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SYSTEMATIC PROPOSITION OF INTEGRATION BETWEEN DEVELOPMENT OF AGRICULTURAL MACHINES AND QUALITY MANAGEMENT SYSTEM FOR THE INDUSTRIAL SECTOR

Franco da Silveira
Universidade Federal de Santa Maria (UFSM), Brazil
E-mail: franco.da.silveira@hotmail.com

Filipe Molinar Machado
Universidade Federal de Santa Maria (UFSM), Brazil
E-mail: fmacmec@gmail.com

Janis Elisa Ruppenthal
Universidade Federal de Santa Maria (UFSM), Brazil
E-mail: profjanis@gmail.com

Leonardo Nabaes Romano
Universidade Federal de Santa Maria (UFSM), Brazil
E-mail: romano@mecanica.ufsm.br

Marcelo Silveira de Farias
Universidade Federal de Santa Maria (UFSM), Brazil
E-mail: silveira_farias@hotmail.com

Luis Cláudio Villani Ortiz
Universidade Regional Integrada do Alto Uruguai e das Missões, Brazil
E-mail: ortizluis@bol.com.br

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ABSTRACT

One of the problems of multiple variables and constraints that is found in the productive systems of the companies and is responsible for influencing the final quality of the product is the proper selection of the material used in the manufacturing. Thus, in order for there to be no divergences between specification and design requirement in the process, effective guidelines are required to verify their conformity upon receipt. The verification is carried out by means of technical tests, on other hand, to obtain the characteristics of the mechanical properties of the same.

The general objective of this paper is to present systematic proposals for the preparation of quality assurance of mechanical tests on the reception of metallic materials applied to the development of agricultural machinery. In methodological terms, a Systematic Literature Review (SLR) was applied and multiple cases were studied. This research is classified as descriptive and comparative, of an exploratory nature that uses a set of data collection, analysis and treatment actions, in order to assist in the development of planned and organized activities that make it possible to implement the necessary tests for the correct qualification of the material received by the companies. The results present a systematic proposition that can be adopted in the accomplishment of mechanical tests in metallic materials in the control of reception in companies that develop agricultural machines and that can help other market segments.

Keywords: Agricultural Machinery; Quality Management; Mechanical Testing.

1. INTRODUCTION

With the presence of factors such as high competitiveness and economic globalization in the industrial sectors, as organizations increasingly seek to adapt as market changes (SIMÕES et al., 2013, SCHÖNERER; WAGNER, 2016). It is necessary that, as developed companies, organizational and productive restructuring, with the purpose of forcing new implementations and technological modifications, which will result in the expansion of its organizational businesses (MOHAGHEGHI; APARICIO, 2017).

As a consequence of the exposure, an adoption of a Quality Management System (QMS) is vital in many companies, especially in taking strategic positions that have advantages over competitors (CATER-STEEL; LEPMETS, 2014; RABIEH et al., 2016).

The implementation of a specific QMS for the laboratory environment of the company has the purpose of delivering reliable and traceable results throughout the production system. A number of authors argue that the introduction of a QMS and the accreditation of laboratories according to standardization are not easy tasks (KONOVALOVA; POPOVA, 2010; GROCHAU; CATEN, 2012; RUIZ-TORRES et al., 2017).

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According to Abdel-Fatah (2010), the technical competence of the laboratories becomes critical for the manufacturer, supplier, exporter and the consumer, which reinforces the importance of the implementation of management systems for testing and calibration laboratories.

As regards standards, the main one is NBR ISO/IEC 17025. It is an international standard aimed at the laboratory environment, which is responsible for determining the necessary requirements for testing and calibration laboratories to demonstrate their technical competence and the validity of the results provided (ABNT, 2005; GROCHAU; CATEN, 2012; SILVA et al., 2015).

In order to obtain the so-called "accreditation", the testing laboratories must meet a number of factors, including monitoring the validity of the mechanical tests performed (GARCIA; SILVA; PEREIRA, 2015; SABBAGHA et al., 2016). Therefore, the quality assurance of the test results is directly associated to the process flow. The methods can include internal comparisons, proficiency testing, test replication, control chart usage, among others and are necessary to avoid problems that relate to the technical specifications of the final product (LIXANDRU, 2016; RABIEH et al., 2016).

The design and implementation of an organization's QMS is influenced by different needs, specific objectives, products supplied, processes employed and by the size of its organizational structure. To be effective, the QMS should identify and manage the various interrelated activities (RABIEH et al., 2016).

In this context, when an activity is dependent on the subsequent one and both are managed in a way that allows the transformation of inputs into outputs, they can be considered a process (SANTOS, 2010). The main factors that influence the process and, consequently, the end product, are the material, part or component received from the supplier.

Thus, in order to obtain satisfactory results, it is necessary to have an efficient performance of the sectors involved in the project (ROZENFELD et al., 2006; HOSSEINIJOU et al., 2014; VELDEN et al., 2015).

The ISO 9000 (ABNT, 2010) standard establishes requirements that help improve internal processes, monitor the work environment, increase employee

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qualification, and verify the satisfaction of customers, employees and suppliers, as part of an ongoing process to improve QMS.

The requirements apply to areas such as materials, products, processes and services (ABNT, 2010). For the different classes of standardizations ISO 9001 is used, which explains the requirements that must be adopted for inspection and testing before the product is shipped by the supplier and upon receipt by the customer.

In addition, for conformity conferencing, the standard refers to inspection, measurement and testing equipment that guide the quality of the product being shipped and received, as well as the final process (RAUBER et al., 2014; PEREIRA; GRACIANO; VERRI, 2016).

The determination or knowledge of the mechanical properties is relevant for the selection of materials as well as for their application. Properties are responsible for defining the behavior of the material that is subject to mechanical stresses during the process or service (CALLISTER JÚNIOR, 2006).

The properties can be obtained by means of mechanical tests, which are standard methods. Standardization is important so that there is a common language between suppliers and users/customers of materials (SOUZA, 1995; GARCIA; SPIM; SANTOS, 2012).

In this sense, this study aimed to present systematically propose guidelines for the preparation of quality assurance of mechanical tests on the receipt of metallic materials applied to the development of agricultural machinery. In order to do so, the work begins by presenting a theoretical rescue on the quality management system, its main aspects of implementation and benefits generated for the company and its suppliers.

In addition, we emphasize the quality assurance of testing laboratories and fundamentals of mechanical tests on materials. Subsequently, the methodological approach that was used in the empirical part of the study is presented. In the sequence, the results are presented and, finally, the conclusions of the work.

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2. BACKGROUND

2.1. Quality Management System

The importance of Quality Management System (QMS) is directly related to the company's processes and how to improve the quality of products and services to customers (SILVA et al., 2015). The QMS is an organizational strategy used to deal with the diversities arising from a constantly evolving economy (PEREIRA, 2015).

Material selection is one of the key elements that actively acts in business strategies. Thus, the suppliers choice for their production chain represents a continuous improvement, aiming to guarantee the improvement in the processes that involve the different components and services acquired (GALDAMEZ; LOPES, 2013).

Figure 1 exemplifies the information process and the flow of materials involved in the decision-making process for product manufacturing, which should be optimized to reduce consumer waiting time.

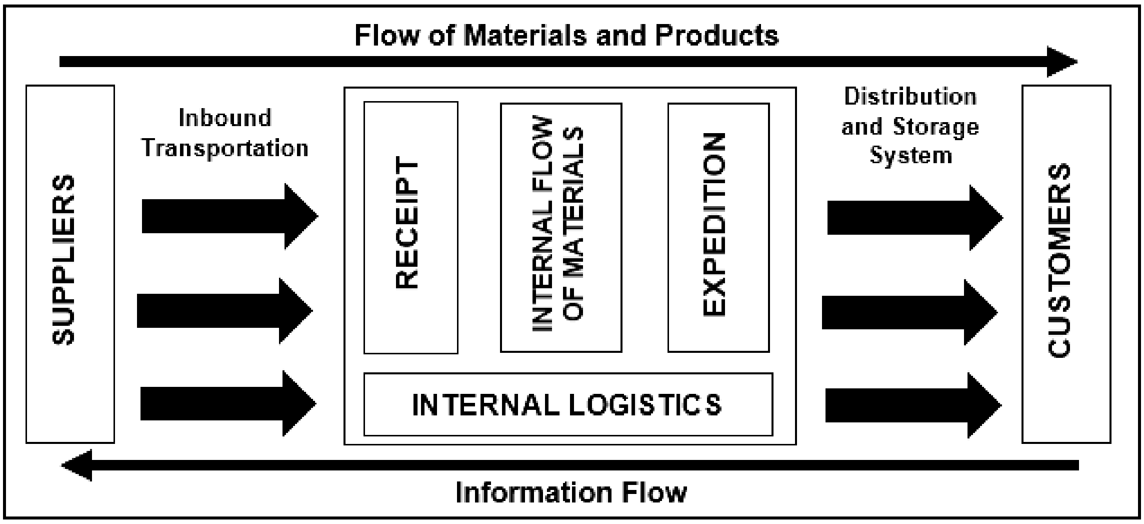

Figure 1: Flow of materials and information in business logistics.
Source: Adapted from Slack et al. (1999).

One of the factors of great importance to obtain greater assurance of the conformity of the materials received is to identify and select the suppliers correctly. The supplier selection process is not simple and the complexity increases depending on the characteristics of the item to be purchased (MOHAGHEGHI; APARICIO, 2017).

The ISO 9001 standard provides a set of standardization for a given service or product and specifies the requirements for a QMS that can be used by organizations

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for internal application, certification or for contractual purposes that seek to meet customer requirements (RAUBER et al., 2014, NOGUEIRA; DAMASCENO, 2016).

With the implementation of the standard, there is a relationship of trust between the company and the client results. An organization that has a QMS according to ISO 9001 can request certification and obtain the "ISO 9001 compliance seal" (ABNT, 2015).

It should be noted that the QMS has the function of helping the manager to find and correct inefficient processes that occur in the organization (SILVA et al., 2015; PEREIRA; GRACIANO; VERRI, 2016). The adoption of a QMS is a strategic decision and its development and implementation are specific to each type of organization. The main objectives of a QMS are: i) to meet customer requirements in order to increase customer satisfaction; ii) obtain a view of the organization using the process approach; iii) ensure continuous process improvement; iv) measure and evaluate the results of the performance and effectiveness of the process; and v) continuously monitor customer satisfaction (ABNT, 2015).

Thus, it is noted that ISO 9001 aims to provide confidence that the supplier can consistently and repetitively supply goods and services as specified. Thus, the ISO 9001 certified supplier is characterized by meeting the requirements of ISO 9001, for establishing a systemic approach to quality management and for managing its business in such a way that it ensures that its needs are understood, accepted and (ABNT, 2015). Table 1 shows the different requirements that are determined by ISO 9001 and that contribute to a correct acquisition of products or materials.

Table 1: Main objectives of ISO 9001.

Factors	Conditions	Specifications
Acquisition of Products and Services	Acquisition Process	The organization shall ensure that the product purchased complies with the specified procurement requirements. The type and extent of control applied to the supplier and the product purchased should depend on the effect of the product purchased on subsequent product realization or on the final product.
	Acquisition Information	Procurement information should describe the product to be procured and include, where appropriate, requirements for: a) product approval, procedures, processes and equipment; b) qualification of personnel; and c) quality management system. The organization shall ensure the adequacy of the specified procurement requirements prior to its communication to the supplier.
	Verification of Purchased Product	The organization shall establish and implement inspection or other activities necessary to ensure that the product meets the specified procurement requirements.

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Production and Supply of Services	Control of Production and Service Provision	The organization shall plan and perform production and service provision under controlled conditions. Controlled conditions shall include, where applicable: a) the availability of information describing the characteristics of the product; b) the availability of work instructions, when necessary; c) the use of adequate equipment; d) the availability and use of devices for monitoring and measurement; e) the implementation of measurement and monitoring; and f) the implementation of the release, delivery and post-delivery activities.
	Control of Measuring and Monitoring Devices	Where it is necessary to ensure valid results, the measuring device shall be: a) calibrated or checked at specified intervals or before use, against measurement standards traceable to international or national measurement standards; when this standard does not exist, the basis used for calibration or verification shall be recorded; b) adjusted or readjusted, when necessary; c) identified to enable the calibration situation to be determined; d) protected against adjustments that may invalidate the measurement result; and e) protected from damage and deterioration during handling, maintenance and storage.

Source: Adapted from ABNT (2015).

The organization shall plan and implement the necessary monitoring, measurement, analysis and improvement processes to demonstrate product or material conformity. It should be noted that for inspection and testing ISO 9001 requires that the raw material be inspected (by documented procedures) prior to use; that inspection, measurement and testing equipment shall receive procedures for calibration/measurement, control and maintenance; that for the inspection and testing situation there should be in the product or material some indicator that shows what inspections and tests it has passed and whether it has been approved or no.

2.2. Quality Assurance of Testing Laboratories

The presentation of reference documents, replication of retained item essays and participation in reference documents, replication of retained item essays, and participation in intra-laboratory and interlaboratory programs. In accordance with an ISO/IEC 17025 (ABNT, 2005; GROCHAU; CATEN, 2012) standard specifies the requirements for quality assurance of test and calibration results in section 5.9, the laboratory shall have a quality control procedure to monitor the validity of the tests and calibrations performed. In addition, the resulting data must be provided according to trends and detectable, where practicable, statistical techniques should be applied for critical analysis of results.

Dicla/Cgcre mentions the requirements regarding the participation of laboratories in proficiency testing activities through the NIT-DICLA-026 standard. In

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the case of non-compliance by laboratories accredited in ISO/IEC 17025, this constitutes non-compliance, since item 4.1.2 emphasizes that it is "the responsibility of the laboratory to carry out its testing and calibration activities in order to meet the requirements of standardization and meet the needs of customers, regulatory authorities or organizations that provide recognition" (ABNT, 2005; INMETRO, 2011).

In addition, item 9.1 of NIT-DICLA-026 refers to the general policy for participation in proficiency testing, in which laboratories must demonstrate the technical competence in performing the accredited tests and calibrations through satisfactory participation in proficiency testing (TP) where they are available. If there are no TP activities available at the required frequency, the laboratory must demonstrate by other mechanisms that it has technical competence. After obtaining accreditation, the laboratory must participate in at least one TP activity for each significant part of its accreditation scope, every four years (INMETRO, 2011).

2.3. Mechanical Tests on Materials

The design of any mechanical component, or any engineering project, requires a thorough knowledge of the properties, characteristics and behavior of the materials. From the practical point of view, the mechanical properties stand out with greater importance in the engineering, since they are related to the resistance of the metals that are subjected to efforts of mechanical nature. Based on their determination and knowledge, all metallic components used in industry and fixed and mobile structures are designed, calculated and executed (CALLISTER JÚNIOR, 2006).

Some industries use tests to control production, and are called routine tests. They are performed in analysis laboratories or in industrial machines, with no need for precision, and a machine error of up to 1% can be admitted. However, when they aim to obtain mechanical properties for research or study of materials, they use more precise machines, increasing reliability. Thus, control devices with a high degree of precision are required, unlike ordinary machines used in companies for routine tests (SOUZA, 1995; ASKELAND, 2012). In addition, it is important to emphasize the performance of tests in specialized laboratories, since the development and

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improvement of the products depend significantly on the availability and quality of mechanical and technological tests (SHIGLEY, 2005).

According to Garcia, Spim and Santos (2012), the mechanical properties of the metallic materials are determined through several tests, where they can be destructive, where the rupture or destruction of the part and the test or non-destructive component occurs, which are used to detect internal faults in parts and components, not causing them to become unusable. The tests shall be performed according to the geometry of the part and component, the manufacturing process and according to the current technical standards. The methods of testing may be by means of part or component tests, model tests, sample tests, and tests on specimens taken from part of the structure (CALLISTER JÚNIOR, 2006; ASKELAND, 2012).

2.4. Agricultural Machinery Development Process

The Agricultural Machinery Development Process (PDMA) is used in the context of the Brazilian companies of the industrial sector of agricultural machinery to guarantee important competitive advantages against the market competitors (OLIVEIRA; DALLMEYER; ROMANO, 2012; SILVEIRA; MACHADO; RUPPENTHAL, 2017). Figure 2 represents the reference model, which aims to disseminate knowledge about the PDMA process and its formal practices.

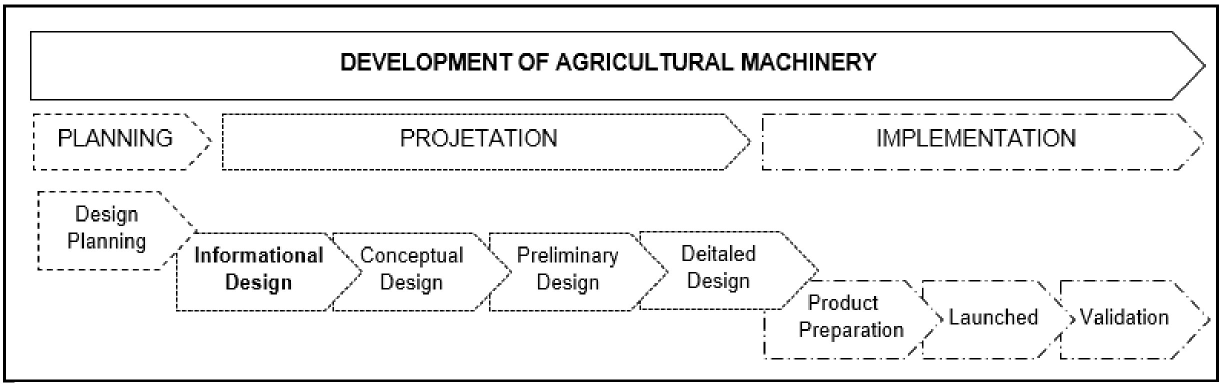

Figure 2: Process, macro phases and phases of the reference model for PDMA.
Source: Adapted from Romano (2013).

The reference model encompasses a planning macro phase, which covers the planning phase of the project itself; a macro phase of design, which involves the elaboration phases of the informational, conceptual, preliminary and detailed designs of the product and the manufacturing process; and the implementation macro phase, which includes the phases of production preparation, market launch, validation of the

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agricultural machine and closure of the project (ROMANO, 2013; BERGAMO; ROMANO, 2016).

In general, as practices that seek to achieve improvements in cost, time, and manufacturability are related to the informational design phase in PDMA. Figure 3 represents how tasks are part of the information design phase, which is intended to define the design specifications of the agricultural machine and is responsible for establishing a presentation by the agricultural machine design plan.

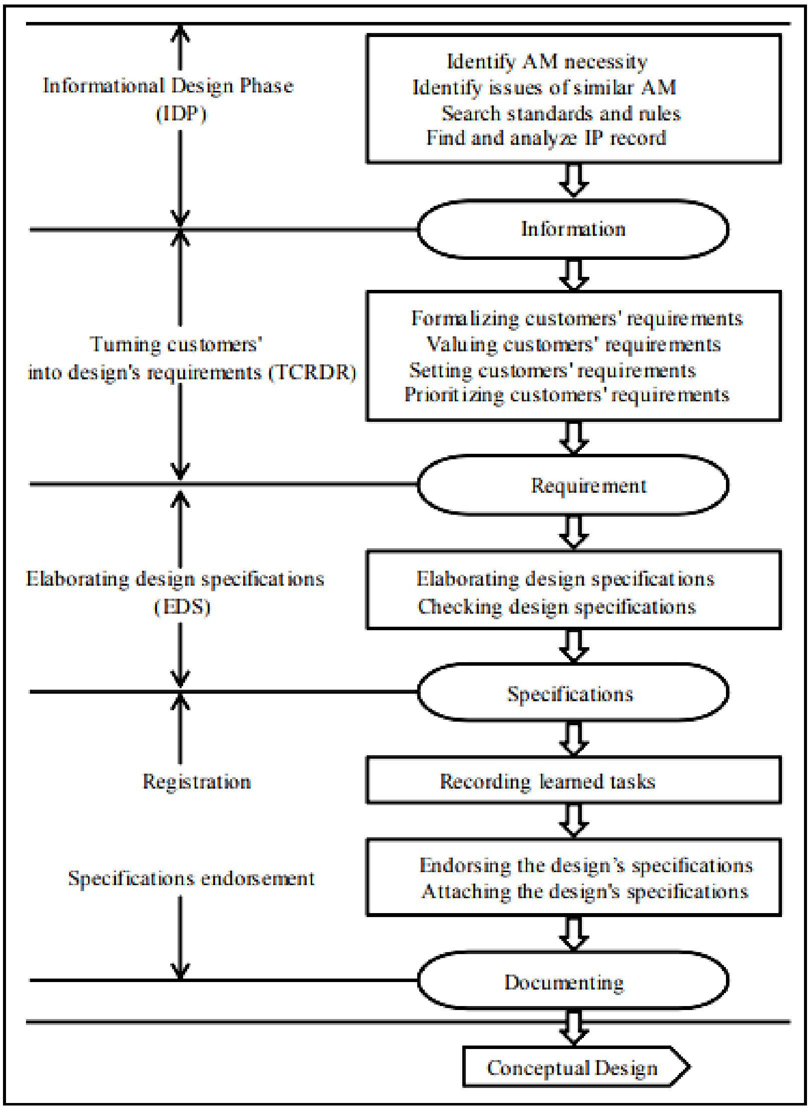

Figure 3: Informational Design PDMA.
Source: Bergamo and Romano (2016).

The phase of the informational project is characterized as the moment of the project to collect and analyze a set of information that specifies the product with the greatest clarity in order to guide the generation of future project solutions. Design is the second macro phase of the PDMA, which begins with the informational project that is responsible for defining the design specifications of the agricultural machine,

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according to Figure 3, and consolidate the product requirements from information from sources such as customers, vendors and the competition to deploy them in design specifications.

3. METHODOLOGY

The research methodology adopted to conduct the theoretical part of the present study was the Systematic Literature Review (SLR). The SLR is a methodology that uses as a data source the existing literature on a given topic, selects and evaluates contributions, analyzes and synthesizes data. It describes the evidence in order to allow clear conclusions about what is already known, as well as what is not known about the subject matter in question (DENYER; TRANFIELD, 2009).

Were selected the databases Google Academic, ISI Web of Science, SciELO, Science Direct and Scopus. The scope of the literature review includes articles published in journals and journals that deal with mechanical tests, metal materials, quality management, mechanical testing laboratories, laboratory quality assurance, test accreditation, standards for testing metal materials, materials.

The databases were selected for presenting more comprehensive and thus enable the identification of information to improve the context of the research theme. The scan is characterized as theoretical-conceptual (LOPES; CARVALHO, 2012).

The scope of SLR includes articles published in periodicals and journals dealing with mechanical testing, quality management and laboratory quality assurance. It was necessary to adopt logical operators available for advanced searches, thus, the keywords (without quotes and without refinement by area of knowledge) to be used in the theoretical survey in the databases were established.

After searching the databases, the refinement of the research considered all available years and adopted the criteria of language (Portuguese/English), types of documents (article/review).

After application of the initial filters, approximately 37 articles were identified. It should be noted that the chronological survey of articles is allocated according to the search string. Considering the searches made in the selected databases, the research reference points were defined, which compose the synthesis set elaborated on each one of the topics listed in the general structure of the article.

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Subsequently, the articles were analyzed from the literature found and, thus, a synthesis of each of them was carried out, presenting its main characteristics. There were also identified none articles in which there are intersections between the themes and that were later analyzed in the light of the mentioned research questions. The analysis was done with the help of Mendeley and NVivo® software.

In the second part of the research, from the flow illustrated in Figure 4 and Figure 5, the steps that were necessary for the practical accomplishment of the research are sequentially observed. The initial stage was the formulation of the research problem and its delimitation, where an interface between the material selection area and the logistics was carried out. The general and specific objectives were then elaborated. In the third stage, the theoretical study was done, as a way of knowing the state of the art on the areas of interface, material selection and logistics.

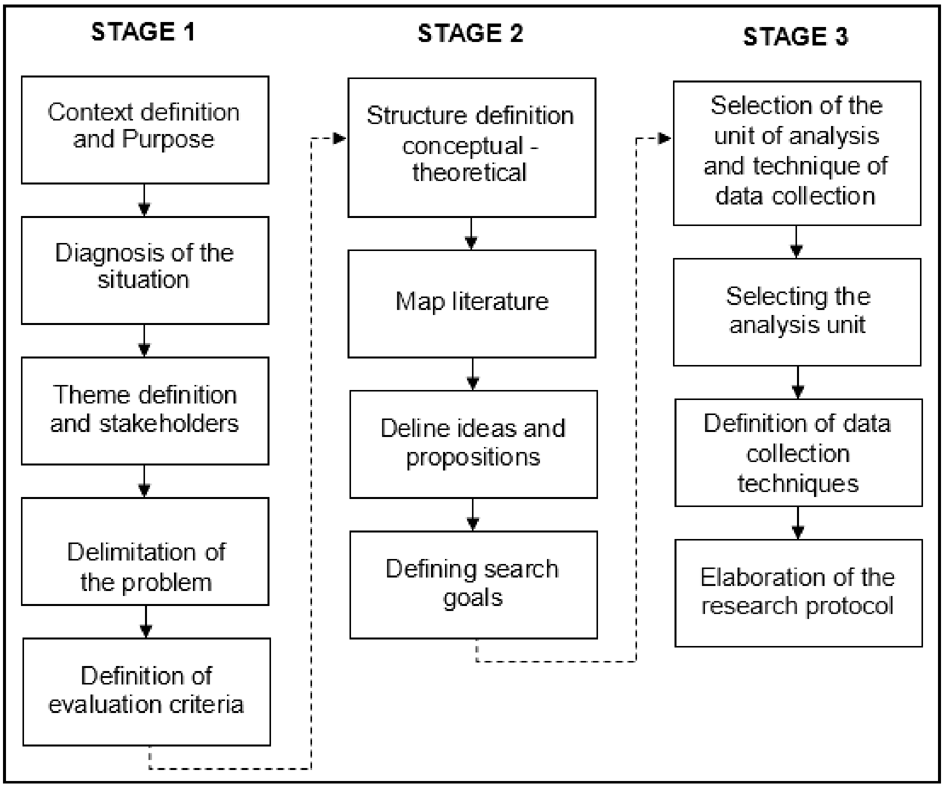

Figure 4: Activities conducted to conduct research.
Source: Authors (2017).

In the fourth stage, through the theoretical study, the general framework of variables and indicators was determined. In the fifth step, the candidates to compose the guidelines were selected from the table of variables and indicators. In the sixth stage, the theoretical guidelines were elaborated, in the form of a flowchart, through the selected indicators.

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In the seventh stage, the model was discussed and the need to optimize it was verified. Figure 5 depicts the flow of the steps described above. In addition, it is noteworthy that the data collection was performed based on the structured questionnaire applied in companies and the results obtained in this research underwent a statistical analysis process.

The questionnaire was sent to 20 companies in the metal mechanics sector, located in the northwestern region of Rio Grande do Sul (RS), from January to May 2017.

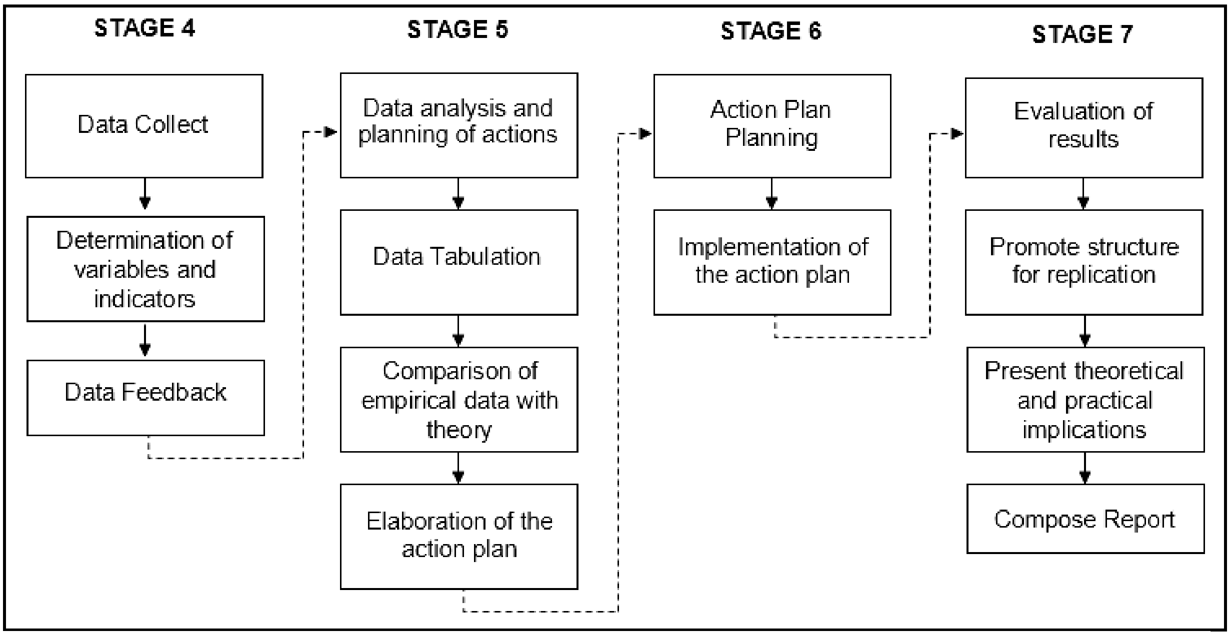

Figure 5: Activities conducted to conduct research.
Source: Authors (2017).

The questions in the questionnaire were related to the procedures and tests used to receive metallic materials. In the questionnaire, information regarding the main metallic materials purchased was considered; number of suppliers for each material; the function of the acquired material; the specifications of the materials required in the acquisition; to the selection process carried out by the company; the use of logistics information in the selection of material; the details of catalogs; to the company's view on a system that selects material and supplier at the same time, based on the interrelationship between technical material information and logistical information. In order to maintain the confidentiality of the companies, numbering was used to characterize them. The procedures used to analyze the information were: coding of the answers, tabulation of data and interpretation of the particularities. The Microsoft Office® Excel 2013 tab was used.

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4. RESULTS AND DISCUSSIONS

The characteristics of the respondent and the company of each of the questionnaires applied can be observed in Table 2. It can be verified that the responses were from companies of different sizes, as medium-sized companies (with 100 to 499 active employees) or as large (with 500 or more active employees).

Table 2: Characterization of the respondent and the company.

Company	Sector of the Respondent	Respondent's Position	Company Activity	Number of Employees	Number of Suppliers of Metal Products	Present Laboratory for Receiving and Testing Material
1	Production	Management	Manufacture of Agricultural Components	250	20	-
2	Shopping	Purchasing Assistant	Parts and Agricultural Implements	150	18	-
3	Quality	Quality Inspector	Manufacture of Agricultural Implements	2500	56	✓
4	Quality	Quality Inspector	Metallurgy	200	25	-
5	Production	Production Coordinator	Machines and Equipment	500	30	✓
6	Production	Production Manager	Casting and Machining	900	42	✓
7	Warehouse	Warehouse Coordinator	Parts and Agricultural Implements	1500	65	✓
8	Shopping	Purchasing Manager	Metallurgy	350	25	-
9	Shopping	Purchasing Assistant	Metallurgy	100	16	-
10	Production	Production supervisor	Foundry	300	30	-
11	Shopping	Business Analyst	Machines and Implements	250	22	-
12	Warehouse	Auxiliary Warehouse	Metallurgy	200	32	-
13	Production	Production Supervisor	Machines and Equipment	180	17	-
14	Quality	Quality Manager	Agricultural Machinery	75	16	-
15	Management	Production Manager	Agricultural Machinery	240	31	-

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16	Project	Project Leader	Metallurgy	175	19	-
17	Product	Product Director	Machines and Equipment	90	14	-
18	Laboratory	Laboratory Chief	Lifting Machines	160	20	-
19	Quality	Quality Inspector	Machines and Implements	210	26	-
20	Quality	Quality Inspector	Agricultural Machinery	195	21	-

Source: Authors (2017).

All the companies interviewed stated that they have differences in the metallic products received by the suppliers. For 67% of the companies, they are made in metallic products received from suppliers and suppliers for 33% of companies and frequency of inspection performed weekly. It should be noted that the lowest percentage of reference in medium-sized companies, which is a smaller number of suppliers. In addition, 50% are satisfied with the sampling control currently used by them and 50% are not fully satisfied with the present system to verify the conformity of the metallic materials received.

When questioned about the existence of own laboratories to analyze the metallic materials received, 75% of the companies reported that they have equipment and 25% do not have any type of equipment with these ends and that they end up outsourcing this service. Thus, it was verified that the durometer is used in 67% of the companies as a method of verification of the metallic materials received, the spectrometer is used in 25% of the companies and in 17% the microdurometer. None of the companies has a tensile testing machine and 25% said they do not have any machines for inspection.

Figure 6 shows the percentage of trials that are outsourced by companies. It was verified that 58,33% of the companies interviewed outsourced the chemical analysis, because they did not have the necessary equipment to obtain the percentage of each chemical element in the material; 50% of the companies outsource the traction test; 25% of companies outsource the hardness test; and 16,67% of the companies interviewed do not outsource any type of trial. Recalling that the type of test varies according to the needs of the company and the characteristics of the material that the company wishes to analyze.

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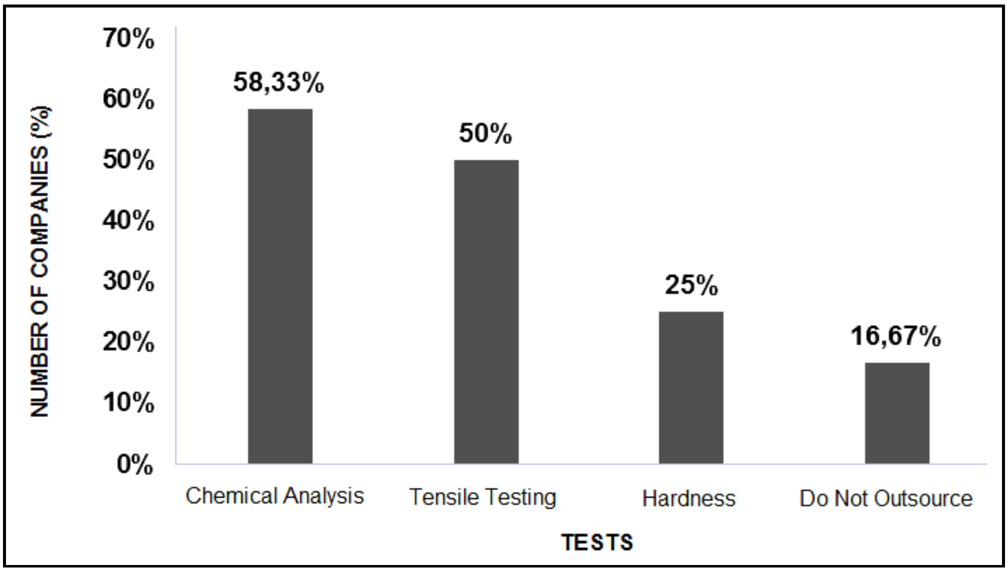

Figure 6: Trials outsourced by companies.
Source: Authors (2017).

Figure 7 refers to the investments in technology areas presented by the companies participating in the research. From the question about the acquisition of machinery and equipment, laboratory implantation, technology acquisition, and development/optimization of the process of compliance control in the receipt of material, the percentage was the same for both questions, resulting in 66.67% of the companies interviewed have invested in the last two years and intend to invest in the next two years in these technological areas.

In addition, 25% of the companies replied that there was no investment in the last two years, but they intend to invest in the next two years. Only 8% of the companies responded that they invested in the last two years and do not intend to invest in the next two years; and 8% of the companies did not invest in the last two years and do not intend to invest in the next two years in technological areas.

The results expressed by Figure 7 are directly related to the development of new products in Brazilian companies, which, according to studies by Iacono and Nagano (2016), this occurs predominantly in the internal environment of the industry, with little involvement of external partners.

In Brazil, there is a predominance of process innovation in relation to product innovation (SOARES et al., 2016). Through a survey by PINTEC (IBGE, 2013), approximately 17.3% of Brazilian companies implemented product innovations, while 31.7% implemented process innovations, thus maintaining the innovation model based on the access to technological knowledge through the incorporation of

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machines and equipment (IBGE, 2013). However, the model is not shared by more developed countries, in which the percentage of companies with product innovations is larger or similar to that of companies with innovations in processes.

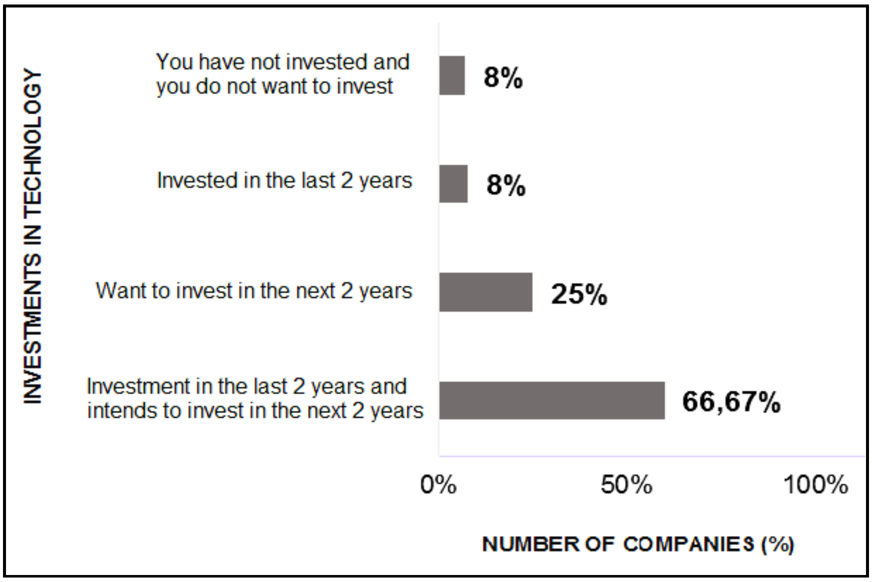

Figure 7: Investments in technological areas.
Source: Authors (2017).

To assist companies in the design and product development activity, it is verified that for the determination of an end product according to the established requirements, a suitable QMS should be used. Thus, based on ISO 9001, Figure 8 shows the operational workflow for quality control in the reception of metallic materials.

Figure 8 denotes material selection that meets specification as an important step in the product development process. However, the selection of materials cannot be done independently of the manufacturing process, and the selection of the manufacturing process depends on other design factors, such as the listing of properties and laboratory resources (ROZENFELD et al., 2006).

As Romano (2013) points out, as production scheduling of the pilot batch is implemented, production and supply personnel should monitor the timing of receipt of the components and the approval certificates of samples, considering that it may occur of components not yet certified. In this situation, product design, manufacturing, quality and supply personnel should follow up on these components, evaluating whether they can be used even with a failed sample approval certificate.

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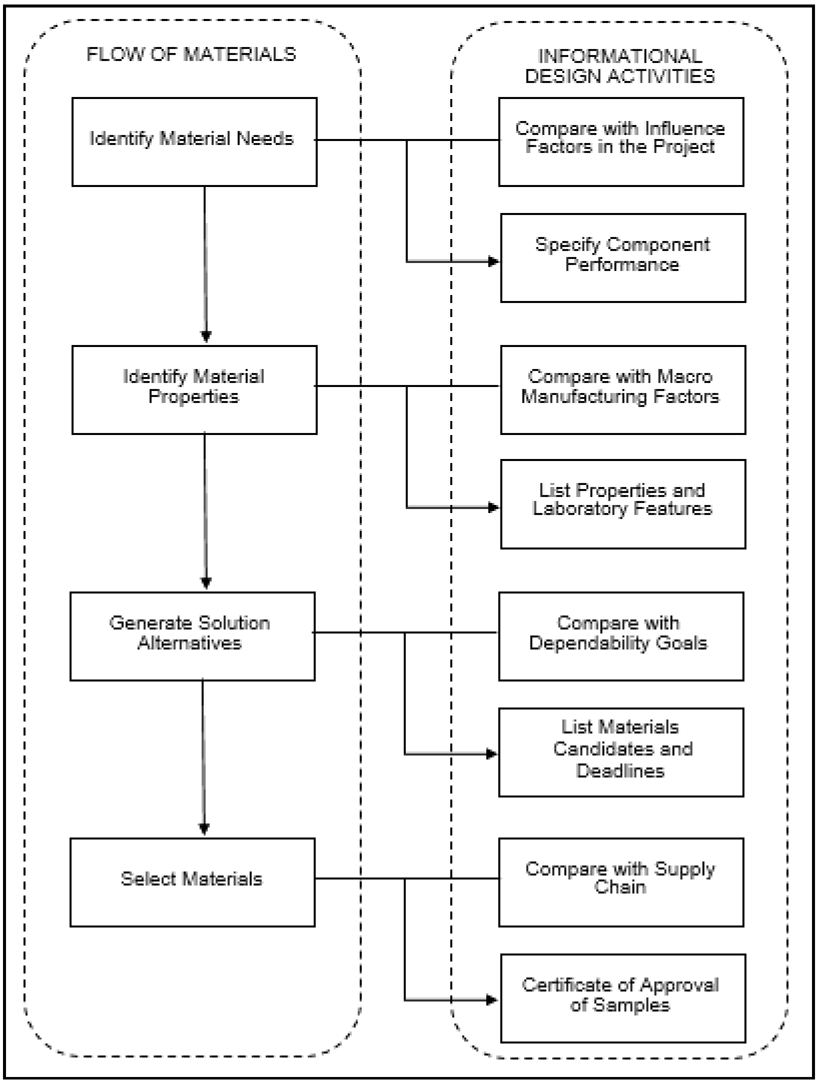

Figure 8: Systematic proposal for the flow between receiving materials and informational Design.
Source: Authors (2017).

In summary, the results and analyzes of the empirical research on the subject of the study reveal that most of the companies in the studied metalwork sector do not have specific characteristics that make the company adequate regarding the operational flow of receiving materials, according to Figure 8.

In many of the companies studied (62%) do not have specific mechanical testing machines for metallic materials, thus compromising the correct specification of the composition of the material and its necessary tests. In addition, they usually group the materials received, albeit informally, in categories or logistic segments (52%) and use mainly as a basis of classification the aspects determined by the operator or directly by the invoice receipt (61%).

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The companies that do not have systematic and defined strategies for the adequate flow of material tests on receipt represent (53%) of the population of the sample. The organizations that do not present mechanisms and professionals for the recognition of tests are (56%) and most of them need to perform mechanical tests in the reception of metallic materials for conference (95%) and knowledge of their properties (90%), before directing them for their proper purpose, thus avoiding failures or even loss of materials, components and/or parts.

It is important to emphasize that investments in equipment for conducting inspections of metallic materials received are of fundamental importance in order to guarantee the conformity of the material that will be used for (95%) of the companies. Moreover, it is stressed that the lack of coordination between government, companies and universities has been one of the main characteristics of the Brazilian innovation system. However, much progress has been made since the 1980s, thanks to government initiatives to bring the academic, public and private spheres closer together (TORKOMIAN et al., 2016; BARBOZA; FONSECA; RAMALHEIRO, 2017).

The companies stated that there are other factors that influence to obtain satisfactory results in the quality of materials received (60%), such as: identify and select suppliers correctly; the buyer must be a professional qualified to perform such activity and the applicant must specify in a correct manner the characteristics of the material to be purchased. In this context, it is important to mention that the role of the government is to create mechanisms of direction and solutions favorable to innovative activities, also involving cooperation between academia and industry in Brazil. Of particular note is the precarious Brazilian performance in the business environment, with the bureaucracy involved in the processes to open, maintain and close a business, since Brazil occupied the 137th position among 143 countries surveyed in this category in 2014 (CORNELL UNIVERSITY, 2014).

Finally, the conceptual framework of the guideline developed according to Figure 8, besides being based on the recommendations of theorists and business agents, presents a systematic proposition that can support future academic research in the field of study, as well as assist in the analysis and identification of deficiencies in laboratory practice and in receiving materials.

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Thus, the flow between the receipt of materials and the informational project developed in the research can help companies from other market niches that need dependability with their products and respective clients. In addition, the integration proposition of Figure 8 can help organizations of different sizes face the challenges related to ISO 9001 certification as they point out the problems found in the research conducted by the authors Ferreira et al. (2015).

5. CONCLUSIONS

The quality management of metallic materials in the industrial sector is complex, since the laboratory procedures that seek to meet the specifications have differences in the metallic products received by the suppliers in all the companies analyzed. To assist in the lack of information that deals with the research topic, the operational workflow was developed for quality control in the reception of metallic materials. However, for each methodological step to be successful it is important to consider its particularities and the time of implementation.

Based on the mentioned considerations, some recommendations should be considered by the companies of the metallurgical sector studied, on systematics, techniques and forms of implementation, if they intend to obtain better results with the application of the strategies expressed by the operational flow of receiving of materials, such as: identification of process flows for receiving mechanical tests for metallic materials using appropriate research methods and multivariate statistical techniques; investment in updating and laboratory formalization, including training of employees, partners, intermediaries and specialists; and regarding competitive differentiation, it is suggested that companies in the metal mechanics sector establish their laboratory strategies based on more deliberate, deliberate and conscious decisions to enable a greater effort in effectively implementing the differentiation strategies identified.

Finally, the study provided some relevant academic contributions and allowed the advancement of knowledge about the application of guidelines for conducting mechanical tests on metallic materials. In addition, the research represents an extension of the academic study on laboratory norms, mechanical tests and reception of metallic materials. However, despite the methodological care and efforts undertaken to ensure the quality and validity of the results, the study is subject to

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several types of limitations that need to be addressed. The recognition of these limitations does not detract from the article nor devalue the results, but it allows the more correct and conscious future use of data, results and analyzes of this study.

The main types of study limitations relate to the non-probabilistic and trial method of sampling, which prevents the inference or generalization of the results and restricts the conclusions of the survey to the companies studied and also to companies that have omitted certain details or data strategic information, secrecy policy or that the study involves competitors, which may have caused some distortion in the results.

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