, connectivity technologies, and sustainable solutions. In this context, smart products offering connectivity and real-time performance monitoring are increasingly appreciated. Additionally, the integration of green technologies, such as photovoltaic panels and more efficient batteries, underscores a growing focus on the sustainability and energy efficiency of power tools.

On the other hand, the rise of the gig economy will significantly influence market demands, driving increased demand for high-performance power tools and rental solutions. Consequently, the market will no longer be defined solely by direct equipment purchases but also by flexible and affordable access to quality tools through rental platforms.

CHAPTER 3. ANALYSIS OF THE DEVELOPMENT OF INDUSTRY LEADERS: MAKITA CO, ROBERT BOSCH GMBH, AND DEWALT LTD

Makita, Bosch, and DeWalt are three of the most prominent players in the power tools industry, each with a remarkable history, a clear vision, and a distinctive approach to development and innovation. These companies have managed to establish a strong presence in the global market through high-quality products tailored to a broad range of users—from construction and industrial professionals to DIY enthusiasts. In Romania, these brands have significantly impacted the local market, meeting the demands of Romanian consumers across various fields.

3.1. Makita: Continuous Innovation and Diversification

- **Company Origins and Vision:** Founded in 1915 in Anjo, Japan, Makita started as a motor repair workshop and quickly transitioned into power tool manufacturing. In the 1970s, the company revolutionized the industry by introducing the first cordless power tools, establishing its foothold in international markets. Makita's vision is to provide innovative, high-performance solutions that address the diverse needs of customers worldwide, with a strong focus on reliability and efficiency.
- **Product Portfolio and Market Strategies:** Makita offers a wide range of power tools, including drills, screwdrivers, grinders, cutting machines, and various accessories. The company is especially renowned for its rechargeable Li-Ion battery technology, which ensures extended autonomy and excellent durability. Makita's strategy focuses on maintaining a diverse product offering tailored to the specific requirements of global markets, serving both household users and professionals in construction, maintenance, and renovation industries.
- **Warranty and After-Sales Services:** Makita provides extended warranties for most of its products, instilling customer confidence in their durability. The company has an extensive network of authorized service centers, offering repairs and technical support. Additionally, Makita delivers efficient after-sales services and consultation to ensure optimal use of its products.
- **Impact of the Pandemic and Risk Factors:** Like many other companies, Makita faced challenges during the COVID-19 pandemic, including a temporary drop in demand in certain segments and disruptions to supply chains. The company had to adapt swiftly to market changes and rethink its distribution strategy. Additionally, currency exchange fluctuations and global political instability pose significant risks to its international operations.

3.2. Bosch: Advanced Technology and Sustainability

- **Company Origins and Vision:** Bosch was founded in 1886 in Germany by Robert Bosch as a precision mechanics workshop. Over the decades, the company has become a technology leader, developing innovative solutions for a wide range of industries. Bosch's vision emphasizes continuous innovation, sustainability, and creating products that meet market needs in an environmentally responsible manner.
- **Product Portfolio and Market Strategies:** Bosch offers a comprehensive range of power tools for both household and professional users. The company is renowned for integrating advanced technologies into its products, including NanoBlade for precise cutting and vibration reduction systems. Bosch's strategy focuses on continuous product diversification and a commitment to sustainability, offering solutions that reduce environmental impact and improve energy efficiency.
- **Warranty and After-Sales Services:** Bosch provides extended warranties for many of its products and stands out for its excellent after-sales services. These include a maintenance plan that

covers the replacement of worn parts under normal usage and an extensive network of service centers. Bosch is also appreciated for its rapid and efficient customer support.

- **Impact of the Pandemic and Risk Factors:** The pandemic affected Bosch, like other companies in the industry, through a temporary decline in demand and supply chain disruptions. However, Bosch maintained steady performance by quickly adapting to market requirements. Economic fluctuations and risks related to international trade policies remain significant challenges for the company, which it addresses through investments in digitization and the development of innovative, sustainable products.

3.3. DeWalt: Extreme Reliability and Solutions for Professionals

- **Company Origins and Vision:** DeWalt was founded in 1924 by Raymond DeWalt, who invented the first vertical woodworking machine. From the outset, the company focused on providing high-performance power tools specifically designed for professionals working in demanding fields like construction. DeWalt's vision is to create power tools that meet the highest standards, ensuring performance and durability in extreme conditions.
- **Product Portfolio and Market Strategies:** DeWalt stands out with its diverse portfolio of power tools for professionals, including drills, grinders, saws, and various accessories. The company is well-known for its robust tools designed to withstand tough working conditions, making it a preferred choice in industries like construction, manufacturing, and renovation. DeWalt prioritizes the development of tools that are reliable, easy to use, and deliver long-term performance.
- **Warranty and After-Sales Services:** DeWalt provides extended warranties for most of its products, giving customers confidence in their purchases. The company places a strong emphasis on after-sales services, ensuring users benefit from an extensive network of authorized service centers that offer quick and reliable technical solutions.
- **Impact of the Pandemic and Risk Factors:** DeWalt was also affected by the COVID-19 pandemic, as global economic activity slowed and supply chains were disrupted. Nevertheless, the company remained a leader in the field, supported by consistent demand from professionals relying on DeWalt tools for their projects. Risk factors for DeWalt include fluctuations in raw material prices, economic instability, and changes in global trade policies.

3.4. Conclusions on the Analysis of Industry Leaders in Power Tools

Makita, Bosch, and DeWalt have distinguished themselves through constant innovation and adaptability, becoming leaders in the power tools industry. In Romania, each of these brands has established a strong market position, meeting the diverse needs of consumers and professionals. Despite challenges such as the pandemic's impact and global economic risks, these companies continue to expand their presence and respond to the demands of a constantly evolving market.

Their commitment to innovation, sustainability, and customer satisfaction ensures a leading role in the power tools sector for the long term.

CHAPTER 4. CONTRIBUTIONS TO THE GOVERNANCE MODELS OF PROJECT MANAGEMENT METHODOLOGIES APPLIED IN THE POWER TOOLS INDUSTRY

The research in this chapter focuses on identifying and developing an innovative approach to project management in the power tools industry—a sector characterized by continuous change and increasingly diverse market demands. In such a context, adopting an effective project management methodology is essential to ensure the successful development and implementation of new technologies and products. The study combines theoretical analysis of traditional methodologies (Waterfall and Agile) with empirical research based on a survey of engineers in the power tools industry to gain a comprehensive view of how these approaches can be applied and optimized in practice.

4.1. Methodological Framework

The research is based on two main components: a detailed analysis of the specialized literature and a survey conducted among engineers working in the power tools industry. The literature review was essential for understanding the characteristics and applications of the Waterfall and Agile methodologies, as well as the advantages and disadvantages of each approach in project management. Academic papers, industry reports, and relevant case studies were analyzed to identify best practices and challenges in implementing these methodologies.

The survey was designed to complement the theoretical analysis with practical data. It involved 30 engineers from the power tools industry and was conducted in two stages to collect insights into their experiences with various project management methodologies, the challenges they encountered during implementation, and their preferences for adopting these approaches in their projects. The questionnaire included both open-ended and closed-ended questions to capture both quantitative and qualitative data, providing a complete picture of their views on project management methodologies.

4.2. The Waterfall Methodology and Its Applicability in the Power Tools Industry

The Waterfall methodology, a traditional approach to project management, is characterized by its sequential and well-defined structure, where each phase of the project is completed before moving to the next. This approach is particularly effective for projects with clear and stable requirements, where detailed planning and rigorous execution are essential. In the power tools industry, where products are often subject to strict safety and performance regulations, the Waterfall methodology offers stability and certainty at every stage of development. However, this methodology may become rigid when faced with unforeseen changes or rapid technological developments, posing significant limitations in meeting the ever-evolving market demands.

4.3. The Agile Methodology and Its Applicability in the Power Tools Industry

In contrast, the Agile methodology is characterized by flexibility, adaptability, and a focus on rapid delivery of value. Through short iterations and constant customer feedback, Agile enables quick adjustments to the project direction, which is crucial in a volatile environment such as the power tools industry. Considering the rapid pace of technological innovation and changing consumer demands, Agile can facilitate more dynamic project management. For instance, in the development of new power tool models, where technical features may evolve rapidly based on user feedback, Agile provides an appropriate framework for continuous product adaptation.

4.4. Proposal for a Hybrid Methodology

The main objective of this research is to propose a hybrid methodology that combines the best practices of Waterfall and Agile, tailored to the specific requirements of the power tools industry. In this hybrid model, each approach will be employed depending on the requirements and characteristics of each project stage. For example, Waterfall will be used in the initial planning stages, where clear requirements and a detailed structure are needed, while Agile will be applied during the development and testing stages, where flexibility and adaptability are critical to responding quickly to changing market and customer needs.

Stages of the Hybrid Methodology

The proposed hybrid methodology consists of the following stages (Fig. 4.1):

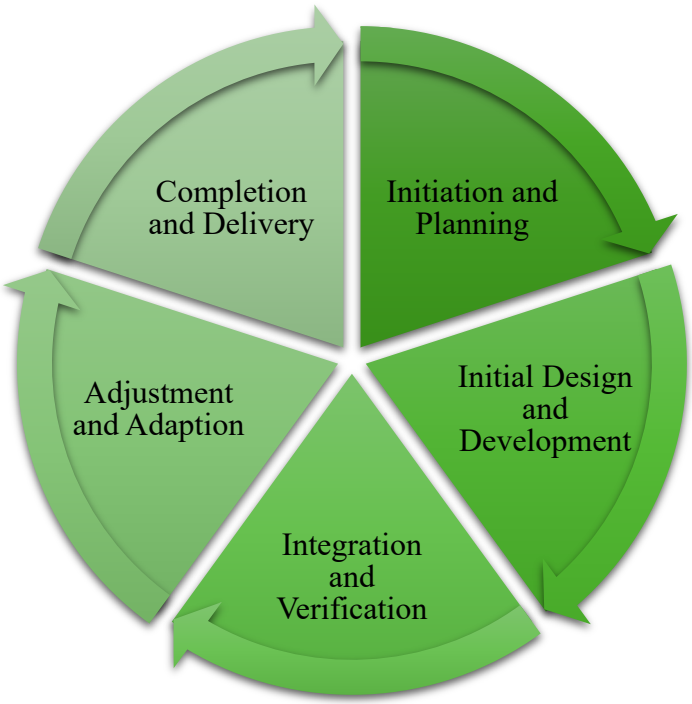


Fig. 4.1. Stages of the proposed hybrid Agile-Waterfall methodology.

Stage 1: Initiation and Planning

This initial phase establishes the foundation for the project. It involves defining requirements, objectives, and necessary resources in detail. The project team conducts a thorough analysis of all critical aspects, including risks, technical requirements, and applicable regulations, to ensure a solid foundation before proceeding to the next phase.

Stage 2: Initial Design and Development

In this stage, the project begins to take shape through a series of iterative cycles. Each cycle is dedicated to a specific activity or functionality and follows a structured framework that includes development, implementation, testing, and validation. Feedback obtained after each cycle is used to improve and refine subsequent project phases.

Stage 3: Integration and Verification

After completing each iteration, the results are integrated into a global system. This stage applies the rigorous principles of the Waterfall methodology, where validation and verification ensure that each developed component aligns with the project's overall requirements. Through phased integration and constant verification, progress is monitored, and the project stays on track.

Stage 4: Adjustment and Adaptation

One of Agile's most significant advantages is its ability to respond quickly to changes. In this phase, the project benefits from Agile's flexibility, enabling rapid adaptation to user feedback, changing requirements, or external factors. This adaptability ensures that the project evolves over time based on new needs and conditions.

Stage 5: Completion and Delivery

In the final stage, the product is prepared for delivery. However, the completion process is not limited to the final handover of the product. In a hybrid methodology, delivery may involve additional cycles of refinement and validation based on continuous feedback from stakeholders and users. This dynamic process ensures that the final product meets the users' requirements and expectations.

4.5. Benefits of the Hybrid Methodology

The hybrid approach offers several key advantages for the power tools industry:

- **Flexibility and Adaptability:** Combining the two approaches allows for rapid responses to market changes and customer requirements while maintaining stability in the project's early phases.
- **Maximizing Value:** The hybrid methodology enables the continuous delivery of value through the integration of constant feedback, leading to the development of products better suited to user needs.
- **Efficient Resource Coordination:** The hybrid model ensures more efficient allocation of resources, with detailed initial planning and rapid, flexible execution throughout the project.

4.6. Differentiating Waterfall and Agile Elements in the Hybrid Methodology

The hybrid methodology integrates elements of both Agile and Waterfall, combining Agile's flexibility and adaptability with Waterfall's structure and rigor (Fig. 4.2).

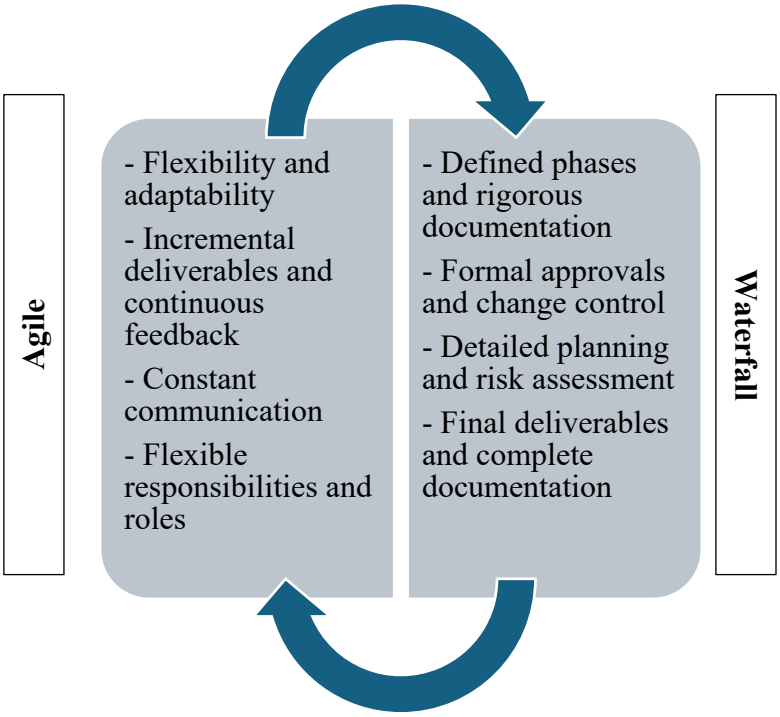


Fig. 4.2. Elements of the hybrid methodology.

Agile Elements:

• **Flexibility and Adaptability:** Allows for adjustments to plans as continuous feedback is obtained, ideal for iterating and refining concepts.

• **Incremental Deliverables and Continuous Feedback:** The project benefits from periodic validated and reviewed deliverables, ensuring rapid improvements.

• **Constant Communication:** Regular feedback sessions are essential for integrating decisions and adjustments into the development process.

• **Flexible Roles:** Teams are allowed to adapt their roles according to emerging project needs.

Waterfall Elements:

• **Defined Phases and Rigorous Documentation:** Project stages are clearly defined and follow a well-established sequence, with detailed documentation.

• **Formal Approvals and Change Control:** Changes are evaluated and approved strictly through formal flows, maintaining stability and control.

• **Detailed Planning and Risk Assessment:** Specific plans are created for each stage, including resource allocation, budget, and risk management.

By combining these elements, the hybrid methodology allows for balanced project management, with both flexibility and structured control, thus guaranteeing adaptability and transparency in the development process.

4.7. Limitations and Challenges of the Hybrid Approach

Despite its advantages, the hybrid approach is not without challenges. The main difficulties include governance complexity, the need for more detailed resource management, and the risk of administrative overload. Integrating Waterfall and Agile requires careful coordination and a clear process structure, which can add an extra layer of complexity. Additionally, resource challenges may arise, as this approach demands a larger team and greater commitment from project teams.

4.8. Conclusions on the Development of the Hybrid Methodology

In conclusion, the proposed hybrid methodology for project management in the power tools industry is a promising solution that combines the stability and structure of Waterfall with the flexibility and adaptability of Agile. This hybrid approach can address the specific challenges of the industry, ensuring efficient management of complex projects and a rapid response to changing market demands. Applying this methodology will enable companies in the field to innovate faster, optimize production processes, and deliver high-quality products that meet increasingly high customer expectations.

CHAPTER 5. ANALYSIS OF TECHNOLOGY TRANSFER METHODS USED IN THE POWER TOOLS INDUSTRY

Innovation is not merely the generation of a new idea but a decision-making process that begins with idea conception and concludes with its implementation. In the context of innovative product development, organizations focus on achieving a competitive advantage and employing appropriate methodologies to address the ever-changing market demands.

5.1. Identifying the Current Process for Developing Innovative Products

This section examines how the process of developing an innovative product unfolds within the headquarters and subsidiaries.

5.1.1. The Process of Developing an Innovative Product at Headquarters

The current stages of product development at headquarters are as follows:

- **Stage 1. Identifying Market Needs and Idea Development:** Collecting market needs and generating multiple ideas based on these inputs.
- **Stage 2. Initial Approval and Project Structuring:** Validating the idea and aligning it with strategic objectives.
- **Stage 3. Project Initiation:** Transferring knowledge and resources from headquarters to subsidiaries.
- **Stage 4. Planning and Design:** Transforming the concept into a tangible product through prototypes and tests.
- **Stage 5. Project Approval and Advancement:** Preparing local teams for mass production.
- **Stage 6. Implementation and Production:** Large-scale production and quality checks.
- **Stage 7. Launch and Monitoring:** Marketing campaigns, distribution, and analyzing product performance in the market.
- **Stage 8. Project Closure:** Official project completion and learning lessons for future initiatives.

5.1.2. The Product Development Process at Subsidiaries

The product development stages at subsidiaries are:

- **Stage 1. Idea Development:** Generating and selecting promising ideas based on feasibility and strategic alignment.
- **Stage 2. Research and Development:** Detailed design, prototyping, and testing.
- **Stage 3. Testing:** Verifying performance and regulatory compliance.
- **Stage 4. Launch:** Developing marketing strategies and coordinating sales.
- **Stage 5. Post-Launch:** Monitoring performance and making adjustments based on customer feedback.

5.2. Developing a New Process for Research, Development, and Implementation of an Innovative Product: From Headquarters to Subsidiaries

This section outlines the proposed process for researching, developing, and implementing an innovative product, starting with the headquarters and extending to regional subsidiaries.

5.2.1. Research and Development Process at Headquarters

The proposed stages for the research and development of an innovative product at headquarters include:

- **Stage 1. Market Research and Customer Needs Analysis:** Analyzing market trends such as battery technologies and eco-friendly tool demands.
- **Stage 2. Prioritizing Needs:** Aligning customer needs with the company's strategic goals.
- **Stage 3. Idea Generation and Selection:** Multidisciplinary teams collaborate to develop innovative solutions evaluated for technical feasibility and cost.
- **Stage 4. Basic Research:** Developing concepts, testing prototypes, and ensuring quality and performance.
- **Stage 5. Applied Research – Planning and Documentation:** Preparing development plans and preliminary technical documentation with input from various departments.
- **Stage 6. Applied Research – Design and Testing: Initial** design and experimental testing.
- **Stage 7. Applied Research – Model Validation:** Adjusting the experimental model and approval for the next phase.
- **Stage 8. Technological Development – Prototype Design and Testing:** Creating physical prototypes for detailed testing and enhancing technical and functional features.
- **Stage 9. Technological Development – Prototype Validation:** Confirming prototypes and preparing for technology transfer.
- **Stage 10. Technological Development – Technical Documentation:** Finalizing the complete technical documentation package and quality standards.

5.2.2. Implementation Process at Subsidiaries

Proposed implementation stages at subsidiaries include:

- **Stage 1. Creating and Transmitting Technical Documentation:** Detailed product documentation for manufacturing and testing.
- **Stage 2. Selecting and Contracting Suppliers:** Identifying essential component suppliers and negotiating contracts.
- **Stage 3. Manufacturing and Verifying Samples:** Producing initial samples, testing, and ensuring compliance.
- **Stage 4. Testing and Validating a Test Batch:** Producing and testing a batch under real-world conditions.
- **Stage 5. Final Validation and Serial Orders:** Making final adjustments, validating the product, and placing mass production orders.

5.2.3. Integration Between Headquarters and Subsidiaries: Critical Success Factors

Proposed integration stages include:

- **Stage 1. Interdepartmental Collaboration:** Ongoing communication between R&D teams at headquarters and subsidiaries with adjustments based on feedback.
- **Stage 2. Adapting to Local Specifics:** Leveraging local market expertise and real-world testing.
- **Stage 3. Continuous Process Monitoring:** Regular reviews, real-time feedback, and continuous improvement.

5.3. Developing a New Process for Research, Development, and Implementation of an Innovative Product: From Subsidiaries to Headquarters and Other Subsidiaries

This subchapter details the proposed process for researching, developing, and implementing an innovative product, starting from the initial conception in the organization's branch and extending to adoption and production in the headquarters and regional branches.

5.3.1. Research and Development Process at Subsidiaries

Proposed stages include:

- **Stage 1. Identifying Local Market Needs and User Feedback:** For instance, a subsidiary in an industrial region might observe increased demand for tools capable of withstanding harsh environments, such as high humidity or heavy dust.
- **Stage 2. Market Study and Defining Technical Requirements:** Research might reveal that users prefer lightweight tools with high performance.
- **Stage 3. Generating Ideas and Prototypes:** Development teams organize brainstorming sessions to create innovative ideas, such as a quick-change head screwdriver.
- **Stage 4. Designing and Testing Prototypes:** The chosen idea undergoes prototyping and field testing for performance, comfort, and safety.
- **Stage 5. Field Testing and Gathering User Feedback:** Prototypes are tested in real-world conditions.
- **Stage 6. Design Adjustments and Prototype Validation:** Design adjustments are made to meet feedback.

5.3.2. Technology Transfer to Headquarters and Final Product Validation

After validation at the subsidiary level, the process moves to headquarters for large-scale production:

- **Stage 1. Documenting and Standardizing Prototypes:** Comprehensive documentation, including technical specifications, performance test results, and manufacturing instructions.
- **Stage 2. Prototype Testing and Final Adjustments:** Headquarters conducts further tests to confirm performance under diverse conditions.
- **Stage 3. Pilot Production and Feedback:** A pilot batch is produced and evaluated by subsidiaries.
- **Stage 4. Global Production Implementation:** After the product has been validated and all necessary adjustments have been made, the headquarters will begin large-scale production of the electric screwdriver and distribute the product to all branches. Each branch will prepare production lines to integrate the product into the local portfolio.

5.3.3. Product Implementation in Other Subsidiaries and Continuous Monitoring

- After validation and production at the headquarters, the product is launched and implemented in other branches. It must be constantly monitored to ensure that it meets market requirements and to be able to make continuous improvements.
- **Stage 1. Dissemination of the product to the regional branches:** After the electric screwdriver has been launched in the main market, the headquarters will coordinate the implementation of the product in the regional branches, where it will be customized according to the requirements of the local market.

• **Stage 2. Ongoing support and training for branches:** The headquarters will organize training sessions for the sales teams and technicians in the branches, so that they understand all the functionalities and advantages of the electric screwdriver and can respond correctly to customer requests.

• **Stage 3. Collection and analysis of continuous feedback from the market:** After the product has been launched in the regional markets, the branch will continue to collect feedback on the performance of the screwdriver, any shortcomings of the product and improvement requirements. This information will be sent to the headquarters for a possible product update.

• **Stage 4. Product performance monitoring and continuous adjustments:** After the large-scale launch, product performance will be continuously monitored, including motor reliability, battery life, and user comfort feedback.

5.4. Benefits and Criteria of the New Development Process

Benefits and criteria of the new product development and implementation of innovative products:

• **Flexibility and Adaptability:** Quickly responding to market changes.

• **Continuous Innovation:** Promoting rapid introduction of new solutions.

• **Efficient Communication and Collaboration:** Streamlined information exchange across global teams.

• **Operational Efficiency:** Optimizing processes and reducing costs.

• **Customer-Centric Approach:** Delivering more relevant and personalized products.

5.5. Effects on the Power Tools Industry

Implementing an innovative process in product development and launch in the power tools industry brings significant improvements in internal operations and customer perception. The main effects include:

• **Rapid response to customer needs:** Identify emerging user needs and quickly adapt products. Reduce time to market by optimizing development processes.

• **Operational efficiency:** Automate and eliminate redundancies in production. Efficient use of resources and reduce unit costs.

• **Continuous innovation:** Generate innovative ideas and develop environmentally friendly and high-performance products. Strengthen market position by constantly improving products.

• **Effective communication and collaboration:** Quickly exchange information between teams to improve development processes. Increase team cohesion and stimulate creativity.

• **Customer orientation and product customization:** Customize power tools for different market segments, improving user experience and satisfaction.

• **Leverage results in subsidiaries:** Local testing and rapid implementation of products in regional markets for global expansion.

• **Clarity and Documentation:** Detailed documentation of the production process for efficient management and ensuring project continuity.

These effects contribute to the development of innovative, efficient and sustainable products, adapted to consumer needs.

5.6. Research Limitations

Research in the power tool industry has certain limitations, which include:

- **Limited Information Sources**: Variable quality and lack of access to confidential data.
- **Lack of Practical Testing:** The model has not been validated in real production environments.
- **Limited Generalization:** Results are specific to the power tools industry.
- **Methodological Constraints:** Subjectivity in interpretation and reliance on secondary sources.

5.7. Conclusions on Developing a New Research and Development Process

In a constantly changing economic environment, the power tools industry requires a product development model that overcomes the limitations of traditional processes, often rigid and inefficient in the face of market dynamics. This study proposes an innovative model, oriented towards agility and adaptability, capable of responding to both global challenges and local consumer needs. This model directly addresses key industry problems, such as delays caused by operational redundancies, lack of effective communication between headquarters and subsidiaries, and the absence of a clear orientation towards continuous innovation. Integrating consumer requirements from the initial stages of product development allows the creation of solutions that faithfully reflect market expectations, reducing the risk of producing non-adapted goods. Also, by promoting efficient connectivity between headquarters and subsidiaries, information and resource flows are optimized, which facilitates the uniform and rapid implementation of new products in global markets. The proposed model encourages the elimination of redundancies and the optimization of internal processes, reducing the time to develop and launch products without compromising their quality. At the same time, the emphasis on continuous innovation and the integration of emerging technologies – from digital solutions to sustainable materials – contributes to increasing long-term competitiveness. This approach offers companies in the power tools industry the advantage of rapid reaction to market changes, increased operational efficiency and a closer relationship with consumers, thus strengthening their position in an increasingly competitive market.

CHAPTER 6. EVALUATION OF THE CURRENT GROWTH STAGE AND ANTICIPATION OF POTENTIAL CRISIS FROM MAKITA CO, ROBERT BOSCH GMBH AND DEWALT LTD

The updated Greiner method represents a modernized version of the organizational growth model initially proposed by Larry E. Greiner in 1972. The update adapts the model to contemporary requirements such as digitalization, globalization, and the dynamics of today's markets, including the transition toward Industry 4.0 and the anticipated Industry 5.0. The classic model, which identifies five key phases of growth (creativity, direction, delegation, coordination, and collaboration), is streamlined and applied practically to assess current stages and anticipate organizational challenges.

6.1. Preliminary Characterization According to the Classic Greiner Model

The classic Greiner model was applied to leaders in the power tools sector: Makita, Bosch, and DeWalt.

(1) Makita Company Characterization

- **Development through Creativity:** Founded in 1915, Makita began in electrical repairs. Its first major evolution occurred with the launch of portable power tools, laying the foundation for future innovations.
- **Development through Direction:** Increasing global demand led to the adoption of centralized management, particularly for product standardization.
- **Development through Delegation:** International subsidiaries were empowered to make local decisions, better adapting to regional markets.
- **Development through Coordination:** The company developed global distribution networks and modern logistics centers to streamline operational flows.
- **Development through Collaboration:** Partnerships with suppliers and research collaborations have enabled the launch of technologies such as LXT batteries.

(2) Bosch Company Characterization

- **Development through Creativity:** Founded in 1886, Bosch quickly gained prominence with innovative technical solutions, delivering products that combined efficiency and durability.
- **Development through Direction:** Rapid growth necessitated a strong managerial system capable of coordinating its various industrial divisions.
- **Development through Delegation:** Regional divisions were granted operational autonomy, particularly for adapting to markets in Asia and Latin America.
- **Development through Coordination:** Major investments in digitalization and automation have improved processes.
- **Development through Collaboration:** Bosch has built an ecosystem of partnerships focused on sustainability and smart technologies.

(3) DeWalt Company Characterization

Development through Creativity: Founded in 1923, DeWalt made its mark with the invention of the radial arm saw. A focus on innovation has continued over the decades.

- **Development through Direction:** As part of Stanley Black & Decker, DeWalt has benefited from a robust brand management strategy.
- **Development through Delegation:** The company has diversified its portfolio, granting increased autonomy to divisions dedicated to power tools and batteries.
- **Development through Coordination:** A global supply chain has been developed, catering to local and international market demands.

• **Development through Collaboration:** DeWalt collaborates with customers to develop customized products, such as the XR FlexVolt series.

6.2. Characterization Based on the Updated Greiner Model

The Greiner model has been adapted and expanded to include seven stages and seven crises, reflecting the specifics of current global economic development, influenced by the fourth industrial revolution (Industry 4.0) and the vision of Industry 5.0. Starting from the original version of the model, which included six stages and six crises, the adaptation integrates characteristics of the modern era and introduces an additional stage, along with a new potential crisis.

(1) Current Characterization of Makita

An analysis of the organizational development questionnaire indicates that Makita is not fully adapted to Industry 4.0 requirements. The crisis related to integrating 4.0 technologies can be addressed by adopting a strategy focused on transitioning toward Industry 5.0. This involves a stronger emphasis on cobots, sustainable development principles, and strict regulation of artificial intelligence use.

(2) Current Characterization of Bosch

Bosch shows solid adaptation to Industry 4.0 requirements. The managerial strategy is oriented toward a gradual and planned transition to Industry 5.0, emphasizing the integration of advanced technologies and sustainability in line with future development objectives.

(3) Current Characterization of DeWalt

DeWalt is in an intermediate stage, with partial adaptation to Industry 4.0. The transition to Industry 5.0 presents a strategic opportunity to overcome these challenges. The company's priorities should include implementing cobots, promoting a sustainable business model, and applying strict regulations for the responsible use of artificial intelligence.

6.3. Conclusions and Solutions Derived from Applying the Updated Greiner Model

Following the analysis of the organizational development of Makita, Bosch, and DeWalt, specific strengths, challenges, and solutions have been identified for each company:

Makita has demonstrated remarkable adaptability to market changes and customer demands, successfully navigating growth stages. However, it faces challenges related to autonomy and internal bureaucracy. Proposed solutions include developing leaders at lower levels, delegating responsibilities, and reassessing the organizational structure to reduce bureaucracy. In terms of development stages, Makita is progressing in delegation and collaboration but needs improvements in coordination and innovation.

Bosch has successfully solidified its market position through innovation and global expansion, overcoming internal growth crises. However, improvements are needed in leadership management and internal coordination. Solutions for Bosch include enhancing communication across organizational levels, developing leaders at lower levels, implementing a performance-based evaluation system, and exploring global expansion opportunities. Bosch is at an advanced stage of development in collaboration and alliances but requires strengthening in leadership and coordination.

DeWalt is in a transitional period, partially adapted to Industry 4.0. The company faces a crisis of control and a need for greater autonomy in leadership. Proposed solutions include expanding the distribution network, investing in innovation and adaptability, collaborating with local partners, and developing local talent. In terms of development stages, DeWalt is progressing in delegation and collaboration but requires improvements in coordination and leadership autonomy.

CHAPTER 7: GLOBAL SOCIO-ECONOMIC CONTEXT - THE IMPACT OF THE COVID-19 PANDEMIC AND THE UKRAINE-RUSSIA WAR ON THE POWER TOOLS INDUSTRY AND THE BRICS COUNTRIES

In 2001, Jim O'Neill, an economist at Goldman Sachs, introduced the term "BRIC" to refer to four emerging economies with significant economic potential: Brazil, Russia, India, and China. These countries were chosen based on factors such as population size, natural resources, and involvement in globalization, suggesting rapid growth and an increasing influence on the global economy.

7.1. Presence and Use of Power Tools in BRICS Countries

This chapter discusses the production and sales subsidiaries of power tool leaders and their usage in each of these countries.

Use of Power Tools in BRICS Countries:

- **Brazil:** Power tools are used in construction, agriculture, and woodworking. Bosch and Makita are significant suppliers in the market.
- **Russia:** In Russia, power tools are essential in construction, the automotive industry, and mining, especially due to extreme climatic conditions.
- **India:** Urban expansion and interest in DIY projects are increasing the demand for power tools. Makita is used in infrastructure projects and small workshops.
- **China:** The use of power tools is influenced by rapid industrialization and infrastructure development. Makita tools are used in construction, furniture manufacturing, and industrial automation.
- **South Africa:** Power tools are used in mining, construction, and agriculture, with high demand for high-performance products.

Presence of Major Brands in BRICS:

- **Makita:** Has a significant presence in all BRICS countries, adapting to local requirements, from large construction projects to agriculture and small workshops.
- **Bosch:** Operates in BRICS with extensive production and distribution facilities. In India, for example, Bosch offers power tools for infrastructure and DIY, while in China, it focuses on advanced technologies for power tools.
- **DeWalt:** Popular in construction and agriculture sectors, DeWalt tailors its products to the local conditions in BRICS countries, including in mining sectors in South Africa and Brazil. However, its activities in Russia have been reduced due to economic sanctions.

Overall, the use and demand for power tools in BRICS countries are influenced by infrastructure development, increasing urbanization, and interest in DIY projects and home improvement. Brands such as Makita, Bosch, and DeWalt have adapted their strategies to meet this diverse demand in these regions.

7.2. The Impact of the COVID-19 Pandemic on BRICS Activities

The BRICS countries (Brazil, Russia, India, China, and South Africa) have become major players in the global economy, but the COVID-19 pandemic had a significant impact on them, affecting their economies and healthcare systems. The proposed study analyzes how each BRICS country managed the pandemic, considering socio-economic, demographic, and political factors such as population density, urbanization, economic development, access to healthcare, and education. A comparative analysis of pandemic responses can provide recommendations for future economic and health policies.

- **Brazil** was heavily affected by the rapid spread of the virus, especially due to international travel, and the poor management of the crisis will leave lasting marks on its economy and society.
- **Russia** adopted proactive measures, including restricting the entry of foreign citizens and imposing a national state of emergency. Russia also cooperated with other BRICS countries to share experiences and resources in fighting the pandemic.
- **India** imposed a strict national lockdown but faced severe economic consequences, particularly for migrant workers and the informal sector. The isolation measures heavily affected sectors like agriculture and construction.
- **China** led in pandemic management by adopting swift and effective measures to control the virus's spread. China supported international cooperation and promoted vaccines as a global public good, facilitating access to treatments and vaccines for all.
- **South Africa** imposed strict measures, including quarantine and travel restrictions, to prevent the virus's spread. The economy was severely impacted, with job losses and the closure of economic sectors having a significant impact on society.

Overall, cooperation between BRICS countries was essential for managing the pandemic. China and Russia managed the impact on production better, while Brazil, India, and South Africa faced significant economic challenges. These experiences can contribute to the development of more effective international policies for managing future crises.

7.3. Post-COVID-19 Situation in BRICS Countries

Post-pandemic recovery within BRICS has been a key topic for global economic and social recovery. The COVID-19 pandemic had a significant impact on public health and the economies of BRICS countries, with each state adopting its own measures for managing the crisis and post-pandemic recovery. This analysis focuses on how the emerging economies of BRICS handled the post-COVID-19 economic, social, and political challenges.

- **Brazil** was strongly affected, with an economic recession and enormous pressure on the healthcare system. The government was criticized for its crisis management, and economic recovery is a difficult process despite vaccination campaigns.
- **Russia** suffered due to the decline in global demand for energy and low prices for natural resources. The government implemented strict restrictions and vaccination campaigns, but the healthcare system was under pressure. However, Russia continues to face economic and social challenges.
- **India** experienced a considerable economic downturn due to lockdowns and strict measures. The healthcare system was overwhelmed, and the government implemented virus containment measures and accelerated vaccination. Economic recovery is difficult due to job losses and limited healthcare infrastructure.
- **China** had a rapid recovery, implementing strict virus control measures and economic stimuli to support the economy. The vaccination campaign was successful, and the economy began to focus on stimulating growth through investments in technology and innovation.
- **South Africa** was profoundly affected by the pandemic, with a significant impact on the economy and social inequalities. Economic recovery has been gradual, and the government has implemented measures to support businesses and improve the healthcare system. However, it remains vulnerable to epidemiological risks.

Each BRICS country faces significant challenges in the recovery process, and tailored measures are needed to support economic development and public health protection.

7.4. Impact of the COVID-19 Pandemic on the Power Tools Industry

The COVID-19 pandemic had a significant impact on the power tools industry, causing important changes in supply chain operations and management. The construction and renovation sectors, which are the main consumers of power tools, were affected by economic restrictions, leading to a decline in demand and supply difficulties. In this context, manufacturers had to reorganize production, adopt online distribution strategies, and diversify export markets, including through localized production.

As demand returns in key sectors (construction and automotive industry), an increase in the demand for power tools is expected. Manufacturers are adapting by adjusting product portfolios, technological innovation, and investment in new technologies. Adaptability and flexibility remain essential for success in this dynamic and uncertain economic environment.

7.5. Post-COVID-19 Situation in the Power Tools Industry

The COVID-19 pandemic significantly impacted the power tools industry, initially causing a decline in demand due to restrictions and economic uncertainty. Construction projects and the automotive industry were affected, and manufacturers had to reorganize production and adjust sales strategies, focusing more on online channels and safety measures.

As economies began to reopen, demand increased, driven by the recovery of postponed projects. Adaptability and innovation became essential for maintaining competitiveness. A significant trend was the localization of production and components, reducing dependence on global supply chains and stimulating local industry development.

In conclusion, the power tools industry has recovered, and adaptation and innovation continue to be key factors for its evolution in a post-pandemic economic environment. Localization of production and strengthening the local industry represent opportunities for economic growth and sustainable development.

7.6. Impact of the Ukraine-Russia War on BRICS Activities

At the 2022 BRICS summit, discussions focused on the impact of the war in Ukraine and the need for peaceful and sustainable solutions. BRICS countries emphasized respect for sovereignty and territorial integrity and promoted dialogue and diplomatic cooperation between Russia and Ukraine to resolve the conflict.

Following Russia's invasion of Ukraine, the relationship between BRICS and Russia changed, reflecting a complex dynamic. Member countries, such as India and China, expressed humanitarian concerns and sought diplomatic solutions, while Brazil adopted a neutral stance. The impact of sanctions imposed on Russia forced BRICS to find ways to maintain economic relations with Russia, including through transactions in local currencies or other financial solutions.

The war had long-term geopolitical and economic implications, disrupting trade and financial markets. BRICS is seeking alternatives to adapt to the new conditions and protect economic interests. Russia, within BRICS, aims to strengthen its status as a great power and counter Western influence.

In conclusion, relations between BRICS and Russia are influenced by the geopolitical context and international sanctions. Continued collaboration within BRICS is essential for the group's stability, and adapting to the geopolitical and economic changes generated by the war in Ukraine will be crucial for its future.

7.7. Analysis of the Impact of the Ukraine War on the Power Tools Industry

The war in Ukraine has had a significant impact on the power tools industry, disrupting the supply chain, production, and distribution.

- **Supply Chain Disruptions:** Many companies in the power tools industry relied on raw materials from the war-affected region, such as metals and other essential materials. Difficulties in accessing these resources led to price increases and production delays.
- **Transport Issues:** Companies used transport routes passing through the affected region or relied on local infrastructure, and disruptions led to additional costs and difficulties in delivering products.
- **Impact of Sanctions and Restrictions:** International sanctions, particularly those imposed by the European Union on Russia, affected companies that had trade relations with this country, generating uncertainty and the need to revise commercial relationships. This led to adjustments in supply chains and diversification of raw material sources.

Overall, the war highlighted the vulnerability of supply chains and underscored the need for the power tools industry to adapt quickly to geopolitical and economic changes.

7.8. Conclusions from the Global Economic-Social Analysis - The Impact of the COVID-19 Pandemic and the Ukraine-Russia War on the Power Tools Industry and the BRICS Countries

The war in Ukraine has brought major challenges to the power tools industry, affecting supply chains, transportation, and trade relations. The main impacts include:

- **Supply chain disruptions:** Many companies in the power tools industry depended on raw materials from the war-torn area, which led to price increases and access difficulties. The conflicts have destabilized supply chains and increased production costs.
- **Transportation:** Road disruptions and changes in transportation infrastructure have forced companies to find alternative routes and incur additional transportation costs.
- **Sanctions and trade restrictions:** Sanctions imposed on Russia have affected trade relations and imposed legislative changes that have prompted companies to adapt their export and import strategies.
- **Strategic adjustments and reassessments:** Companies have diversified their supply sources and invested in innovative technologies to increase their resilience and efficiency in the face of geopolitical and economic changes.
- **Collaboration and stabilization:** Collaboration between the private sector and government authorities is essential for stabilizing markets and managing crises. International organizations play an important role in global coordination.

These challenges highlight the need for rapid adaptation and increased resilience in the industry to cope with geopolitical uncertainty.

CHAPTER 8. THE DEVELOPMENT PROCESS OF INNOVATIVE PRODUCTS IN THE POWER TOOLS INDUSTRY

In this chapter was performed an internal and external analysis of the leaders in the power tools industry, analyze product positioning based on customer needs, conduct conceptual design, apply creativity and quality improvement methods, determine ergonomic conditions, establish basic materials and heat treatments, set durability and recycling conditions, and finally undertake the detailed design of innovative products.

8.1. Internal and External Analysis of Leaders in the Power Tools Industry

An internal and external analysis of the leaders in the power tools industry was conducted:

(1) Makita Co.

- **Strengths:** Product diversification, extensive distribution network.
- **Weaknesses:** Limited presence in North American and European markets, reliance on cordless tools.
- **Opportunities:** Demand for eco-friendly tools, expansion in North America and Europe.
- **Threats:** Intense competition, rapid technological advancements potentially rendering products obsolete.
- **Recommended strategies:** Geographical market diversification, innovation in eco-friendly products, enhancing customer loyalty, and improving the supply chain.

(2) Bosch GmbH.

- **Strengths:** Product diversification, strong presence in North America and Europe.
- **Weaknesses:** Limited presence in Asia, dependence on automotive and industrial divisions.
- **Opportunities:** Growing demand for eco-friendly tools, expansion into the Asian market.
- **Threats:** Strong competition, technological advancements potentially rendering products obsolete, global economic uncertainty.
- **Recommended strategies:** Expansion in emerging markets, accelerating innovation, and strengthening logistics chains.

(3) DeWalt Ltd.

- **Strengths:** High-quality power tools, strong brand image.
- **Weaknesses:** Premium positioning, higher prices.
- **Opportunities:** Expanding the product portfolio, new eco-friendly solutions.
- **Threats:** Competition, rapid technological changes, price sensitivity.
- **Recommended strategies:** Expansion into emerging markets, development of innovative and eco-friendly products, and strengthening customer relationships.

All three companies are in a "speculative situation" where strengths are counterbalanced by external threats. Recommended strategies include market diversification, accelerating innovation, and improving supply chains to remain competitive. All must also address technological and competitive challenges through constant adaptation and innovation.

8.2. Product Positioning Analysis Based on Customer Needs

The customer matrix is a strategic analysis tool that helps companies understand the positioning of their products in relation to customer needs and preferences by evaluating them on two axes: satisfaction and importance of features. For a drill, the analysis follows several steps:

- **Identifying customer needs:** Focus on factors such as performance, speed, ergonomics, extended functionality, and price.
- **Identifying quality features:** Selected features include battery voltage, maximum torque, rotations per minute, chuck capacity, weight, percussion function, battery autonomy, and price.
- **Weight assignment:** Each feature is assigned a weight based on its importance to the user.
- **VUP evaluation:** Products (Makita, Bosch, DeWalt, Parkside) are assessed based on the selected features.
- **Determining positions in the matrix:** Final scores for each product are calculated and positioned in the matrix based on price and performance.
- **Formulating the strategy:** Each brand must adjust its strategy to improve performance, reduce costs, or enhance functionalities depending on identified strengths and weaknesses.

Examples of strategies:

- **Makita:** Improving weight and battery autonomy.
- **Bosch:** Enhancing maximum torque and performance.
- **DeWalt:** Increasing battery autonomy and improving the percussion function.
- **Parkside:** Improving torque, rotations per minute, and battery autonomy.

8.3. Conceptual Design

The conceptual design process for a drill with a built-in handle began with a detailed analysis of customer needs and preferences, which allowed the identification of essential and differentiating product requirements. These requirements were ranked based on their importance, and the results were structured in a priority matrix.

Among the essential requirements were safety, compact dimensions and shock resistance, while differentiating requirements included multifunctionality and aesthetic appearance. The design integrated innovative solutions for safety and comfort, such as an anti-slip handle and balanced weight distribution.

Three power tool variants were proposed: one ergonomic, one with a built-in handle for better grip and one with drill bit protection to prevent accidents. Each variant was evaluated according to performance, safety and usability, and the choice of the optimal product was made through a decision matrix, comparing the available options based on the established criteria.

Thus, the development process focused on improving the user experience, safety in use and performance of power tools, aiming for a product that is attractive and efficient on the market.

8.4. Application of Creativity and Quality Improvement Methods

Several methods of creativity and quality improvement were applied to the developed products:

(1) TRIZ Method: It is a problem-solving system that aims to identify contradictions and find innovative solutions. In the example of a drill press, TRIZ helped to:

- Define ergonomic and performance problems.
- Analyze key components (motor, handle, trigger, chuck).
- Identify contradictions between parameters such as power and weight.
- Propose solutions, such as an adjustable handle and advanced materials to reduce vibration and weight.

(2) Nine-Screen Method: This provided a holistic approach to the evolution of the drill press, analyzing both the present, past and future of the product. Important areas for improvement were identified, such as reducing vibration and improving ergonomics.

(3) Quality Framework Method (QFD): It was used to translate user requirements into precise technical specifications, which led to improvements in safety, comfort and performance. Priorities included safety through non-slip materials, high performance through a powerful motor, and comfort through ergonomic design.

(4) Kansei Engineering Method: Helped integrate user emotions into the design process. For example, to improve perceptions of safety, comfort, and enjoyment, an ergonomic handle, adaptable performance, and an attractive aesthetic were integrated.

(5) Benchmarking: Compares existing products on the market, highlighting models, such as the DeWalt DWE492DUO2-QS, that were appreciated for their handle ergonomics and high performance, indicating directions for future improvements to the drill.

In conclusion, these methods helped identify and resolve contradictions and develop a more ergonomic, high-performance, and enjoyable product for end users.

8.5. Ergonomic Conditions

To ensure comfortable and efficient use of power tools, the following ergonomic conditions must be observed:

- **Improved ergonomics:** Handles should be comfortable and allow a natural grip, reducing strain on the hands. The handle should adapt to various hand sizes and minimize repetitive pressures.
- **Optimal weight distribution:** The weight of the tool should be distributed evenly to prevent fatigue and improve maneuverability.
- **Vibration damping:** Materials and technologies that reduce vibration are essential for preventing Hand-Arm Vibration Syndrome (HAVS).
- **Noise reduction measures:** Modern technologies and sound-absorbing materials protect the user's hearing and reduce environmental stress.
- **Dust management system:** Collection systems and filters that protect the user's health and prevent pollution of the working environment.
- **Smart functionality:** Technologies such as automatic speed control and LED lighting improve accuracy and user comfort.

8.6. Material and Heat Treatment Selection

For performance and durability, the choice of materials and heat treatments is essential.

- **Recommended materials:** Cast iron (reduces vibration), steel (strength and durability), and carbide (wear resistance and hardness).
- **Heat treatments:** Processes such as annealing, normalizing, quenching and tempering improve the strength and durability of materials.
- **Specialized coatings:** Layers such as titanium nitride or titanium carbonitride improve performance by reducing wear and friction.
- **Consulting specialists:** Collaboration with experts in the field ensures the selection of the best materials and treatments.

By choosing the right materials and heat processes, drills can achieve superior performance, reducing maintenance costs and improving the accuracy of operations.

8.7. Durability and Recycling Conditions

Regarding the implementation of sustainability concepts in the power tool industry in the context of Industry 4.0, there are a number of criteria and measures that products can meet to be considered sustainable and to promote recycling.

• **Easy disassembly and repairability:** Modular design and ease of disassembly allow for repair and replacement of parts, extending the product's lifespan.

• **Use of recycled materials:** Incorporating recycled materials reduces dependence on new resources and environmental impact.

• **Energy efficiency:** Designing tools that reduce energy consumption, including through the use of efficient motors.

• **Return and recycling programs:** Creating programs through which users can return old tools, facilitating recycling and responsible disposal.

In order to implement an effective recycling program, four steps are recommended: research and planning, collection, partnerships with recycling centers, and customer education. In addition, recycling is done by material categories, such as plastic, metals, batteries and circuit boards.

Green materials and innovative technologies are essential for protecting the environment, such as the use of biodegradable or recycled plastic, renewable materials (bamboo, wood) and low-toxicity materials. Also, sustainable energy sources, such as lithium-ion batteries, fuel cells and corded tools, are green solutions that reduce pollution.

These measures contribute to a lower environmental impact and the sustainable development of the power tool industry.

8.8.1. Housing with built-in support handle

In the design process of power tools, an essential element was the integration of a support handle directly into the tool housing, with user safety and ergonomics as the main objectives. The aim of this solution was to improve the user experience, reduce fatigue during prolonged use and increase the level of control over the power tool.

The handle integrated into the power tool housing, shown in Fig. 8.1, is the result of a design process focused on user needs and brings numerous benefits that influence the performance and safety of the device:

• **User safety:** The handle ensures a firm and stable grip, significantly reducing the risk of the user's hand slipping or losing control of the power tool. This is a crucial feature especially in industrial or DIY applications, where applied forces and rapid movements can create additional risks.

• **Increased comfort:** The ergonomic design of the handle contributes to the even distribution of the weight of the device, thus reducing user fatigue during prolonged use. This is an important factor, especially for professionals who use these tools for extended periods.

• **Improved balance:** The integration of the handle into the structure of the tool helps to better balance the device, facilitating its maneuverability and control. A correct weight distribution allows the user to maneuver the tool with ease and precision, even in complex applications.

• **Reduced risk of injury:** The careful design of the handle contributes to minimizing uncontrolled movements and ensuring increased stability during operation, which significantly reduces the risk of accidents or injuries.

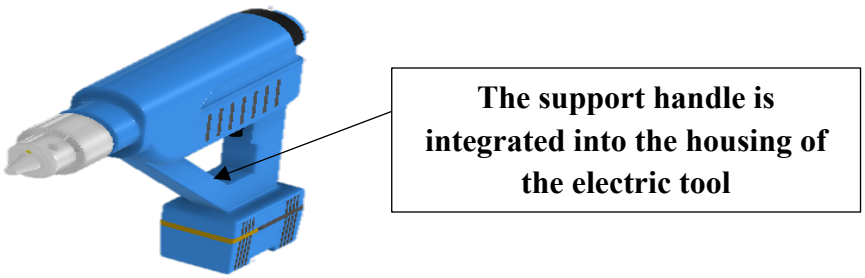


Fig. 8.1. Power tool with support handle built into the housing.

In Fig. 8.2 the overall dimensions of the innovative product and the support handle are presented.

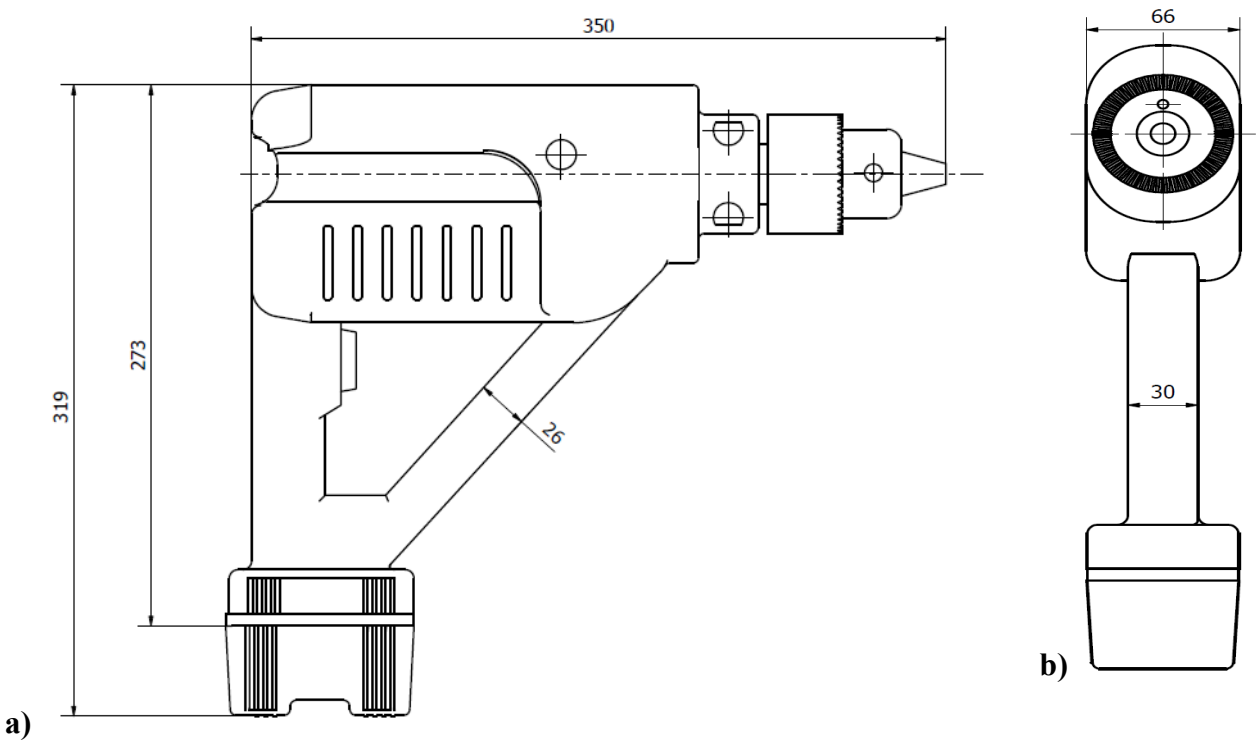


Fig. 8.2. Overall dimensions of the designed product.

8.8.2. Protection against ricocheting of particles released during operation

The drill guard system is designed to ensure a high level of safety during the use of power tools, preventing accidents and reducing the risks associated with their handling. The mechanism includes an assembly consisting of two tubes interconnected by a bushing, each having a specific function in protecting the user and the device.

The components of the guard system are shown in Fig. 8.3:

(1) First tube (fixed guard)

• It is a static element, integrated into the body of the power tool.

• It provides support and stability to the entire guard system.

• It serves as a guide for the second tube, facilitating its movement in a controlled manner.

(2) Second tube (movable guard)

• It is mounted at the end of the drill and can move horizontally towards the body of the power tool.

• Its movement is activated by pressure applied during operation, such as the contact of the drill with the work material.

• Acts as a dynamic barrier against particles and unforeseen forces.

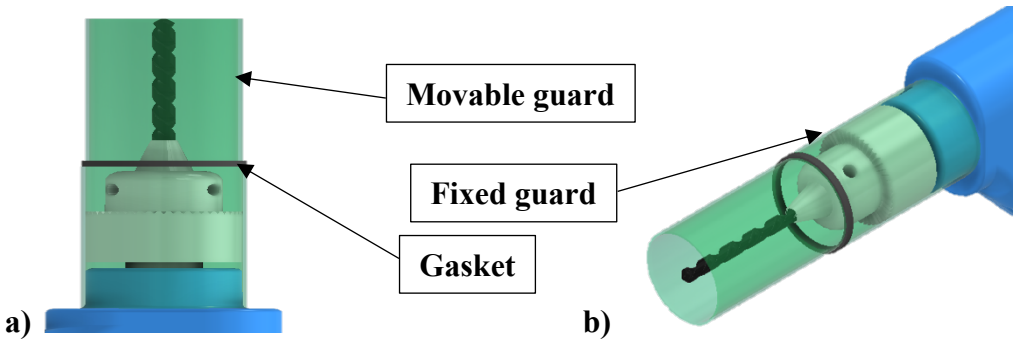


Fig. 8.3. Protection against ricocheting of particles released during operation.

The dimensions of the protection against ricocheting of particles released during operation are shown in Fig. 8.4.

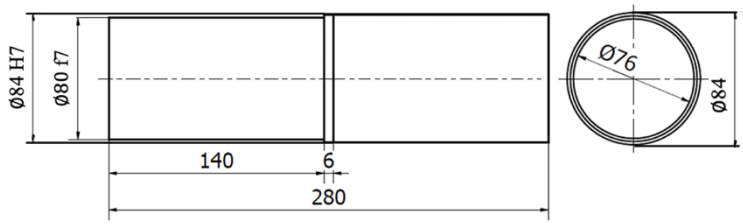


Fig. 8.4. Overall dimensions of the designed product.

8.8.3. Optical sensor for thermal expansion monitoring

A housing that integrates an optical fiber has been designed to monitor thermal expansion during operation (Fig. 8.5). This technological solution represents a significant advance in the field of electric motors, allowing for precise temperature monitoring in real time. The optical fiber is incorporated into the structure of the housing and the motor, being connected to a specialized transmitter. The temperature data collected by the optical fiber is transmitted to the transmitter, which uses Bluetooth technology to send the information directly to the user's smartphone. This wireless connection facilitates quick and convenient access to the monitoring data, giving the user the possibility to assess the thermal state of the motor during operation. The use of optical fiber technology and Bluetooth connection in this brushless motor brings multiple benefits, as thermal expansion monitoring allows the user to obtain a clear view of the motor's performance and to identify any anomalies or thermal overloads.

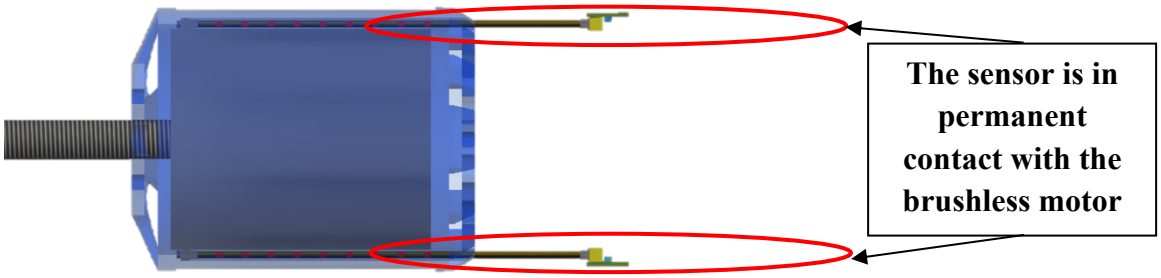


Fig. 8.5. Brushless motor with built-in optical fiber.

The optical fiber is embedded in the engine structure and is connected to a specialized transmitter (Fig. 8.6).

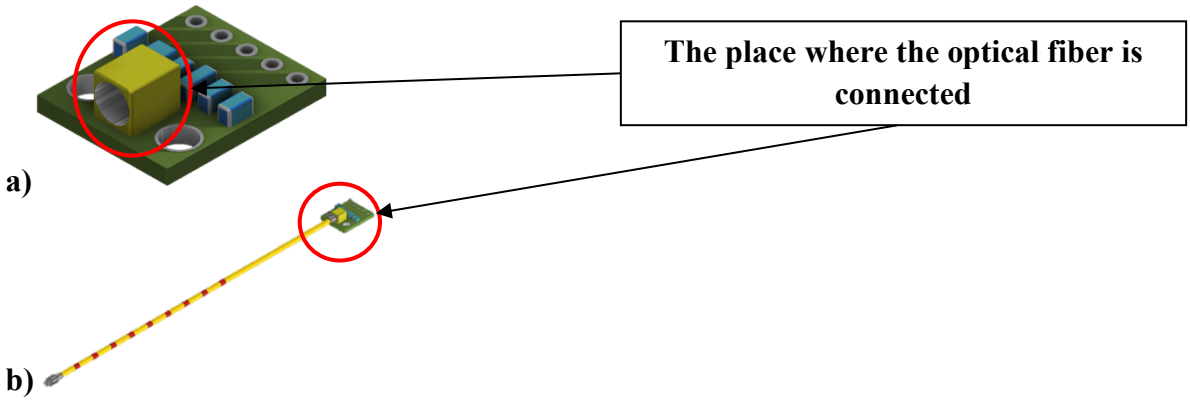


Fig. 8.6. Specialized transmitter.

Fig. 8.7 shows the overall dimensions of the transmitter.

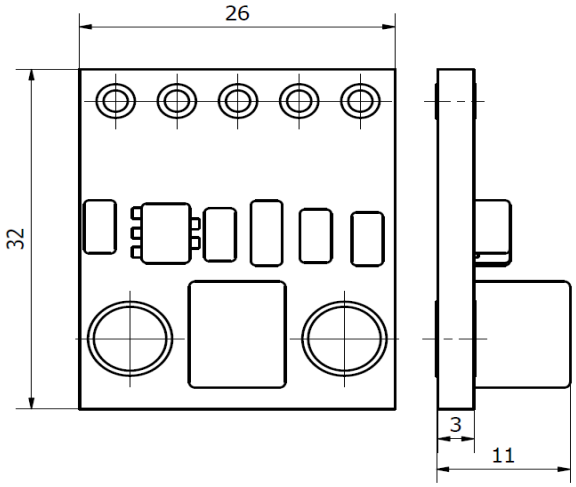


Fig. 8.7. Overall dimensions of the transmitter.

Fig. 8.8 shows the dimensions of the channel in which the optical fiber is mounted.

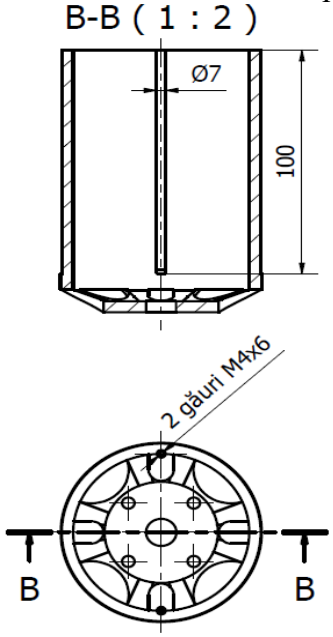


Fig. 8.8. Fiber channel dimensions.

8.8.4. Rechargeable battery using solar energy

In order to solve the challenges related to powering power tools in remote areas, the thesis proposes the use of solar energy to recharge the batteries of these tools. This system would allow efficient power supply in locations with limited access to electricity, while also contributing to protecting the environment through the use of renewable sources. Solutions that integrate solar energy can reduce dependence on traditional power grids, while supporting sustainability and energy security.

In this context, a storage battery system powered by a solar panel was designed. This system captures solar energy and stores it in a rechargeable battery, which can power power tools when needed. The solution includes a visual signaling system, with a green light signal when the battery is fully charged and a red one when the energy is low. This represents an ecological and economical alternative to traditional power sources (Fig. 8.9).

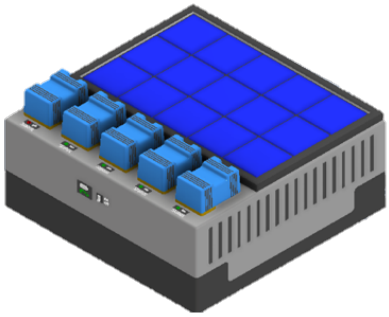


Fig. 8.9. Solar-powered storage batteries.

To ensure the most efficient use of the stored energy, a visual signaling system has been implemented. When the storage battery receives sufficient energy from the solar panel, a green light signal is activated, indicating that the battery is charging and is ready to power the power tools (Fig. 8.10a). On the other hand, when the energy level is low or there is not enough sunlight available to power the battery, the light signal turns red, warning the user that an alternative power source is required (Fig. 8.10b).

a) 

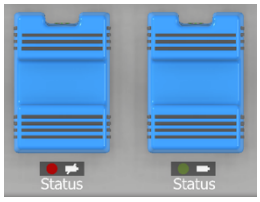
b) 

Fig. 8.10. Light signal for indicating the level of stored energy.

In Fig. 8.11 the overall dimensions of the designed product are presented.

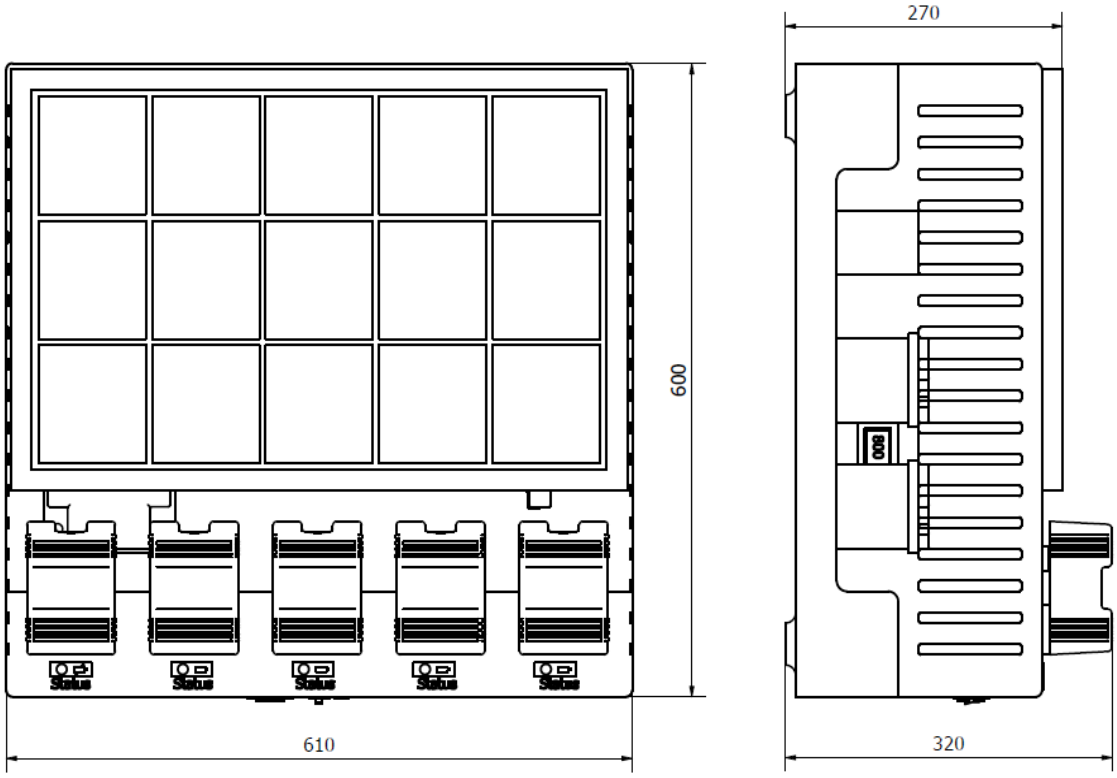


Fig. 8.11. Dimensiuni de gabarit.

9.8.5. Smart Storage Box

A smart storage box has been developed that provides visual feedback about its contents when closed. If all tools are placed correctly, the message "OK" appears on the screen, signaling the user that they can safely close the box. If some tools are missing, the message "NOK" warns the user to check the contents again. This functionality helps users quickly and efficiently check whether the tools are stored correctly, reducing the risk of forgetting or losing tools and contributing to better equipment management.

Fig. 8.12 shows an example where the storage box displays the message "OK" and emits a green light when the tools are placed in the right place and apply appropriate pressure to the pressure sensors.

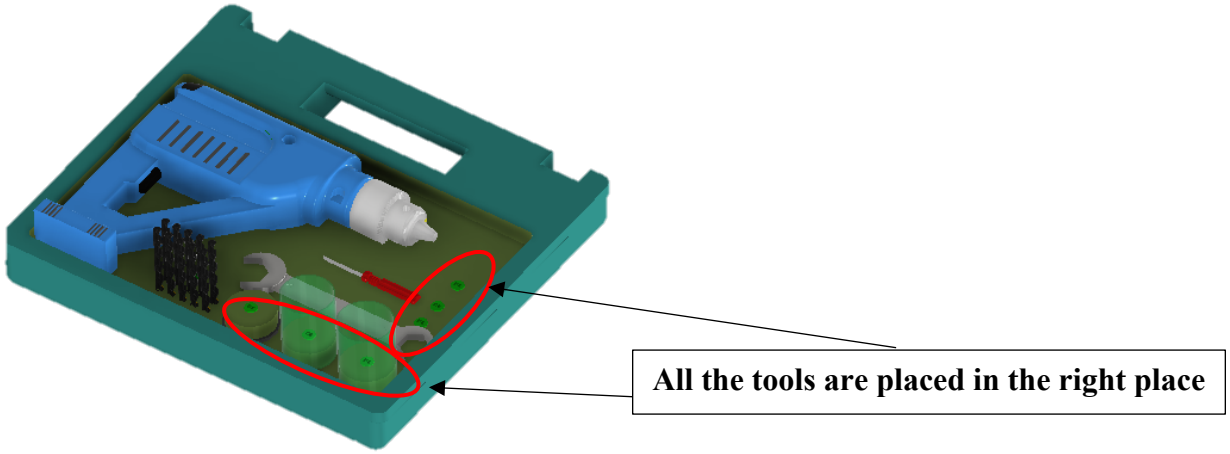


Fig. 8.12. Smart storage box that indicates whether the tools have been placed in the right place.

In Fig. 8.13 the overall dimensions of the designed product are presented.

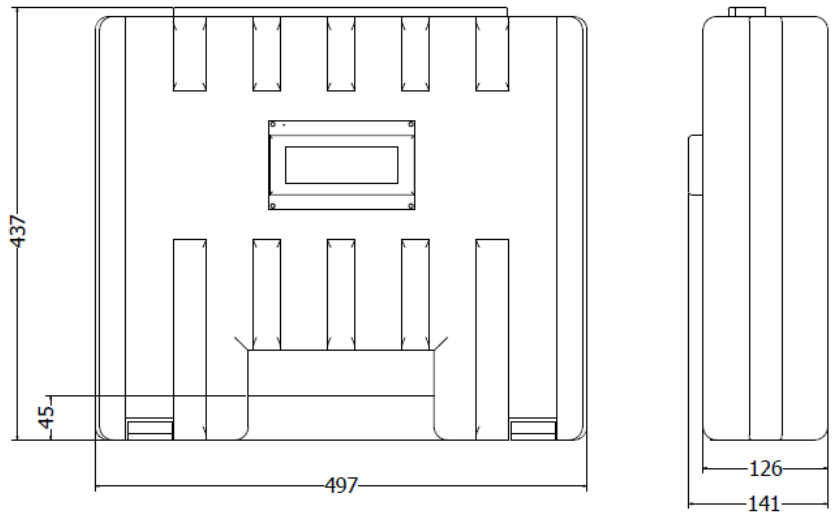


Fig. 8.13. Overall dimensions.

9.8.6. User Guidance Device

The power tool industry is constantly adapting to user needs, and performance in this industry depends on precision, efficiency, and safety. A major factor in this progress are guide systems, which provide control, reduce errors, and increase user safety. They are essential for precise operations such as drilling or cutting, and help even less experienced users to perform quality work.

A modern guide system includes components such as:

- **LED indicator** – helps to correctly align the tool with the work surface.
- **Adjustment sphere** – allows the guide to be adjusted depending on the type of tool used.
- **Spirit level** – ensures the correct positioning of the device on the power tool.
- **Robust support** – fixes the guide system on the tool, providing stability and safety.

These components ensure a high level of precision and safety, improving the performance of power tools in various applications.

Fig. 8.14 shows the components of the user guide device.

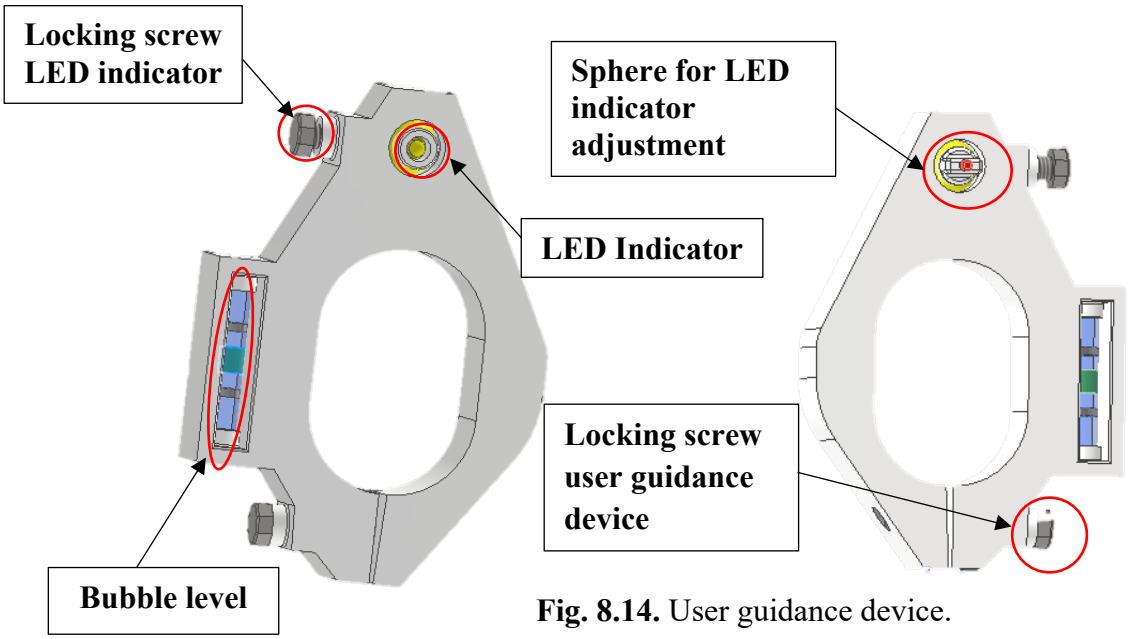


Fig. 8.14. User guidance device.

In Fig. 8.15 the overall dimensions of the developed product are presented.

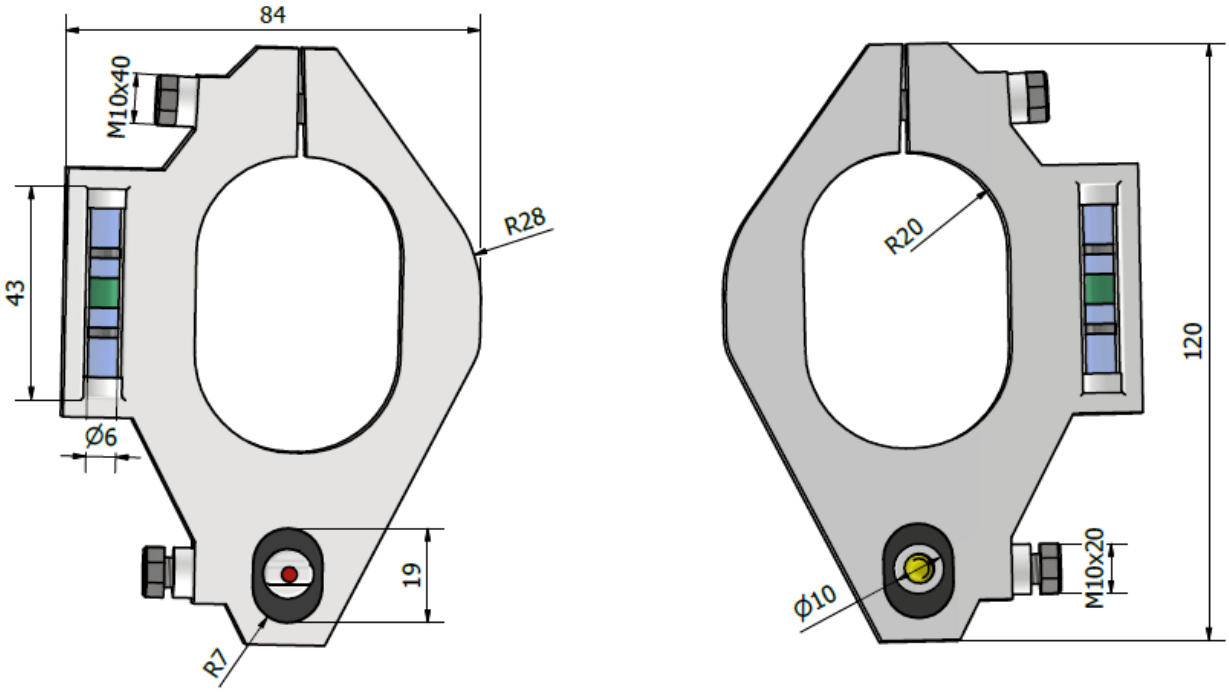


Fig. 8.15. Overall dimensions of the designed product.

CHAPTER 9: MAIN CONTRIBUTIONS REGARDING INNOVATION AND TECHNOLOGICAL TRANSFER FOR ACHIEVING COMPETITIVE ADVANTAGE IN THE ELECTRIC TOOLS INDUSTRY

This chapter presents the theoretical contributions, practical contributions, and future research directions that resulted from the completion of the doctoral thesis.

9.1. Theoretical Contributions

Through the research and the achievement of the set objectives, significant theoretical contributions were made to the electric tools industry:

- **Hybrid project management methodology:** A hybrid methodology was developed that combines the best practices of the Waterfall and Agile approaches, enabling rapid product delivery and adaptation to market requirements through continuous adjustments.
- **Improved technological transfer:** A technological transfer process was developed between the headquarters and global subsidiaries, accelerating the distribution of innovations.
- **Updated Greiner method:** The Greiner model was extended to include the impact of 4.0 and 5.0 technologies, helping to identify the strengths and vulnerabilities of industry leaders.
- **Assessment of the impact of external factors:** An analysis of the pandemic and the Ukraine-Russia war's impact on the electric tools industry, formulating strategies for adaptation and increasing resilience.

9.2. Practical Contributions

The research led to the development of several innovative solutions and products for the electric tools industry:

(1) Innovative Products:

- Drilling machine with integrated support handle for improved control.
- Particle ricochet protection system.
- Fiber Bragg Gratings optical sensor for monitoring the thermal expansion of the motor.
- Improved power supply through the integration of a solar panel.
- Smart storage box for tool inventory checking.
- Device for guiding the user during operation for better precision.

(2) Investigation of Yb3+ material behavior: The behaviors of materials used in manufacturing optical fibers for monitoring thermal expansion of electric tool motors were analyzed, aiming to optimize their performance.

9.3. Future Research Directions

Following the completion of the research, new directions for technological improvement of electric tools emerge:

- **Development of sustainable technologies:** Innovations in energy efficiency and environmentally friendly manufacturing processes.
- **Utilizing artificial intelligence:** Integrating AI to optimize performance and prevent electric tool defects.
- **Exploring new materials:** Researching advanced materials to improve performance and durability.

- **Ergonomics and user safety:** Focus on comfort and safety, by reducing vibrations and developing advanced protective technologies.
- **Advanced manufacturing processes:** Innovation in manufacturing processes, including additive manufacturing technologies and assembly automation, to increase efficiency and reduce production costs.

These research directions will support the development of more efficient, durable, and safe electric tools, in line with the requirements of Industry 4.0 and 5.0.

LIST OF PUBLISHED SCIENTIFIC ARTICLES

The list of scientific articles presented at national and international scientific events reflects the results of the research conducted during this period, as well as their dissemination. To date, the following types of scientific articles have been published:

- Scientific articles published in the proceedings of national and international scientific events indexed as ISI.
- Scientific articles published in the proceedings of national and international scientific events indexed as BDI.

A. Published ISI scientific articles

A.1. Ghena, M., Ghiculescu, D., Optimizing technology transfer: a methodology for HQ to subsidiary implementation, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, vol. 66, no. 5, pp. 373-380, ISSN 1221–5872, **2023**, indexată ISI, **WOS: 001267255200025**, Thomson Reuters, Index Copernicus, WorldCat, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2318

A.2. Ghena, M., Iamandi, A., Ghiculescu, D., Methods used to gain a competitive advantage in the power tool industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, vol. 65, no. 4S, pp. 1221-5872, ISSN 1221–5872, **2022**, **1 citare**, indexată ISI, **WOS: 000969679100021**, Thomson Reuters, Index Copernicus, WorldCat, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2040

A.3. Hongisto, D., Danto, S., Ghena, M., et. al., Response of Various Yb3+-Doped Oxide Glasses to Different Radiation Treatments, Materials, vol. 15, no. 9, pp. 3162-3177, ISSN 1996-1944, **2022**, **5 citări**, indexată ISI, **WOS: 000795424700001**, disponibil la: https://www.mdpi.com/1996-1944/15/9/3162

A.4. Bartos, D., Burducea, C., Burducea, I., Caragheorgheopol, G., Constantin, F., Craciun, L., Dorobantu, N., Ghena, M., et. al., Ageing studies of Multi-Strip Multi-Gap Resistive Plate Counters based on low resistivity glass electrodes in high irradiation dose, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 1024, pp. 166122 – 166147, ISSN 1872-9576, **2022**, **6 citări**, indexată ISI, **WOS: 000784292400007**, disponibil la: https://www.sciencedirect.com/science/article/abs/pii/S0168900221010160

B. Published scientific articles and in progress to be ISI indexed

B.1. Ghena, M., Ghiculescu, D., Designing an innovative product to reach the current trends in the power tools industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, ISSN 1221–5872, **2024**, indexată ISI, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2437

C. Published BDI scientific articles

C.1. Ghena, M., Ghiculescu, D., Nonconventional power tools: real-time thermal expansion monitoring for brushless motors, Nonconventional Technologies Review, vol. 27, no. 4, pp. 95-102, ISSN 2359-8646, **2023**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts, disponibil la: https://www.revtn.ro/index.php/revtn/article/view/453/409

C.2. Ghena, M., Ghiculescu, D., Applicability of Waterfall and Agile Methodologies, FAIMA Business & Management Journal, vol. 11, no. 4, pp. 55-65, ISSN 2344-4088, **2023**, **2 citări**, indexată BDI, ProQuest, EBSCO, ERIH PLUS; Google Scholar, Index Copernicus, disponibil la: https://www.proquest.com/docview/2903041222?pq-origsite=gscholar&fromopenview=true&sourcetype=Scholarly%20Journals

C.3. Pîrnău, C., Ghiculescu, D., Pîrnău, M., Ghena, M., The dimensions balance of the energy trilemma and the current energy crisis, 15th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), Bucharest, Romania, pp. 01-05, ISBN: 979-8-3503-2139-5, **2023**, indexată BDI, IEEE Xplore, disponibil la: https://ieeexplore.ieee.org/document/10194098

D. Scientific articles accepted for publication and to be ISI indexed

D.1. Pîrnău, M., Pîrnău, C., Priescu, I., Țîțu, A., Ghiculescu, D., Ghena, M., The impact of nanotechnologies in the virtual world, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, ISSN 1221–5872, **2024**

D.2. Ghena, M., Ghiculescu, D., A hybrid approach to project management in the power tools industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, ISSN 1221–5872, vol. 67, no. 2S, pp. 663-670, **2024**

E. Scientific articles accepted for publication and to be BDI indexed

E.1. Todescu, A., Ghena, M., Ghiculescu, D., Development of an eco-friendly solution for charging power tool batteries, , ISBN: 979-8-3503-2139-5Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts

E.2. Ghena, M., Todescu, A., Ghiculescu, D., Real-time monitoring of power tools location using a smart storage box, Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts

E.3. Pîrnău, C., Ghiculescu, D., Ghena, M., Nonconventional technologies, effects of changes in the knowledge-based economy, Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts

REFERENCES

[1] Mučenski, V., Pesko, I., Velkovski, T., Chaloska, J., Vujkov, A., and Bibić, D., Impact of Construction Machinery and Tools on Non-Fatal Injuries in the Building Processes, Tehnicki Vjesnik., vol. 25, no. 6, pp. 1680–1689, ISSN 1330-3651, 2018, doi: 10.17559/TV-20170703160241.

[2] Ghena, M., Iamandi, A., Ghiculescu, D., Methods used to gain a competitive advantage in the power tool industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, vol. 65, no. 4S, pp. 1221-5872, ISSN 1221–5872, **2022**, indexată ISI, **WOS: 000969679100021**, Thomson Reuters, Index Copernicus, WorldCat, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2040.

[3] Lidstone, J., Malone, G., Porto, R., et al., A survey of right-angle power tool use in Canadian automotive assembly plants, Applied Ergonomics, vol. 90, pp. 103171, ISSN 0003-6870, 2021, doi: 10.1016/j.apergo.2020.103171.

[4] Helmstetter, S., Dörr, M., Germann, R., and Matthiesen, S., User-centered design of power tools: a generic process for evaluation of usability aspects, Forsch Ingenieurwes, vol. 86, pp. 93-104, ISSN 0015-7899, 2022, doi: 10.1007/s10010-021-00546-y.

[5] Azri, N. M., Effendi, M. S. M., and Rosli, M. F., Preliminary studies on DFMA and sustainable design approach: A case study on a cordless drill, AIP Conference Proceedings 2030, pp. 020069, ISSN 0094-234X, 2018, doi: 10.1063/1.5066710.

[6] Kotkunde, K., Ashwin, A., Gosavi, A., and Gaur, M., Life Cycle Assessment of Nickel Cadmium Battery, IOP Conference Series: Materials Science and Engineering, vol. 1123, pp. 012022, ISSN 1757-8981, 2021, doi: 10.1088/1757-899X/1123/1/012022.

[7] McDowall, J., Nickel-cadmium batteries for energy storage applications, Fourteenth Annual Battery Conference on Applications and Advances. Proceedings of the Conference (Cat. No.99TH8371), Long Beach, CA, USA, pp. 303–308, ISSN 1089-8182, 1999, doi: 10.1109/BCAA.1999.796008.

[8] Hariprakash, B., Shukla, A. K., and Venugoplan, S., Secondary Batteries – Nickel Systems | Nickel–Metal Hydride: Overview, Encyclopedia of Electrochemical Power Sources, J. Garche, Ed., Amsterdam: Elsevier, pp. 494–501, ISBN 978-0-444-52745-5, 2009, doi: 10.1016/B978-044452745-5.00158-1.

[9] Tarabay, J. and Karami, N., Nickel Metal Hydride battery: Structure, chemical reaction, and circuit model, 2015 Third International Conference on Technological Advances in Electrical, Electronics and Computer Engineering (TAEECE), pp. 22–26, ISBN 978-1-467-35612-1, 2015, doi: 10.1109/TAEECE.2015.7113594.

[10] Gui, C., and Wang, Y., The vital role of anode and cathode materials in lithium-ion battery, EMIE 2022, The 2nd International Conference on Electronic Materials and Information Engineering, Hangzhou, China, pp. 1–9, ISBN 978-1-713-86562-9, 2022.

[11] Brisilla, R. M., et. al., Modeling of Lithium-ion Batteries: An Overview, 2021 Innovations in Power and Advanced Computing Technologies (i-PACT), Kuala Lumpur, Malaysia, pp. 1–9, ISBN 978-1-6654-2691-6, 2021, doi: 10.1109/i-PACT52855.2021.9696920.

[12] Scrosati, B., and Garche, J., Lithium Batteries: Status, Prospects and Future, Journal of Power Sources, vol. 195, no. 9, pp. 2419–2430, ISSN 0378-7753, 2010, doi: 10.1016/j.jpowsour.2009.11.048.

[13] Millner, A., Modeling Lithium Ion battery degradation in electric vehicles, 2010 IEEE Conference on Innovative Technologies for an Efficient and Reliable Electricity Supply, Waltham, MA, USA, pp. 349-356, ISBN 1-4244-6078-6, 2010, doi: 10.1109/CITRES.2010.5619782.

[14] Miraz, M. H., Ali, M., et. al., A review on Internet of Things (IoT), Internet of Everything (IoE) and Internet of Nano Things (IoNT), 2015 Internet Technologies and Applications (ITA), Wrexham, UK, pp. 219–224, ISBN 978-1-4799-8036-9, 2015, doi: 10.1109/ITechA.2015.7317398.

[15] Theodore, A. M., Progress into lithium-ion battery research, Journal of Chemical Research, vol. 47, no. 3, pp. 1–9, ISSN 1747-5198, 2023, doi: 10.1177/17475198231183349.
[16] Abu, S., Hannan, M.A., Hossain Lipu, M.S., et al., State of the art of lithium-ion battery material potentials: An analytical evaluations, no.s and future research directions, Journal of Cleaner Production, vol. 394, pp. 136246, ISSN 0959-6526, 2023, doi: 10.1016/j.jclepro.2023.136246.
[17] Carvalho, N., Chaim, O., et. al., Manufacturing in the fourth industrial revolution: A positive prospect in Sustainable Manufacturing, Procedia Manufacturing, vol. 21, pp. 671–678, ISSN 2351-9789, 2018, doi: 10.1016/j.promfg.2018.02.170.
[18] Soebandrija, K., Olannye, A.P., Industrial engineering and the perspectives on leadership, performance, innovation, competitive advantage and sustainable competitive advantage, The International Journal of Business & Management, vol. 8, no. 12, pp. 294-304, ISSN 2321-8916, 2020, doi: 10.24940/theijbm/2020/v8/i12/BM2012-054.
[19] Odum, K., Castillo, M. C., et. al., Sustainability Analysis of Grinding with Power Tools, Procedia CIRP, vol. 14, pp. 570–574, ISSN 2212-8271, 2014, doi: 10.1016/j.procir.2014.03.011.
[20] Kuncoro, W., and Suriani, W. O., Achieving sustainable competitive advantage through product innovation and market driving, Asia Pacific Management Review, vol. 23, no. 3, pp. 186–192, ISSN 1029-3132, 2018, doi: 10.1016/j.apmrv.2017.07.006.
[21] Anandh, S, Anandh, K.S., Sankar, S.S., A review on tools and methods applied to enhance ergonomics in the construction industry, AIP Conference Proceedings, pp. 020011, ISSN 0094-243X, 2022, doi: 10.1063/5.0102960.
[22] Armstrong, T., Cochran, D. J., et al., Hand Tool Ergonomics - past and present, Proceeding of the Human Factors and Ergonomics Society Annual Meeting, vol. 54, no. 15, pp. 1145–1148, ISSN 1071-1813, 2010, doi: 10.1177/154193121005401512.
[23] Marsot, J. and Claudon, L., Design and Ergonomics. Methods for Integrating Ergonomics at Hand Tool Design Stage, International journal of occupational safety and ergonomics: JOSE, vol. 10, no.1, pp. 13–23, ISSN 1080-3548, 2004, doi: 10.1080/10803548.2004.11076591.
[24] Kim, B. J., Effect of Ergonomic Design Changes in Hand Tools on Physiological Cost and Subjective Ratings, International journal of occupational safety and ergonomics: JOSE, vol. 18, no. 2, pp. 267–77, ISSN 1080-3548, 2012, doi: 10.1080/10803548.2012.11076932.
[25] Susihono, W., and Saputri, T. A., Identify eight aspects of ergonomics to determine the improvement of human-machine interaction work (case studies in manufacturing industry), The 1st International Conference on Industrial, Electrical and Electronics (ICIEE 2018), vol. 218, pp. 04018-04027, ISSN 2261-236X, 2018, doi: 10.1051/matecconf/201821804018.
[26] Mustafa, S., Khan, M., and Faraz, H., Ergonomics in Product Design—Past, Present, and Future: A Review, Ergonomics for Improved Productivity, no. 24, pp. 213–218, ISSN 2509-5986, 2021. doi: 10.1007/978-981-15-9054-2_24.
[27] Echle, A., Neubauer, A., and Parspour, N., Design and Comparison of Radial Flux and Axial Flux Brushless DC Motors for Power Tool Applications, 2018 XIII International Conference on Electrical Machines (ICEM), pp. 125-130, ISSN 2381-4802, 2018, doi: 10.1109/ICELMACH.2018.8507221.
[28] Tripathi, P., Hardware Engineer's Guide to a Brushless-DC Motor Controller Design and challenges, IEEE Power Electronics Magazine, vol. 9, no. 1, pp. 40–45, ISSN 2329-9215, 2022, doi: 10.1109/MPEL.2021.3139257.
[29] Al Mashhadany, Y. I., Abbas, A. K., and Algburi, S. S., Modeling and analysis of brushless DC motor system based on intelligent controllers, Bulletin Electrical Engineering and Informatics, vol. 11, no. 6, pp. 2995–3003, ISSN 2302-9285, 2022, doi: 10.11591/eei.v11i6.4365.
[30] Raja, M., and Geethalakshmi, B., Evaluation of brushless DC motor structure design for the electric impact using 3-D finite element analysis, International Journal of Applied Power Engineering (IJAPE), vol. 11, no.2, pp. 156, ISSN 2252-8792, 2022, doi: 10.11591/ijape.v11.i2.pp156-164.

[31] Pîrnău, M., Pîrnău, C., Priescu, I., Țîțu, A., Ghiculescu, D., Ghena, M., The impact of nanotechnologies in the virtual world, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, ISSN 1221–5872, **2024**
[32] Pîrnău, C., Ghiculescu, D., Ghena, M., Nonconventional technologies, effects of changes in the knowledge-based economy, Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts
[33] Negruța, A. L., Japanese professional development at Makita Romania, Review of International Comparative Management, vol. 1, pp. 70-75, ISSN 1582-3458, 2019.
[34] Dörr, M., Ries, M., Gwosch, T., and Matthiesen, S., Recognizing Product Application based on Integrated Consumer Grade Sensors: A Case Study with Handheld Power Tools, Procedia CIRP, vol. 84, pp. 798–803, ISSN 2212-8271, 2019, doi: 10.1016/j.procir.2019.04.317.
[35] Andersson, T., Aesthetic Flexibility: In Industrial Design Practice, Linköping University Electronic Press, Linköping, Suedia, pp. 1122021, ISSN 0345-7524, 2021, doi: 10.3384/diss.diva-173826.
[36] Schwager, B., The Bosch Group's Approach to Innovation and Sustainability Communication: Social Responsibility as Competitive Advantage, Innovation Management and Corporate Social Responsibility, pp. 181–194, ISBN 978-3-319-93628-4, 2018, doi: 10.1007/978-3-319-93629-1_10.
[37] Hunt, S., and Arnett, D., Market Segmentation Strategy, Competitive Advantage, and Public Policy, Australasian Marketing Journal (AMJ), vol. 12, pp. 7–25, ISSN 1441-3582, 2004, doi: 10.1016/S1441-3582(04)70083-X.
[38] Jamaludin, J., and Rohani, J., Cyber-Physical System (CPS): State of the Art, 2018 International Conference on Computing, Electronic and Electrical Engineering (ICE Cube), Quetta, Pakistan, pp. 1–5, 2018, ISBN 978-1-5386-7940-1, doi: 10.1109/ICECUBE.2018.8610996.
[39] Oks, S. J., et al., Cyber-Physical Systems in the Context of Industry 4.0: A Review, Categorization and Outlook, Information Systems Frontiers, vol. 26, pp. 1731-1772, ISSN 1387-3326, 2022, doi: 10.1007/s10796-022-10252-x.
[40] Sanislav, T., and Miclea, L., Cyber-physical systems - Concept, challenges and research areas, Control Engineering and Applied Informatics., vol. 14, no. 2, pp. 28–33, ISSN 1454-8658, 2012.
[128] Ali, Z., Ali, H., and Badawy, M., Internet of Things (IoT): Definitions, Challenges, and Recent Research Directions, International Journal of Computer Applications, vol. 128, no. 1, pp. 975–8887, ISSN 0975-8887, 2015.
[41] Nimodiya, A., and Ajankar, S., A Review on Internet of Things, International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), vol. 2, no. 1, pp. 135–144, ISSN 2581-9429, 2022, doi: 10.48175/IJARSCT-2251.
[42] Wang, L., Vidosav, M., Mourtzis, D., et. al., Proceedings of 5th International Conference on the Industry 4.0 Model for Advanced Manufacturing, Lecture Notes in Mechanical Engineering, Spring Charm, ISBN 978-3-090-4621-6, 2020, doi: 10.1007/978-3-030-46212-3.
[43] Majerník, M., Daneshjo, N., Malega, P., et. al., Sustainable Development of the Intelligent Industry from Industry 4.0 to Industry 5.0, Advances in Science and Technology Research Journal, vol. 16, no. 2, pp. 12–18, ISSN 2299-8624, 2022, doi: 10.12913/22998624/146420.
[44] Demir, K. A., Döven, G., and Sezen, B., Industry 5.0 and Human-Robot Co-working, Procedia Computer Science, vol. 158, no. C, pp. 688–695, ISSN 1877-0509, 2019, doi: 10.1016/j.procs.2019.09.104.
[45] Adenowo, A., and Adenowo, B., Software Engineering Methodologies: A Review of the Waterfall Model and Object- Oriented Approach, International Journal of Science and Engineering Research, vol. 4, vol. 7, pp. 427–434, 2229-5518, 2020.
[46] Chukwulozie, O., Azaka, O., Celestine, O., and Jude, S., Analysis and Forecasting Of the Production Quantity in a Manufacturing Industry Using Historical Data, The International Journal of Engineering and Science, vol. 4, no. 10, pp. 7-17, ISSN 2319-1805, 2015.

[47] Säisä, M., Tiura, K., and Roslöf, J., Waterfall vs. Agile Project Management Methods in University-Industry Collaboration Projects, Proceeding of the 14th International CDIO Conference, Kanazawa Institute of Technology, Kanazawa, Japan, ISSN 2002-1593, 2018.
[48] Kisielnicki, J., and Misiak, A., Effectiveness of Agile Compared to Waterfall Implementation Methods in it Projects: Analysis Based on Business Intelligence Projects, Foundations of Management, vol. 9, no, 1, pp. 273-286, ISSN 2300-5661, 2017, doi: 10.1515/fman-2017-0021.
[49] Yahya, N., and Maidin, S., The Waterfall Model with Agile Scrum as the Hybrid Agile Model for the Software Engineering Team, 2022 10th International Conference on Cyber and IT Service Management, Yogyakarta, Indonesia, pp. 1-5, 2022, ISSN 2770-159X, doi: 10.1109/CITSM56380.2022.9936036.
[50] Ghena, M., Ghiculescu, D., Applicability of Waterfall and Agile Methodologies, FAIMA Business & Management Journal, vol. 11, no. 4, pp. 55-65, ISSN 2344-4088, **2023**, indexată BDI, ProQuest, EBSCO, ERIH PLUS; Google Scholar, Index Copernicus, disponibil la: https://www.proquest.com/docview/2903041222?pq-origsite=gscholar&fromopenview=true&sourcetype=Scholarly%20Journals
[51] Aina, T. S., Akinte, O., Awelewa, A., and Adelakun, D., Critical evaluation of waterfall project management methodology: A case study of digital management conference project, International Journal of Advanced Multidisciplinary Research and Studies, vol. 2, no. 3, pp. 266-269, ISSN 2583-049X, 2022.
[52] Iqbal, M., and Rizwan, M., Application of 80/20 rule in software engineering Waterfall Model, 2009 International Conference on Information and Communication Technologies, Karachi, Pakistan, pp. 223-228, ISB 978-1-4244-4739-8, 2009, doi: 10.1109/ICICT.2009.5267186.
[53] Ismail, M., and Mansor, Z., Agile Project Management: Review, Challenges and Open No.s, Advanced Science Letters, vol. 24, no. 7, pp. 5216–5219, ISSN 1936-6612, 2018, doi: 10.1166/asl.2018.11705.
[54] Alaidaros, H., Omar, M., and Romli, R., The State of the Art of Agile Kanban Method: Challenges and Opportunities, Independent Journal of Management & Production, vol. 12, no. 8, pp. 2535-2550, ISSN 2236-269X, 2021. doi: 10.14807/ijmp.v12i8.1482.
[55] Fidyawan, M., and Raharjo, T., A Systematic Review of the Aspects and Benefits Agile Project Management Innovation, Indones. J. Comput. Sci., vol. 12, Dec. 2023, doi: 10.33022/ijcs.v12i6.3531.
[56] Stare, A., Agile Project Management in Product Development Projects, Procedia - Social and Behavioral Sciences, vol. 119, pp. 295-304, ISSN 1877-0428, 2024.
[57] Mishra, A., and Alzoubi, Y. I., Structured software development versus agile software development: a comparative analysis, International Journal of Systems Assurance Engineering and Management, vol. 14, no. 1, pp. 1504–1522, ISSN 0975-6809, 2023, doi: 10.1007/s13198-023-01958-5.
[58] Hayat, F., Rehman, A., Arif, K., et. al., The Influence of Agile Methodology (Scrum) on Software Project Management, 2019 20th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD), Toyama, Japan, pp. 145-149, ISSN 1860-949X, 2019, doi: 10.1109/SNPD.2019.8935813.
[59] Brezočnik, L., and Majer, Č., Comparison of Agile methods: Scrum, Kanban, and Scrumban, Proceedings of the 19th International Multiconference Information Society - IS 2016: Collaboration, software and services in information society, Ljubljana, Slovenia, 2016.
[60] Thesing, T., Feldmann, C., and Burchardt, M., Agile versus Waterfall Project Management: Decision Model for Selecting the Appropriate Approach to a Project, Procedia Computer Science, vol. 181, pp. 746–756, ISSN 1877-0509, 2021, doi: 10.1016/j.procs.2021.01.227.
[61] Mokhtar, R., and Khayyat, M., A Comparative Case Study of Waterfall and Agile Management, SAR J., vol. 5, no. 1, 55-62, ISSN 2619-9955, 2022, doi: 10.18421/SAR51-07.

[62] Jamous, N., Garttan, G., Staegemann, D., and Volk, M., Hybrid Project Management Methods Efficiency in IT Projects, 27th Americas Conference on Information Systems, Montreal, Canada, pp. 1-10, ISSN 978-1-7336-3258-4, 2021.
[63] Krupa, M., Šimůnek, K., and Hajek, J., Hybrid Project Management: A Literature Review, Proceeding of the International Scientific Conference Hradec Economic Days, vol. 13, pp. 344-355, ISBN 978-8-0743-5901-9, 2023. doi: 10.36689/uhk/hed/2023-01-034.
[64] Gonzalez-Leyba, A. C., Rana, M. Q., Salazar, A. M., et. al., Deploying the Hybrid Project Management Methodology Framework in Major Transportation Projects in the United Kindom, Journal of Architectural Engineering Technology, vol. 13, no. 2, pp. 377, ISSN 2168-9717, 2024.
[65] Gemino, A., Reich, B., and Serrador, P., Agile, Traditional, and Hybrid Approaches to Project Success: Is Hybrid a Poor Second Choice?, Project Management Journal, vol. 52, no. 2, pp. 161-175, ISSN 8756-9728, 2020, doi: 10.1177/8756972820973082.
[66] Azenha, F., Reis, D., and Fleury, A., The Role and Characteristics of Hybrid Approaches to Project Management in the Development of Technology-Based Products and Services, Project Management Journal, vol. 52, pp. 1–21, ISSN 8756-9728, 2020, doi: 10.1177/8756972820956884.
[67] Ghena, M., Ghiculescu, D., A hybrid approach to project management in the power tools industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, vol. 67, no. 2S, pp. 663-670, ISSN 1221–5872, **2024**.
[68] Bhatti, M., Awan, H., and Razaq, Z., The key performance indicators (KPIs) and their impact on overall organizational performance, Quality & Quantity, vol. 48, pp. 3127-3143, ISSN 0033-5177, 2014, doi: 10.1007/s11135-013-9945-y.
[69] Cegliński, P., The Concept of Competitive Advantages. Logic, Sources and Durability, Journal of Positive Management., vol. 7, no. 3, pp. 57–70, 2392-1412, 2017, doi: 10.12775/JPM.2016.016.
[70] Ghiculescu, D., Calitatea proceselor și produselor, Printech, București, 303 p., ISBN 978-606-23-0678-6, 2016.
[71] Ghena, M., Ghiculescu, D., Optimizing technology transfer: a methodology for HQ to subsidiary implementation, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, vol. 66, no. 5, pp. 373-380, ISSN 1221–5872, **2023**, indexată ISI, **WOS: 001267255200025**, Thomson Reuters, Index Copernicus, WorldCat, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2318
[72] Powell, T. C., The philosophy of strategy, Strategic Management Journal, vol. 23, no. 9, pp. 873–880, ISSN 0143-2095, 2002, doi: 10.1002/smj.254.
[73] Hine, D., and Ryan, N., Small service firms – creating value through innovation, Managing Service QualityȘ An International Journal, vol. 9, no. 6, pp. 411–422, ISSN 0960-4529, 1999, doi: 10.1108/09604529910302109.
[74] Yeh-Yun Lin, C. and Yi-Ching Chen, M., Does innovation lead to performance? An empirical study of SMEs in Taiwan, Management Research News, vol. 30, no. 2, pp. 115–132, ISSN 0140-9174, 2007, doi: 10.1108/01409170710722955.
[75] Linder, J. C., Does innovation drive profitable growth? New metrics for a complete picture, Journal of Business Strategy, vol. 27, no. 5, pp. 38–44, ISSN 0275-6668, 2006, doi: 10.1108/02756660610692699.
[76] Al-Shuaibi, K., Zain, M., and Kassim, N., Performance Indicators for Quality, Innovation, and Competitiveness; A Survey on the Saudi Manufacturing Sector, International Business Research, vol. 9, pp. 99–113, ISSN 1913-9004, 2016, doi: 10.5539/ibr.v9n2p99.
[77] Kuei, C., Madu, C. N., and Lin, C., The relationship between supply chain quality management practices and organizational performance, International Journal of Quality & Reability Management, vol. 18, no. 8, pp. 864–872, ISSN 0265-671X, 2001, doi: 10.1108/EUM0000000006031.

[78] Madu, C. N., Kuei, C., and Lin, C., A Comparative Analysis of Quality Practice in Manufacturing Firms in the U.S. and Taiwan, Decision Sciences, vol. 26, no. 5, pp. 621–635, 1540-5915, 1995, doi: 10.1111/j.1540-5915.1995.tb01443.x.
[79] Prajogo, D. I., and Sohal, A. S., The relationship between TQM practices, quality performance, and innovation performance: An empirical examination, International Journal of Quality & Reability Management, vol. 20, no. 8, pp. 901–918, ISSN 0265-671X, 2003, doi: 10.1108/02656710310493625.
[80] Bell, M., and Omachonu, V., Quality system implementation process for business success, International Journal of Quality & Reability Management, vol. 28, no. 7, pp. 723–734, ISSN 0265-671X, 2011, doi: 10.1108/02656711111150814.
[81] Samson, D., and Terziovski, M., The relationship between total quality management practices and operational performance, Journal of Operations Management, vol. 17, no. 4, pp. 393–409, ISSN 0272-6963, 1999, doi: 10.1016/S0272-6963(98)00046-1.
[82] Richard, P., Devinney, T., Yip, G., and Johnson, G., Measuring Organizational Performance as a Dependent Variable: Towards Methodological Best Practice, Journal of Management, vol. 35, no. 3, pp. 718-804, ISSN 0149-2063, 2008, doi: 10.2139/ssrn.814285.
[83] Poulfelt, F., and Buono, A., Larry E. Greiner: Actionable Knowledge in Action, 2016, pp. 1–12. doi: 10.1007/978-3-319-49820-1_41-1.
[84] Coad, A., The Growth of Firms : A Survey of Theories and Empirical Evidence, New Perspect. France, Edward Elgar Publishing Ltd., ISBN 978-1-8484-4327-3, 2009, doi: 10.4337/9781848449107.
[85] Zhu, J., Yan, W., Zhu, L., and Liu, J., COVID-19 pandemic in BRICS countries and its association with socio-economic and demographic characteristics, health vulnerability, resources, and policy response, Infectious Diseases of Poverty, vol. 10, pp. 10-97, ISSN 2049-9957, 2021, doi: 10.1186/s40249-021-00881-w.
[86] Jareño, F., Escribano, A., and Umar, A., The impact of the COVID-19 outbreak on the connectedness of the BRICS's term structure, Humanities and Social Sciences Communications, vol. 10, pp. 4-12, ISSN 2662-9992, 2023, doi: 10.1057/s41599-022-01500-1.
[87] Jiao, J., et al., Core policies disparity response to COVID-19 among BRICS countries, International Journal of Equity Health, vol. 21, no. 1, pp. 9, ISSN 1475-9276, 2022, doi: 10.1186/s12939-021-01614-z.
[88] Bobylev S., and Grigoryev, L., Sustainable Development Goals and BRICS: In search of the contours of the post-COVID world economy, BRICS Journal of Economics, vol. 1, no. 2, pp. 4–24, ISSN 2712-7702, 2020, doi: 10.38050/2712-7508-2020-7.
[89] Rahman, M., Manini, M., and Fatima, Z., Economic Indicators and Climate Change for BRICS Economies in the Post-COVID-19 World: Neural Network Approach, Management and Economics Research Journal, vol. 7, pp. 1–9, ISSN 2676-184X, 2021, doi: 10.18639/MERJ.2021.9900058.
[90] Samuel, M., An overview of SWOT analysis theory as a strategic management instrument, Hallmark University Journal of Management and Social Sciences, vol. 3, no. 1, pp. 196–208, ISSN 2705-358X, 2021.
[91] Gürel, E., Tat, M., SWOT analysis: a theoretical review, The Journal of International Social Research, vol. 10, no. 51, pp. 994–1006, ISSN 1307-9581, 2017, doi: 10.17719/jisr.2017.1832.
[92] Griffin, A., and Hauser, J., The voice of the customer, Marketing Science, vol. 12, no. 1, pp. 360–373, ISSN 0732-2399, 1993.
[93] Ekmekci, I., and Koksal, M., Triz Methodology and an Application Example for Product Development, Procedia - Social and Behavioral Sciences, vol. 195, pp. 2689–2698, ISSN 1877-0428, 2015, doi: 10.1016/j.sbspro.2015.06.481.

[94] Livotov, P., Sustainable European Collaboration in the Field of Knowledge-Based Innovation and Inovetive Problem Solving with TRIZ, 16th International TRIZ Future Conference, vol. 1, no. 3, pp 1-3, ISSN 1866-4180, 2008.
[95] Chen, J., An architecture-oriented kansei engineering system for innovative long chi inkstone design, vol. 9, no. 12, pp. 1-15, ISSN 2405-8440, 2023.
[96] Nagamachi, M., Kansei engineering and its applications., The Japanese Journal of Ergonomics, vol. 32, no. 6, pp. 286–289, ISSN 0549-4974, 1996, doi: 10.5100/jje.32.286.
[97] Schütte, S., Eklund, J., Axelsson, J., and Nagamachi, M., Concepts, methods and tools in Kansei Engineering, Theoretical No.s in Ergonomics Science, vol. 5, no. 3, pp. 214–231, ISSN 1464-536X, 2004, doi: 10.1080/1463922021000049980.
[98] Kahraman, F., and Sagbas, A., An investigation of the effect of heat treatment on surface roughness in machining by using statistical analysis, Iranian Journal of Science and Technology Transaction B: Engineering, vol. 34, no. 5, pp. 591–595, ISSN 1028-6284, 2010.
[99] Shaojun, S., Xianping, Z., and Chengtong, S., Heat-treatment and properties of high-speed steel cutting tools, IOP Conference Series: Materials Science and Engineering, vol. 423, pp. 012031, ISSN 1757-899X, 2018, doi: 10.1088/1757-899X/423/1/012031.
[100] Zhou, A., The Origin, Process, and Advantages of Recycling and its Benefit to the Environment, BCP Business & Management, vol. 34, pp. 1424–1429, ISSN 2692-6156, 2022, doi: 10.54691/bcpbm.v34i.3194.
[101] Ghena, M., Ghiculescu, D., Designing an innovative product to reach the current trends in the power tools industry, ACTA TECHNICA NAPOCENSIS-Series: APPLIED MATHEMATICS, MECHANICS, and ENGINEERING, ISSN 1221–5872, **2024**, indexată ISI, **WOS: X**, Thomson Reuters, Index Copernicus, WorldCat, disponibil la: https://atna-mam.utcluj.ro/index.php/Acta/article/view/2437
[102] Ghena, M., Ghiculescu, D., Nonconventional power tools: real-time thermal expansion monitoring for brushless motors, Nonconventional Technologies Review, vol. 27, no. 4, pp. 95-102, ISSN 2359-8646, **2023**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts, disponibil la: https://www.revtn.ro/index.php/revtn/article/view/453/409 9rHKlLrihgMVkWaRBR2wtAVTEAEYASAJEgIV3_D_BwE, Accesat la: 08.07.2024.
[103] Ghena, M., Stancalie, A., and Lacatus, E., Comparative study of structures temperature monitoring using FBG array and distributed sensing in real time, Nonconventional Technologies Review, vol. 23, no. 4, pp. 67–71, 2019, ISSN 2359-8646, **2019**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts
[104] Hongisto, M., Danto, S., Ghena, M., et. al., Response of Various Yb3+-Doped Oxide Glasses to Different Radiation Treatments, Materials, vol. 15, no. 9, pp. 3162-3177, **2022**, indexată ISI, **WOS: 000795424700001**, disponibil la: https://www.mdpi.com/1996-1944/15/9/3162
[105] Pîrnău, C., Ghiculescu, D., Pîrnău, M., Ghena, M., The dimensions balance of the energy trilemma and the current energy crisis, 15th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), Bucharest, Romania, pp. 01-05, ISBN: 979-8-3503-2139-5, **2023**, indexată BDI, IEEE Xplore, disponibil la: https://ieeexplore.ieee.org/document/10194098
[106] Todescu, A., Ghena, M., Ghiculescu, D., Development of an eco-friendly solution for charging power tool batteries, Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts
[107] Ghena, M., Todescu, A., Ghiculescu, D., Real-time monitoring of power tools location using a smart storage box, Nonconventional Technologies Review, ISSN 2359-8646, **2024**, indexată BDI, ProQuest, EBSCOhost, DOAJ, Index Copernicus, Google Scholar, CAB Abstracts

ABBREVIATIONS

No.	Abbrev.	Semnificație	Significance
1	ACD	Avantaj competitiv durabil	Sustainable Competitive Advantage
2	BMS	Sistemul de gestionare a energiei	Battery Management Systems
3	BRIC	Brazilia, Rusia, India, China	Brazil, Russia, India, China
4	BRICS	Brazilia, Rusia, India, China, Africa de Sud	Brazil, Russia, India, China, South Africa
5	CAD	Proiectare asistată de calculator	Computer-Aided Design
6	CAGR	Rată anuală de creștere compusă	Compound Annual Growth Rate
7	CNC	Comandă numerică computerizată	Computer Numerical Control
8	COVID-19	Boala coronavirus	Coronavirus Disease
9	DIY	Consumatorii de bricolaj	Do It Yourself
10	FBG	Fiber Bragg Grating	Fiber Bragg Grating
11	HAVS	Sindromul de vibrație mână-braț	Hand-Arm Vibration Syndrom
12	HQ	Sediu central	Headquarter
13	IFIN-HH	Institutul National de Cercetare Dezvoltare pentru Fizică și Inginerie Nucleară Horia Hulubei	National Institute for Research and Development in Nuclear Physics and Engineering Horia Hulubei
14	INFLPR	Institutul Național pentru Fizica Laserilor, Plasmei și Radiației	National Institute for Laser, Plasma, and Radiation Physics
15	IoT	Internetul lucrurilor	Internet of Things
16	ISO	Organizația Internațională de Standardizare	International Organization for Standardization
17	KPI	Indicatorii cheie de performanță	Key Performance Indicators
18	Li-Ion	Litiu-Ion	Lithiu-In
19	NLP	Procesarea limbajului natural	Natural Language Processing
20	PM	Manager de proiect	Project Manager
21	PMO	Biroul de management al proiectelor	Project Management Office
22	R&D	Cercetare și dezvoltare	Research & Development
23	RAID	Riscuri, presupuneri, probleme, dependențe	Risk, Assumptions, Issues, Dependencies
24	SEMIP	Sculă electrică cu mâner încorporat și protecție a burghiului pentru a nu ricoșa particule în timpul utilizării	Power tool with built-in handle and drill guard to prevent particles from ricocheting during use
25	SHM	Monitorizarea sănătății structurale	Structural Health Monitoring
26	SWOT	Puncte tari, puncta slabe, oportunități, amenințări	Strengths, Weakness, Opportunities, and Threats
27	TRIZ	Teoria rezolvării inventive a problemelor	Theory of Inventive Problem Solving
28	TTO	Transfer către operațiuni	Transfer to Operations
29	VUP	Valoare de utilizare percepută	Perceived Use Value