Industry 4.0: Iot Implementation Project In Injection Molding Machines
Indústria 4.0: Projeto de Implementação de IoT em Máquinas Injetoras

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[1]Kátia Diniz da Silva Piccirillo, [2]Luciano Ferreira da Silva,
[3]Jefferson Augusto Piccirillo, [4]José Celso Contador, [5]Walter Cardoso Satyro

[1]Universidade Nove de Julho - UNINOVE
katia_diniz@outlook.com
https://orcid.org/0009-0004-9722-7814

[2] Universidade Nove de Julho - UNINOVE
prof.lfs7725@gmail.com
https://orcid.org/0000-0001-6482-8729

[3]Fatec jornalista Omair Fagundes de Oliveira - Bragança Paulista
jkcontrol@hotmail.com
https://orcid.org/0009-0006-4282-3170

[4]Universidade Paulista - UNIP
celsocontador@terra.com.br
https://orcid.org/0000-0003-4695-3379

[5] Universidade Nove de Julho - UNINOVE
satyro.walter@gmail.com
https://orcid.org/0000-0002-0201-222X

Abstract
Objective: with globalization and technological advances, industries have evolved a lot, and it is relevant to follow this evolution for effective business management. The Internet of Things - IoT, a technology used in the so-called Industry 4.0, aids in the management of companies by enabling communication and integration of equipment through the internet, providing relevant information, and assisting in decision-making. This technical report aims to analyze the implementation project of this technology in a small automotive parts injection company.
Diagnosis and/or opportunity: some injection machine operators were neglecting their tasks, negatively impacting the company's production and resulting in financial losses.
Methodology/approach: data collection involved interviews with the responsible individuals from the injection company and the automation company that implemented IoT. Additionally,

an analysis of financial indicators (Return on Investment - ROI and Payback) and non-financial indicators (production quality, injection machine performance, and machine availability) was conducted.
Results/application: as a solution, IoT technology was implemented in two injection machines. The results obtained demonstrated the effectiveness of the IoT implementation project as it contributed to solving the injection company's problems and improving its production process.
Contributions: the company achieved significant financial returns in a short period of three months, which the manager considered relatively quick.
Keywords: industry 4.0, IoT; project, implementation, financial indicators, non-financial indicators.

Resumo
Objetivo: com a globalização e os avanços tecnológicos, as indústrias evoluíram significativamente, e é essencial acompanhar essa evolução para uma gestão empresarial eficaz. A Internet das Coisas – IoT, tecnologia utilizada na Indústria 4.0, auxilia na gestão das empresas ao possibilitar a comunicação e a integração de equipamentos pela internet, fornecendo informações relevantes e auxiliando na tomada de decisões. Este relatório técnico tem como objetivo analisar o projeto de implantação desta tecnologia em uma empresa de injeção de peças automotivas de pequeno porte.
Diagnóstico da problematização e/ou oportunidade: alguns operadores de máquinas injetoras estavam negligenciando suas tarefas, causando impactos negativos à produção da empresa e resultando em prejuízos financeiros.
Metodologia/abordagem: a coleta de dados deu-se por entrevistas com os responsáveis da empresa de injeção e da empresa de automação que implementaram IoT. Adicionalmente, foi realizada análise de indicadores financeiros (Retorno sobre Investimento - ROI e Payback) e indicadores não financeiros (qualidade de produção, desempenho de máquinas injetoras e disponibilidade de máquinas).
Resultados/aplicação: como solução, a tecnologia IoT foi implementada em duas máquinas injetoras. Os resultados obtidos demonstraram a eficácia do projeto de implementação de IoT, pois contribuiu para solucionar os problemas da empresa de injeção e melhorar seu processo produtivo.
Contribuições: a empresa obteve retornos financeiros significativos em um curto período de três meses, avaliado pelo gestor como relativamente rápido.
Palavras-chave: indústria 4.0, IoT, projeto, implementação, indicadores financeiros, indicadores não financeiros.

1. Introduction

Globalization and technological advancements have brought significant changes to economies and policies. In response, companies seek access to technology to better position themselves for successful competition (Costa, et al., 2023; Lenart-Gansiniec, 2019). In this context, Abdulaziz et al. (2023) emphasize that the benefits stemming from the adoption of Industry 4.0 technologies provide companies with a competitive advantage, offering increased productivity, efficiency, adaptability, expanded manufacturing capability, cost reduction, enhanced quality monitoring and control, and reduced waste and delivery time.

The concept of Industry 4.0 emerged in 2011 at the Hannover Fair in Germany (Silva et al., 2020) with the aim of strengthening industrial competitiveness (Contador et al., 2020). This fourth industrial revolution is based on fully mechanized and automated systems, combining the internet and future-oriented technologies with machine intelligence (Nouinou et al., 2023). Despite the potential for increased productivity, small and medium-sized enterprises are still at a disadvantage concerning these new technologies (Nagy, Lazaroiu, & Valaskova, 2023).

Industry 4.0 represents a new era of industrial production characterized by a highly connected, intelligent and automated environment where technology is used to improve efficiency and productivity (Upadhyuay et al., 2023). One of the key enabling technologies of Industry 4.0 is the Internet of Things (IoT), which allows the connectivity of devices and systems, generating a large amount of real-time data (Li et al., 2019).

IoT is transforming industry in various aspects, enabling the creation of new business models, improving operational efficiency, and enhancing product and service quality (Javaid et al., 2022). Through data collection and analysis, IoT facilitates more precise and rapid decision-making, allowing for the identification of failures and the implementation of solutions more effectively (Illa & Padhi, 2018).

By integrating Industry 4.0 technology devices as IoT-based services, companies can collect and analyze real-time data to identify inefficiencies and areas for improvement, leading to immediate adjustments and performance enhancements (Li et al., 2019). Thus, with the dynamic service coordination in an IoT environment, companies can improve efficiency, reduce costs and increase overall productivity (Abdulaziz et al., 2023; Kumar & Iyer, 2019).

In Industry 4.0, IoT is used in various areas, from the factory floor to supply chain management (Illa & Padhi, 2018). With IoT, it is possible to monitor and control equipment in real-time, perform predictive maintenance, optimize production, and even customize products to meet specific customer needs (Abdulaziz et al., 2023).

Implementing IoT projects can represent a significant challenge for companies, especially in an increasingly connected and digital world (Abdulaziz et al., 2023; Sátyro, Contador, & Spinola, 2020). However, the non-implementation of technologies like IoT can affect competitiveness, operational efficiency, cybersecurity, relevant data collection, and market image (Nouinou et al., 2023). Therefore, it is essential for companies to carefully assess the opportunities and challenges of IoT and strategically and effectively implement this technology (Costa et al., 2023).

This technical report narrates the problem that occurred in a micro-enterprise engaged in the injection of automotive parts, where some injection machine operators were neglecting their tasks, negatively impacting the company's production and causing financial losses. As a solution, IoT technology was implemented on two injection machines. This technical report aims to analyze the implementation project of IoT technology in this micro-enterprise and present its results. For this purpose, the structure suggested by Biancolino et al. (2012) was adopted: Introduction, Theoretical Framework, Technical Production Method, Project Context or Problem Situation, Type of Intervention and Mechanisms Adopted, Results Obtained and Analysis, Conclusion, and References.

2. Theoretical Framework

In this section, it is presented Industry 4.0, IoT and some aspects of its implementation, opportunities and challenges in the context of micro, small and medium-sized enterprises (MSMEs) that face this new technology. Additionally, it covers aspects related to project management, production and financial indicators.

2.1. Industry 4.0

Industry 4.0 is a concept that emerged in 2011 during the Hannover Fair in Germany (Da Silva et al., 2020). It represents an approach to improve manufacturing performance driven by the use of digital technologies and automation (Satyro et al., 2022). However, it does not yet have a widely accepted definition due to the challenges companies face in understanding and adopting Industry 4.0, which involves technologies such as IoT, Cyber-Physical Systems, Big Data, Simulation, Autonomous Robotics and Artificial Intelligence (Taqi et al., 2023).

According to Satyro et al. (2022), Industry 4.0 and technological advancements have enabled the integration of humans and machines through the exchange of information, fostering greater interaction within the supply chain, consumers and stakeholders.

The significance of Industry 4.0 lies in its ability to reduce costs, increase efficiency, deal with uncertainty, promote competitiveness and drive sustainable practices (Elnadi & Abdallah, 2023), ultimately creating smart factories (Taqi et al., 2023). However, its adoption is low due to complex and interconnected factors, such as a lack of strategy, digital resources, standards, knowledge and human and financial resources (Elnadi & Abdallah, 2023; Taqi et al., 2023). Understanding the barriers to Industry 4.0 adoption is crucial for its advancement (Taqi et al., 2023).

The implementation of Industry 4.0 offers benefits such as mass customization and increased productivity (Satyro et al., 2022). However, the challenges associated with its implementation include the need for cultural change in organizations, the development of new managerial skills and the difficulty in hiring and training people in technology (Satyro et al., 2022).

2.2. IoT – Internet of Things

The Internet of Things (IoT) is a cornerstone of Industry 4.0, playing a crucial role in integrating physical objects, humans, intelligent machines, product lines and processes throughout the organization. It has broad applications in manufacturing processes, enabling more autonomous and efficient scenarios (Zheng et al., 2021).

IoT is revolutionizing various areas, including engineering, agriculture, medicine and other yet-to-be-explored sectors, offering a new perspective of progress and significant advancements in terms of efficiency and societal benefits (Nižetić et al., 2020).

In essence, IoT is an interconnected network of physical devices, vehicles, appliances and other objects equipped with sensors, software and connectivity to exchange data and perform automated actions (Silva et al., 2020). Through IoT, devices can collect and transmit real-time information, enabling a higher level of interaction and control over the surrounding environment (Costa et al., 2023).

2.2.1. IoT – Implementation

Lee & Lee (2015) identify five essential IoT technologies:

a) Radio-frequency identification (RFID): This technology uses electromagnetic fields to automatically identify and capture data using radio waves, employing tags to enable greater data storage.

b) Wireless sensor networks (WSN): This involves devices with autonomous sensors spatially distributed to monitor physical and environmental conditions.

c) Middleware: It acts as an intermediate software layer between the application and technological levels, facilitating the communication implementation for software developers.

d) Cloud computing: It enables universal access to a shared set of communication resources. As IoT generates large amounts of data from internet-connected devices, cloud computing provides access to this data from anywhere and at any time.

e) IoT Application Software: It allows for the development of industry-oriented applications. Unlike devices and networks providing physical connectivity, IoT applications enable reliable and robust interactions between device-to-device and human-to-device.

Lee & Lee (2015) identify three categories of IoT applications:

a) Monitoring and Control: These systems collect data on equipment performance, energy consumption and environmental conditions, allowing real-time monitoring of the production system from anywhere and at any time.

b) Big Data and Business Analysis: Sensors and actuators embedded in devices and machines generate large amounts of data, transmitting them to systems for stakeholders to analyze and make decisions. This data is used to identify and solve business problems, such as changes in market conditions or customer behavior.

c) Information Sharing and Collaboration: In IoT, information sharing and collaboration can occur between people, objects, or even between people and objects. Typically, the first step in information sharing is the detection of a predefined event.

It is essential to note that the implementation of IoT goes beyond its parts, components and techniques; it encompasses people, interactions, financial management, challenges, opportunities, among other details that must be taken into account to achieve the best results for the company.

2.3. Opportunities and Challenges for MSMEs

The digitalization of Micro, Small and Medium-sized Enterprises (MSMEs) aims to enhance products and/or services, reduce costs, manage operations more efficiently through production performance monitoring and improve competitiveness (Nagy et al., 2023). It is crucial to raise awareness among these companies about the opportunities offered by Industry 4.0 and emphasize the added value of cooperation in this dynamic and complex context (Santos, et al., 2018). Following the example of large companies and multinational groups, despite difficulties, MSMEs can also adopt technologies and working methods to remain competitive and connected to the production chain (Iszczuk et al., 2021).

The Internet of Things (IoT) and Industry 4.0 offer interesting opportunities for MSMEs, such as access to resources and tools that were previously only available to large companies, enabling them to become more competitive in the market (Vu et al., 2023). With IoT, these companies can implement remote monitoring and control solutions, improve the efficiency of production processes and create connected products that meet customer needs (Iszczuk et al., 2021).

Furthermore, Industry 4.0 offers the automation of repetitive tasks, reducing costs and freeing up time for entrepreneurs to focus on higher value-added activities (Abdulaziz et al., 2023). The digitization of processes also provides better visibility and data analysis, enabling more informed decision-making (Zheng et al., 2021).

If MSMEs have the ability to quickly adapt to market changes and customize production according to specific customer demands, the implementation of IoT will bring opportunities for innovation and business expansion (Vu et al., 2023).

Although IoT and Industry 4.0 offer exciting opportunities for micro, small and medium-sized enterprises, they also prevent significant challenges, with one of the main challenges being the initial investment required to implement these technologies (Satyro et al., 2022; Zheng et al., 2021). MSMEs may face financial constraints that hinder the adoption of IoT solutions and process digitization (Iszczuk et al., 2021).

Santos et al. (2018) describe that the technological complexity involved in the implementation and integration of systems can become barriers, as many of these companies lack the necessary technical knowledge. Cybersecurity is also a significant concern, given that the interconnection of devices and data collection increases the risk of cyberattacks (Iszczuk et al., 2021).

Finally, Rocha & Kissimoto (2022) note that a lack of awareness and digital skills among employees can hinder the transition to the era of IoT and Industry 4.0.

2.4. Project Management

According to Carvalho & Rabechini Jr. (2011), a project consists of different phases executed sequentially to ensure its structured and organized implementation. These phases provide an overview of the project's life cycle and serve as a guide for its effective management (Carvalho & Rabechini Jr., 2011):

- Initiation: In this stage, the main objective is to identify the need or opportunity that drives the project. A detailed analysis of the problem or goal to be achieved is conducted, defining the project's vision and clear objectives. Additionally, stakeholders involved, constraints, necessary resources and potential risks are identified;
- Planning: Detailed plans guiding the project's execution are developed. The schedule is prepared, defining activities, their sequences and durations, as well as resource allocation. Planning also includes defining performance indicators, the budget, and the risk mitigation strategy. In this phase, it is essential to involve all team members and ensure clarity in all aspects of the project;

- Execution: In this stage, planned activities are carried out, resources are allocated and tasks are distributed among team members. The project manager monitors progress, ensures that activities are executed as planned and addresses any problems or deviations that may arise. Effective communication and coordination within the team are crucial for the success of this phase;
- Monitoring and Control: In this phase, the project's progress is regularly monitored to ensure that it complies with the plan. Performance is measured against established indicators and corrective actions are taken when necessary. Cost, schedule, and quality control are also conducted to ensure that the project stays within established limits;
- Closure: The project is formally concluded and delivered to stakeholders. Final evaluations are conducted to determine if objectives were achieved, results obtained and lessons learned. It is important to document all relevant project information, conduct an analysis of lessons learned and celebrate the team's successes.

2.5. Production

Effective production is an essential element for the success of any company, involving the ability to maximize the utilization of available resources, minimize waste and achieve high levels of productivity (Perdoná et al., 2017).

Effective production requires a careful analysis of existing processes, which involves identifying bottlenecks, detecting improvement opportunities and implementing strategies that increase efficiency by simplifying processes and eliminating unnecessary activities that do not add value (Sehnem et al., 2020). Additionally, effective production also involves the proper use of technology, as automation and digitization of processes can increase production speed, reduce errors and improve accuracy (Veit, 2018).

According to Tavares et al. (2017), the involvement and engagement of employees, i.e., teamwork, proper training and clear communication, are fundamental to achieving high levels of efficiency. By promoting a culture of continuous improvement and encouraging active employee participation, companies can leverage the full potential of their workforce (Tavares et al., 2017).

Effective supply chain management also plays a crucial role in production, including establishing strategic partnerships with reliable suppliers, efficient stocks management and proper demand planning (Sehnem et al., 2020).

2.6. Financial Indicators

It is common for companies to seek to reduce costs and increase productivity (Januário, 2021). Through financial indicators, they assess and monitor their finances, as these indicators provide valuable information about profitability, liquidity, operational efficiency and financial strength (Miranda & Alves, 2018).

Through the analysis of these indicators, managers can identify trends, make informed strategic decisions and anticipate possible challenges (Nunes et al., 2020). Moreover, financial indicators are also essential for investors, financial institutions and other stakeholders who use these metrics as a basis for evaluating the performance and viability of a company (Miranda & Alves, 2018).

Return on Investment (ROI) is one of the most important financial indicators for evaluating the efficiency and profitability of an investment, representing the relationship between the net gain obtained from an investment and the cost of that investment, expressed as a percentage or an absolute value (Januário, 2021). ROI allows managers and investors to measure the financial return of a particular initiative or project in relation to the resources employed, playing a fundamental role in strategic decision-making, providing a tangible measure of the return obtained concerning the investment made (Nunes et al., 2020).

Payback, or the payback period, is a financial indicator that measures the time required to recover the initial investment made in a project or venture, representing the time elapsed until the cash flows generated by the project equal the initial investment (Januário, 2021). By calculating the payback, managers can identify the financial feasibility of a project and compare it to other investment opportunities, considering the desired payback period (Januário, 2021).

3. Technical Production Method

For this technical report, the method of a single case study with interviews was employed, involving interviews with professionals from the automotive parts injection company and the IoT service provider company, along with the analysis of financial and non-financial indicators.

Ribeiro et al. (2012) discuss the importance of measuring organizational performance, emphasizing that this practice is crucial for both business managers and academics. The measurement involves quantifying the efficiency and effectiveness of past actions, generating relevant information to guide decision-making and add value to the organization's activities. There are different approaches and models for evaluating performance, including financial and non-financial measures. While financial indicators are the most common, they are not sufficient on their own. Therefore, performance evaluation should also cover operational aspects such as productivity and quality, as well as socio-environmental dimensions, aiming for sustainable development (Ribeiro et al., 2012).

Interviews are widely used to collect qualitative data and there are different approaches that have emerged from various disciplines. The purpose is to actively involve the interviewee in constructing meaning to generate knowledge (DiCicco-Bloom & Crabtree, 2006).

For this technical report, interviews were conducted with the person in charge of the thermoplastic injection microenterprise that installed IoT in two of its injection molding machines and with the person in charge of the automation microenterprise that implemented the technology.

The implementation project took place in 2020 after negotiations between the company's stakeholders. In these negotiations, the technology developer (responsible for the automation company) presented the advantages of its implementation, such as real-time control of production processes, production improvements and cost reduction.

4. Project Context/Problem Situation

The microenterprise specializing in automotive injection parts, located in the eastern zone of São Paulo, which commissioned the installation of IoT technology and provided this technical report, is a company serving clients from various regions of the country. It caters to both large corporations and small to medium-sized enterprises in the automotive sector.

As such, it is a crucial supplier of parts for the automotive market, including motor couplings, drag adapters, pulley adapters, reclining lever, seat handle, among many other parts for various car models.

4.1. Production Context

The production of these plastic parts is carried out through the injection molding process, and it is important to describe the process of the injection molding machine and its operator.

An injection molding machine is an industrial equipment used for manufacturing plastic parts through the injection molding process. The plastic injection process involves injecting molten plastic into a mold to create a part with the desired shape. For this process, a step-by-step approach is followed, where initially, the mold is fixed on the injection molding machine and closed so that the two halves of the mold are close to each other. The mold typically consists of two steel plates containing an injection channel and the cavity for the molded part. Next, the plastic is heated and melted in an injection cylinder located in the injection molding machine.

The melted plastic is then injected into the mold through an injection nozzle, which pushes the plastic into the injection channel and the mold cavity. After the plastic is injected into the mold, the material begins to cool and solidify. The cooling time varies depending on the type of plastic and the complexity of the part. When the plastic solidifies, the mold is opened to remove the molded part. The part is ejected from the mold using ejector pins that push the part out of the mold cavity.

Once the part is ejected from the mold, it is removed from the injection molding machine by a robot or a human operator. The part is then inspected to ensure it meets quality requirements. Finally, the remaining plastic not used for molding is recycled and can be used in future injection processes. It is important to note that each injection process may vary depending on the complexity of the part, the type of plastic used, and the specifications of the injection molding machine.

The operator of an injection molding machine is the professional responsible for operating and monitoring the equipment during the plastic injection process. Among the necessary responsibilities and skills are:

- Equipment preparation: before starting the injection process, the operator needs to check whether the machine is clean and correctly lubricated. The operator must configure the mold, injection channel and injection cylinder temperature;
- Process monitoring: During the injection process, the operator must monitor the machine and the injection process to ensure that everything is proceeding as expected. He must check the injection pressure, plastic temperature and injection speed;

- Troubleshooting: if a problem occurs during the process, the operator must be able to identify the cause of the problem and take measures to resolve it, and notify his supervisor. This may involve modifying some settings, changing parts or maintaining the machine;
- Quality inspection: after injection, the operator must inspect the quality of the molded part, checking the appearance, dimensions and mechanical properties to ensure that the part is within specifications.

In addition to these responsibilities, an injection molding machine operator must have communication skills to report any problems or concerns to the supervisor or maintenance department. Therefore, it is important that the operator has attention to detail and is able to work accurately and safely.

4.2. Company in Analysis

Inaccuracies during the company's injection process, until 2020, occurred due to human error. Among the main mistakes made by operators were:

- Use of inadequate pressure and temperature, which resulted in problems with the equipment;
- Increased injection cycle time, resulting in constant trips to the bathroom and cafeteria, which reduced production;
- Do not notify the leader about the machine being stopped in order to have idle time.

It is worth mentioning that the machine is a complex piece of equipment, full of electronic and mechanical components, it can present defects, and that during the injection process, some gear can get stuck, a part can get stuck, in short, but the operator has the responsibility and duty to inform the leader so that action can be taken.

With the problem reported above, knowing that the company provides training for its employees and that even so, some continued to neglect their tasks, the automation micro company from the city of Atibaia, proposed a project to implement IoT in its injection molding machines. This technology has the capacity to report information relevant to the business, fully customizable, in which those responsible for the company have access to any information about the operation of their machinery regardless of whether they are present in the organization or not.

5. Type of Intervention and Mechanisms

The system was installed on two injection machines, significantly improving the processes of both the equipment and its operators, which resulted in better business management, as since then it has been possible to act more punctually in current situations, which has generated greater productivity, cost reduction and, consequently, increased profit.

To develop the implementation of IoT in the injection micro company, the steps described in table 1 were followed, as proposed by Carvalho & Rabechini Jr. (2011).

Table 1

IoT implementation project stages

Stage	Step Description	Involved
Initiation	Defining the project objective	Responsible for injection and automation micro-companies
Planning	Company management maturity analysis	Responsible for injection and automation micro-companies
Planning	Infrastructure analysis	Responsible for the automation micro-company and IT Technician for the injection micro-company
Execution	Programming, manufacturing of IoT devices and installation	Responsible for automation microcompany
Execution	Dashboard Generation	Responsible for automation microcompany
Execution	Training the company's operational team	Responsible for the automation micro-company, injection molding operators and supervisor
Monitoring and Control	Data tracking and sharing	Responsible for injection and automation micro-companies
Closing	Customization of data to be made available and monitoring	Responsible for injection and automation micro-companies

Fonte: Elaborado pelos autores.

The project began, as shown in Table 1, through a meeting between those responsible for the injection company and the automation company, where the objectives were defined. The manager of the injection company was looking for a solution for his production. The problems were:

- Use of inadequate pressure and temperature, which led to problems with the equipment;
- Changing the injection cycle time on purpose, in order to make constant trips to the bathroom and cafeteria, which reduced production;
- Do not notify the leader about the machine being stopped in order to have idle time.

Given the report, the person responsible for the automation company carried out a survey and monitored the maturity of the company's management, that is, he gathered and verified the documentation of the production processes. This process aims to identify whether the company is capable of receiving IoT technology. Furthermore, to implement the Industry 4.0 project, the company's infrastructure was analyzed together with its IT technician. To continue the project, the company needed to provide a robust Wi-Fi network with a router that could support multiple devices connected at the same time.

Once ready to receive IoT technology, the processes began to be executed. First, the electronic boards containing microprocessors to receive digital signals and transmit them via Wi-Fi, in addition to reading RFID cards, were manufactured, programmed (with Firmware developed for the respective injection molding machines) and tested. These plates were then installed in the injection molding machines.

Once installed, the injection production process began, which at this point already had data capture and transmission. In this way, dashboards were created, which are used to visualize data individually. This data can be viewed using a cell phone, notebook or tablet.

Training was carried out with the injection molding operators and supervisor. During the training, the procedures for swiping an RFID card and identifying and interpreting the information on the device's display screen were covered.

Then, a new meeting was held between those responsible to analyze the data that was already being generated, and check which data were the most important (customization) for the company's management. In this case, the relevant information was:

- Injection stoppage, as this way, any problem with the equipment, the manager would know about this stoppage in real time. Thus, solutions to such a situation would be taken more quickly and effectively;
- Employee who is operating the injection molding machine, in order to hold him responsible for production during his working period;
- Production service order, to identify which production, which product, quantity, in short, the details of the process.

With the details defined, reports began to be generated, monitored and sent to the company's management. All this information is available in the cloud and can be viewed at any time and from anywhere. For this, an MQTT broker platform based on AWS is used.

The IoT implementation project lasted three months, and the entire process was rigorous and guaranteed the confidentiality of the company's information, as the data is end-to-end encrypted.

6. Results Obtained and Analysis

All data, financial and non-financial, were collected using an Excel spreadsheet prepared with financial calculations for financial indicators and free-filling for non-financial indicators. To inform the percentages of non-financial indicators, the injection company used documents and histories of its production processes, in order to analyze the evolution or not of these before and after the implementation of IoT.

From the documents completed by the injection company, the financial results described in table 2 and non-financial results in table 3 were obtained.

Table 2
Financial Results

Financial Indicator	Result
ROI	182,73%
PayBack	3,06 months

Fonte: Elaborado pelos autores.

As financial indicators, observed in table 2, according to Miranda & Alves, (2018), ROI and Payback were analyzed. To calculate the ROI, the following was used: ROI = Total Annual Gain (Gain in labor + Gain in increased machine operating time) – Total Annual Project Cost / Total Annual Project Cost. To calculate the payback, the following formula was followed: Payback = Project Cost / (Total Annual Gain / 12 months) – (Annual project cost / 12 months).

For the calculations, only gains greater than the revenues that the company earned before implementation were used. In other words, this information already expresses that the company had positive returns with IoT. An ROI of 182.73% is very significant and important to make the IoT implementation project viable. Furthermore, a payback of 3.06 months also demonstrates that the project was viable, as the investor recovered his investment, considering the short term.

Table 3

Non-Financial Results

Non-Financial Indicator	Before	After
Production quality	97%	98%
Injector performance	95%	98%
Injector availability	54%	60%

Fonte: Elaborado pelos autores

Table 3 shows three non-financial indicators. It is possible to see a small but significant evolution in production quality, from 97% before to 98% after implementation. To obtain this indicator, the injection company management's assessment of the quality of the entire production process before and after the project was taken into account.

Regarding the performance of the injection molding machine, which increased from 95% to 98%, it was mainly observed its production. Before implementing the project, the manager had reported problems with the poor operation of his equipment by the operators, in addition to them not informing their leader about necessary repairs to the injection molding machine in order to have idle time, which resulted in more maintenance and a reduction in production.

Finally, an increase in injection availability was observed from 54% to 60%, confirming Sehnem et al. (2020), who consider the elimination of unnecessary tasks to be relevant. In this case, the implementation of IoT significantly improved the problem of increasing the production cycle due to constant trips to the bathroom and cafeteria, which caused lower production of the injection molding machine, confirming Nižetić et al. (2020) and Zheng et al. (2021), who cite relevant gains with IoT.

7. Conclusion

This technical report aimed to analyze the IoT technology implementation project in two injection molding machines in a thermoplastic injection microcompany, from financial and non-financial aspects.

IoT is one of the technologies arising from Industry 4.0 that aims to digitize equipment in order to improve the effectiveness of processes. Through it, it is possible to obtain information in real time, about a company's assets, helping in decision making.

As a methodology, a technical report was used with data collection through interviews with those responsible for the injection company, in the automobile sector, and with the person responsible for the automation company. Financial indicators (ROI and Payback) and non-financial indicators (production quality, injection molding performance and injection molding availability) were analyzed.

The project was implemented in 2020, lasting three months, and followed the five phases proposed by Carvalho & Rabechini Jr. (2011) of a project: initiation, planning, execution, monitoring and control, and closure.

The results obtained showed the effectiveness of the IoT implementation project, as it contributed to solving the injection company's problems, improving its production process. Furthermore, the company obtained a significant financial return within a three-month period considered short by the investor.

The single case study method is a limitation that does not allow the generalization of this study, although it points significant direction. For future studies it is suggested to increase the number of companies involved to verify the generalization of these findings.

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