A MODEL FOR PRODUCT-INTEGRATION TECHNOLOGY FOR HIGHLY COMPLEX ENVIRONMENTS: AN EMPIRICAL STUDY OF Ti-6Al-4V ALLOY TREATED WITH PULSED LASER Nd:YAG IN AEROSPACE INDUSTRY

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Abstract

This article aims to contribute to a new planning policy in the innovative products development. To do so, it presents a new modeling proposal to integrate technological innovation and new product development (NPD) in Ti-6Al-4V Alloy Treated With Pulsed Laser Nd:YAG for turbines for Aerospace Industry, carried out according to the following stages: Phase 1: Modeling of the information needs; Phase 2: Determining of technology integration dimensions to the product; Phase 3: Evaluation of performance of technology integration dimensions to the product. To demonstrate the feasibility and plausibility of the modeling, a case study was conducted in a high tech company in Brazil (hypothetical application). The investigation was helped by the intervention of specialists with technical and scientific knowledge about the research object. To reduce subjectivity in the results, the following methods were used: Law of Categorical Judgment - psychometric scaling of Thurstone (1927), Multivariate Analysis statistical methods and method Compromise Programming, Electre III and Promethee II - multi-criteria analysis; and Neurofuzzy Technology. It is hoped that this study will stimulate a broad debate on the issue and it is acknowledged that more studies are needed to build more robust results in the near future. The results were satisfactory, validating the present proposal

Keywords: Modeling proposal, technological innovation, new product development, highly complex environments, titanium alloys

Introduction

Recently, relevant changes have made organizational boundaries more fluid and dynamic in response to the rapid pace of knowledge diffusion (Abrahamson, 1991; Teece, 1986; Griliches, 1990), and innovation and international competition (Damanpour, 1996). This helps to reconsider how to succeed with innovation (Teece; Pisano, Shuen, 1992). Innovative companies make use of their capabilities to appropriate the economic value generated from their knowledge and innovations (Griliches, 1990). Therefore, the supply of innovative products is presented as a quality standard in the race for pressing demands. In this spectrum, the innovation process management becomes one of the greatest challenges. The literature refers to the product development process (PDP) and the technology development process (TDP) as the most relevant to the development of innovative products (Johansson et.al., 2006). Thus, it is feasible that there is a concurrent and harmonic planning between these processes. For that, it is logical that the integration between these processes is successful, since the success of the innovation depends on the integration of them (Johansson et.al., 2006). This article aims to contribute to a new planning policy in the development of innovative products. To do so, it presents a new modeling proposal to integrate technological innovation and new product development (NPD) in Ti-6Al-4V Alloy Treated With Pulsed Laser Nd:YAG for Aerospace Industry, carried out according to the following stages: Phase 1: Modeling of the information needs; Phase 2: Determining of technology integration dimensions to the product; Phase 3: Evaluation of performance of technology integration dimensions to the product. To demonstrate the feasibility and plausibility of the modeling, a case study was conducted in a high tech company in Brazil. Next, the details of the phases and steps are presented.

Modeling: Steps and Implementation:

This article aims to contribute to a new planning policy in the development of innovative products. To do so, it presents a new modeling proposal to integrate technological innovation and new product development in high tech environments. This modeling was developmen. The research was developed over the literature specialized and applied to a high tech in Brazil to confirm the modeling proposal and the theoretical excerpts. The research also had the intervention from specialists give more detail with knowledge about the investigated object. Next, the details from the modeling phases and stages were detailed. Phase 1: Modeling of the information needs; Phase 2: Determining of technology integration dimensions to the product; Phase 3: Evaluation of performance of technology integration dimensions to the product. Next, those procedures are detailed:

Phase1: Modeling of the Information Needs

This phase is structured according to the following stages and sub-stages: *stage 1* - Definition of the characteristics of the products; *stage 2:* Determination of the strategies of technological synchronization used by companies to the development of products; *stage 3* – Definition of the strategies of the innovation development and *stage 4*: Prioritization of the information needs, *Sub-stage 4.1*: Definition of the characteristics of the product: here are presented the product main characteristics. *Sub-stage 4.2: Determination of the strategies of the technological synchronization* used by companies to manage the development of products. There are two strategies listed in the consulted literature: 1) simultaneous transfer; 2) sequential transfer. *Sub-stage 4. 3: Definition of the strategies of the innovation development:* Two strategies were identified in the literature [13] consulted: bottom-up and top-down, and *Sub-stage 4.4: Prioritization of the needs of information:* This stage is structured in three sub-stages: *1) Determination of the Critical Success Factors (CSF); 2) Determination of the information areas (IAs); and 3) Prioritization of the information needs starting from the crossing of CSF and the Areas of Information*.

Sub-stage 4.1: Determination of CSF: This phase is focused on determining the CSF, and is itself structured in two stages: (A) identification of CSF and (B) evaluation of CSF. (A) Identification: The identification of CSF is based on the combination of various methods: (a) environmental analysis; (b) analysis of the industry structure; (c) meeting with specialists and decision makers; and (d) the study of literature. (B) CSF Evaluation: After their identification, the CSF is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by [8] has been adopted. Thus, the evaluation of the CFS is systematized in the following steps: Step 1: determination of the frequencies by pairs of stimuli. Step 2: determination of the frequencies of ordinal categories. Step 3: calculation of the matrix [pij] of the relative frequencies accumulated. It is highlighted though that the results to be achieved in Step 3 reflect the probabilities of the intensity of the specialists' preferences regarding the stimuli, the CSF in this work. As a result, a hierarchical structure of CSF is obtained.Sub-stage 4.2: Determination of the Areas of Information: The CSF having already been defined, the information areas are delimited with respect to the different CSFs. After determining the CSF, the determination of the areas of information ensues. Thus, after their identification, the IAs is evaluated in order to establish a ranking by relevance. Here the scale model of categorical judgments designed by [8] has been adopted. As a result, a hierarchical structure of IAs is obtained.

Sub-stage 4.2.1: Determine the activities of the PDP. In this sub-stage the main activities realized during the PDP are identified. The following activities performed according to the literature were identified (Wheelwright and Clark, 1992; Clark. and Fujimoto, 1991; Creveling et.al., 2006) development of the concept of product, elaboration of the product syllabus, preparation of the production, launching and after-launching of the product. Determine strategies and product portfolio; elaboration and detailing of the project syllabus; determine technical and marketing merits of the project; realization of preliminary research to identify and analyze the market, among others.

Sub-stage 4.2.2: Determine the TDP activities: In this sub-stage the main activities of TDP based on Wheelwright and Clark (1992); Clark. and Fujimoto (1991); Clausing (1993) are identified: (i) company strategic planning; (ii) determination of the technologic strategy; (iii) technology; (iv) consumer; (v) generation of ideas (vi) elaboration of project syllabus; (vii) future plans mapping; (viii) patent research; (ix) Identification of opportunities; (x) identification of the possibility of the idea in determined conditions through preliminary experiments; (xi) identification of the necessary resources and solutions for the identified failures; (xii) projection of platforms of products; (xiii) creation of QFD for technology (technological needs), among others. Soon, after this procedure, the critical activities for integration are determined.

Sub-stage 4.2.3: Determination of the critical activities for integration: In this stage, the critical activities for integration of the technology to the product are defined. Integration must be understood as the set of activities or compatible practice between TDP and PDP (Drejer, 2002), which aim at improving the application of knowledge to the products. Next, the IA global performances are evaluated according to the CSF.

Sub-Stage 4.3: Prioritization of the information needs starting from the crossing of CSF and the Areas of Information: Again, these information areas are ranked by application of the same CJL and put into relation with the CSF. At this moment the following tools have been adopted: multi-criteria analysis - *Compromise Programming™, Promethee II™ and (c) Electre III™*

Phase 2: Determination of the dimensions of the integration of the technology to the product.

In this stage the dimensions of the integration of the technology to the product are defined. Drejer (2002) presents the following dimensions of the integration of the technology to the product: aspects, activities and time horizon. Nobelius (2004) considers other three dimensions of the integration: Strategic and Operational synchronization, 2) Syllabus Transference, and 3) Transference Management. Finally, Eldred and McGrath (1997) points out three basic elements for integration: 1) Synchronization; 2) Technology Equalization; and 3) Technological Transference Management. Iansiti (1998) adopts the knowledge as the main dimension for the integration of the technology to the product. For this author, there will be integration if the knowledge generated by the area of R&D is applied to a new product. In this work, the knowledge is the dimension to be considered for the integration. This dimension is detailed ahead.

Identification and Acquisition of Knowledge. Initially, information topics which have been already identified will be elaborated, analyzed and evaluated in order to be understood by the decision makers during the formulation and the PDP and TDP. Following this, they will be reviewed and organized and validated by NPD and TDP specialists. Afterwards, relevant theories and concepts are determined. With respect to the acquisition procedures, the different procedures of the process of acquisition represents the acquisition of the necessary knowledge, abilities and experiences to create and maintain the essential experiences and areas of information selected and mapped out [17]; [18]. Acquiring the knowledge (from specialists) implies, according to Buchanan (2002), and Eliufoo (2008)], obtaining information from specialists and/or from documented sources, classifying it in a declarative and procedural fashion, codifying it in a format used by the system and validating the consistence of the codified knowledge with the existent one in the system. Therefore, at first, the way the conversion from information into knowledge Herschel, Nemati, and Steiger (2001) is dealt with, which is the information to be understood by and useful for the decision making in technological innovation integration and new product development. First the information is gathered. Then the combination and internalization is established by the explicit knowledge (information) so that it can be better understood and synthesized in order to be easily and quickly presented whenever possible (the information must be useful for the decision making and for that reason, it must be understood). In this work, we aim to elaborate the conversion of information into knowledge. The conversion (transformation) takes place as follows: first, the comparison of how the information related to a given situation can be compared to other known situations is established; second, the implications brought about by the information for the decision making are analyzed and evaluated; third, the relation between new knowledge and that accumulated is established; fourth, what the decision makers expect from the information is checked. The conversion of information into knowledge is assisted by the information maps (elaborated in the previous phase by areas, through analysis and evaluation of the information). We highlight that the information taken into account is both the ones externally and internally originated. The information from external origins has as a main goal to detect, beforehand, the long-term opportunities for the project. The internal information is important to establish the strategies, but it has to be of a broader scope than that used for operational management, because besides allowing the evaluation of the performance it also identifies its strengths and weaknesses. Following from this, the proceedings for the acquisition of theoretical background and concepts are dealt with. Such proceedings begin with the areas of information, one by one, where the concept and the theory on which is based the performance of the actions (articulations) developed in those areas that allow to guarantee the feasibility of the new products development projects are identified. In other words, which knowledge and theory are required to be known in order to ensure the success of projects in the NPD in that area. Then, the analysis of surveys in institutions about the job market for these institutions takes place bearing in mind the demands of similar areas studied in this work. As for the offer, we intend to search for the level of knowledge required by the companies and other organizations in those areas, as well as what concerns technical improvement (means) for the professionals. This stage determines the concept of knowledge to be taken into account on the development of this work. So, for the operational goals of this work, we have adopted them as the "contextual information" and the theoretical framework and concepts.

Phase 3: Assessment of the performance of the integration of technology process to the product

In this phase the assessment of the performance of the integration of technology process to the product is done. This procedure is realized based on the Neurofuzzy technology. This phase focuses on determining the optimal efficiency rate (OERP) of the high-tech industries' product development and technology integration using Neurofuzzy modeling. This model combines the Neural Networks and Logic Fuzzy technology. The model shown here uses the model proposed in Oliveira and Cury (2004). Based on the Neurofuzzy technology, the qualitative input data are grouped to determine the comparison parameters between the alternatives. The technique is structured by combining all attributes (qualitative and quantitative variables) in inference blocks (IB) that use fuzzy-based rules and linguistic expressions, so that the preference for each alternative priority decision of the optimal efficiency rate of the high-tech industries' product development and technology integration, in terms of benefits to the company, can be expressed by a range varying from 0 to 10. The model consists of qualitative and quantitative variables, based on information from the experts. The Neurofuzzy model is described below.

*Architecture of the Neurofuzzy Network (*Oliveira and Cury, 2004): In each network node, two or more elements are assembled in one single element, originating a new node. This new node is then added to other nodes, produced in parallel, which give rise to a new node, and so on, until the final node is attained. The neurofuzzy network architecture (NNA) is defined by the input variables in its first layer, always converging to their network nodes. Each node corresponds to a fuzzy rule base, designated as Inference Block (IB), in which the linguistic variables are computed by aggregation and composition in order to produce an inferred result, also in the linguistic variable form. Thus, the rules are defined in the IB of NNA. In summary, the input variables (IV) pass through the fuzzification process and through the inference block (IB), producing an output variable (OV), called the intermediate variable (IVa), if it does not correspond to the last IB on the network. This IV, then joins another IV, forming a set of new IVs, hence configuring a sequence on the last network. In the last layer, also composed of IV, it produces the output variable (OV) of the final NNA. The NNA architecture should be applied according to the number of specialists. These steps are detailed below.

Determination of Input Variables (IV): These variables were extracted (15 variables) from the phase 2 (ranking of dimensions of knowledge). The linguistic terms assigned to each IV are: High, Medium and Low. Accordingly, phase 2 shows the IVs in the model, which are transformed into linguistic variables with their respective Degrees of Conviction or Certainty (DoC), with the assistance of twenty judges opining in the process. The degrees attributed by the judges are converted into linguistic expressions with their respective DoCs, based on fuzzy sets and aggregation rules next composition rules.

Determination of Intermediate Variables and Linguistic Terms: The qualitative input variables go through the inference fuzzy process, resulting in linguistic terms of intermediate variables (IV). Thus, the linguistic terms assigned to IV are: Low, Medium and High. The intermediate variables were obtained from: knowledge performance. The architecture proposed is composed of eight expert fuzzy system configurations, four qualitative input variables that go through the fuzzy process and through the inference block, thus producing an output variable (OV), called intermediate variable (IV).Then, the IV, which join the other IV variables form a set of new IV, thereby configuring a sequence until the last layer in the network. In the last layer of the network the output variable (OV) of the Neurofuzzy Network is defined. This OV is then subjected to a defuzzification process to achieve the final result: Optimal Efficiency Rate (OERP) of product development and technology integration performance of high-tech industries.

Determination of Output Variable – Optimal Efficiency Rate of product development and technology integration Performance: The output variable (OV) of the neurofuzzy model proposed was called Optimal Efficiency Rate of product development and technology integration in high-tech company.

Fuzzy Inference: The fuzzy inference rule-base consists of IF-THEN rules, which are responsible for aggregating the input variables and generating the output variables in linguistic terms, with their respective pertinence functions. According to [23], a weighting factor is assigned to each rule that reflects their importance in the rule-base. This coefficient is called Certainty Factor (CF), and can vary in range [0-1] and is multiplied by the result of the aggregation (IT part of inference).

Defuzzification: For the applications involving qualitative variables, as is the case in question, a numerical value is required as a result of the system, called defuzzification. Thus, after the fuzzy inference, fuzzification is necessary, i.e., transform linguistic values into numerical values, from their pertinence functions (Von Altrock, 1997). The Maximum Center method was popularized to determine an accurate value for the linguistic vector of OV.

Application and Underlying Analyses:

This paper presents a new modeling proposal to integrate technological innovation and new product development (NPD) in a Ti-6Al-4V Alloy Treated With Pulsed Laser Nd:YAG for a turbine, in Aerospace Industry in Brazil (hypothetical application).. The referred alloy provides greater resistance to oxidation and greater life span in creep. Studies have been carried out, regardless of commercial goals or getting new alloys and, in particular, to re-assess existing commercial alloys, through data acquisition in conditions of greater severity [24]. The easy reaction between titanium and oxygen is one of the main factors that limit the application of their alloys as structural materials for high temperature applications. Despite the remarkable progress in the development of titanium alloys with high resistance to traction, ductility and creep resistance at high temperatures, problems with oxidation limit the use of these alloys at temperatures higher than 600oC [24]. Titanium alloys are used in service conditions that require high temperatures, for instance, turbine components, which is the case of this application. The Ti-6Al-4V alloy properties are sensitive to microstructural changes (Oliveira et.al., 2008). The aerospace industry uses roughly 75% of the worldwide production of titanium, with the Ti-6Al-4V alloy being one of the most used ones. One of the features that have contributed to its growth is associated to its use for structural ends in what concerns the high melting point (1610-1660 C). The use of the Ti-6Al-4V alloy is concentrated in the aerospace area, in which the resistance to creep, fatigue and degradation are considered essential [24] Ti-6Al-4V alloy has great commercial value, comprehending more than half of the application of titanium alloys in the USA and Europe, offering high resistance to traction and good formability capacity of, despite presenting a weldability reduction . Its main use is for wrought compounds such as turbine blades for Jet engines (Oliveira et.al., 2008). In this way, the applications and conditions in which the magnesium and aluminum based alloys are not adapted, titanium alloys are normally used, presenting a better performance (Oliveira et.al., 2008). The data were gathered by consulting the partner-owners of the investigated company, through a structured questionnaire. In this investigation, it was possible to know details of the company's PDP and TDP, in a way of verifying the practices conducted in the process of integration of the technology to the product. The research was based on a product (from the turbine production industry) well succeeded in the national market, according to its innovation degree (for the market). It is believed that the product passed through the 2 fundamental stages identified in the theoretic excerpts: the PDP and TDP. The following CSF from the company were identified: Political/Legal; Economical and Financial; Market and Technical. The main IAs identified was: R&D; Marketing, Production, Commercial and Financial (Priority).

The process of development of the Technology: The technology of the studied product was developed in an approximately 2 year's time. During its whole development, the partner owners from the turbine production industry in Brazil, who are responsible for the P&D information, Marketing, Production, Commercial and Financial areas participated directly. The main TDP activities were as it follows: (i) carry out research through the literature, (ii) select and develop a superior concept of technology, define functionalities of the new technology (iii) optimize the technology from its critical parameters. Thus, the technology (for Ti-6AI-4V alloy) presented usescylindrical bars (Multialloy Eng. Mat. Ltd.), in wrought condition, annealed at 190 C for 6 hours and air cooled. The microstructural configuration obtained from the mechanical and thermal treatments corresponds to the condition of major application in the aeronautic industry. The characterization regarding the chemical composition of the main elements (percentage in weight), meets the standards of the ASTM B265-89. The results obtained (% w) in the analysis (optical emission spectroscopy with inductively coupled plasma, in an ARL equipment model 3410) were: Ti = 89,16 %, Al = 6,61% and V = 4,23%. The finishing phase, nitriding by pulsed Nd:YAG laser (ROFIN DY 033 and Talymap Silver 4.0 software) was conducted through a cooperation with Universidade Politécnica de Madrid (Madrid, Spain). The treatments were conducted using a combination of gases (40% N and 60% Ar), with power of 2,1 W, speed of 10 m/s, spot diameter of 7 mm and gas flow of 12,5 l/min. The samples were previously sanded with 600 mesh granulometry SiC sandpapers and cleaned in ultrasound with an acetone + ethanol solution, to prepare the surface for the laser treatment . After this treatment, they were microstructurally characterized and tested in creep conditions [24]. The were conducted in creep machines from the Instituto Tecnológico de Aeronáutica (ITA/CTA), acquired in partnership with EMEC (The Eletronic and Mechanical Engineering Co. Ltda.). Electrical systems and controllers were adapted inside the ovens (developed by BSW Tecnologia, Indústria e Comércio Ltda.) in accordance with ASTM E139/83 (ASTM, 1995). The data related with samples deformation and temperature measurement in pre-determined periods of time was collected by Antares software , which was developed in partnership with BSW (Tecnologia, Indústria e Comércio Ltda)and obtained through a high resolution extensometer gauge caliper Instron model 2602-004, and an LVDT transducer (Linear Variable Differential Transformer) Schlumberger D 6,50, with the specification of 53,18 mV/V/mm, at a temperature of approximately 35 ºC . The thermocouples used for temperature control were Cromel-Alumel AWG24. The LVDT output signal was sent to two independent systems: an x-t graphical recorder, model RB101, series 1000, 110V and 60Hz from ECB (Equipamentos Científicos do Brasil Ltda); and to a processing unit that converts the signals into stretching measures at pre-determined periods of time and that feeds the Antares software. The Ti-6Al-4V treated alloy samples were analyzed under air creep conditions of, at 600oC and 319 MPa, in the constant load mode. With the results a sets of graphics and experimental parameters related to the primary, secondary and tertiarycreep areas in relation to the initially applied tension were obtained. Experimental parameters related to these regions allow to establish a comparative analysis with results obtained in previous studies from the Ti-6Al-4V just in the annealed condition (CORTEZ, L. D., 2002) and (BARBOZA, M. J. R., 2001). The preparation of the tested samples for analysis through the techniques of optical microscopy (Leica optical microscope model DMRXP) and scanning electronic microscopy (SEM model 435 VPI, belonging to the Material Division of the *Instituto de Aeronáutica e Espaço do CTA (AMR/IAE/CTA*) followed the standard metallography procedures, that is, hot emedding (150 C) under 21 MPa of pressure, followed by manual sanding with SiC sandpapers, sequenced as follows: 120, 240, 320 400, 600 and 1200. The final polishing was conducted with colloidal silica solution (OP-S). Through the analysis via SEM the main characteristics of the fracture surfaces were studied. I and a LEO scanning electronic microscope (Oliveira et.al., 2008). The activities were developed in labs of academic research, which enabled to obtain a structure of human resources involving teachers and physical resources comprising labs with the necessary support for the generation of the development of the technology.

The product development process: The main PDP activities identified are as it follows: realization of the concept test; realization of the test and validation of the proposal of new product; realization of strength tests according to parameters; start the pilot production; launching of the product and realization of the effective production. After the results of the test, conclusions were released, and the optimization of the application was started. In this stage, it was defined the structure of production for the application of the technology and improvement in the composition of materials. It was produced a pilot lot so the client company could launch the product in an event within its sector. From the satisfactory results of product acceptance in the market, the large-scale production was started, which remains until the current moment of this study. The time between the first commercial contact and the delivery of the product with the applied technology was approximately one year, with half of this period oriented to experiments and tests of application of the technology on the selected pieces.

The strategy of the development of the innovation adopted by the company for the development of the technology was bottom-up, or technology push, for on its beginning the development team, composed of three partner-owners, did not own a clear plan or idea to integrate this technology to the studied product. They did not even possess a more detailed vision about the possible consumer market or the focus of these markets. Initially the company did not have as the main target the studied product. In the beginning the idea was to develop a technology to cover the metal characterization. This strategy at first is top-down and later as a redirecting of its application, identifying market trends and the needs of applications of the technology in other products.

The *strategy of technological synchronization* adopted was the sequential technology transfer. At first, the technology was developed, then, the product. This was due to the fact that the technology was developed first to the market during the research in the post-graduation course. Moreover, the company participated in the event that led to the studied product in this work with the technology ready to be applied to the product. Yet not validated, but already in advanced stage of development. After some experiments were conducted with the selected pieces, it was verified the need of some adaptations in the technology. At this moment, the existing synchronization between the processes becomes the simultaneous transference of technology, for during the adaptation of some compositions of the technology; activities such as appearance and performance tests were also realized. Besides, this case allowed to identify a time of 2 years, more than which the chance is smaller for the product project team and technology to share the results of the project. Thus, it is assumed that if the projects were realized with a time difference of 2 years maximum, they can be characterized as simultaneous synchronization. It is important to point out that through the identification of the strategy of synchronization the two-year time was noted as the necessary time for the company to validate and incorporate technology in a product so it can be commercialized. Once the activities of PDP and TDP and the critical activities were defined, the next step was to define the concept of technology to be adopted in this application. The concept adopted has basis in the knowledge. The literature defines technology as the knowledge applied to obtain a product (a practical result). Afterwards, the procedure of technology transfer (knowledge) to the product was started. On one hand, the knowledge/technologies demanded by the product (PDP). On the other hand, the knowledge offered by technology (TDP). As aforementioned, the integration of the technology to the product has basis on the proposal of [16], which has the knowledge as the main dimension of the integration of the technology to the product. The information area adopted in this application was R&D. The process of integration using the knowledge is shown as it follows.

The process of integration of the technology to the product: The concept adopted to knowledge are the theoretical bases and concepts and information of context. In this sense, the necessary knowledge to carry out the concept test was adopted; realization of test and validation of the proposal of a new product; realization of strength tests according to parameters; start of the pilot production; product launch and realization of the effective production, among others. The knowledge (technology) presented in Figure 1 was preliminarily identified.

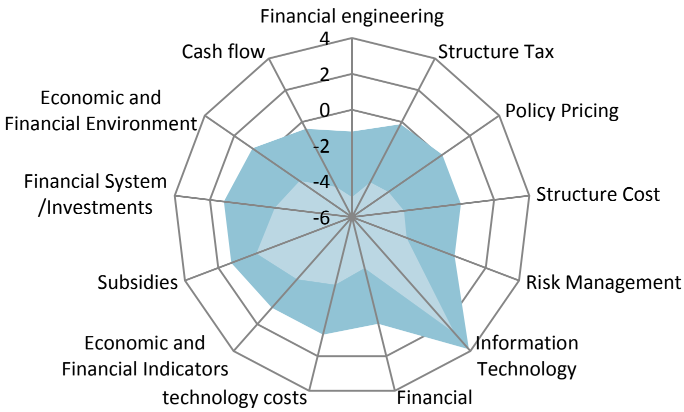

Fig. 1: Knowledge / Technology

After being identified and acquired, the knowledge is evaluated, with the aid of the Method of Categorical Judgments of Thurstone (1927) and artificial neural network (ANN).

Evaluation for the method Categorical Judgments' Laws (1): The achievement method of the research results with the specialists of technological innovation, TDP and PDP, who revealed their preferences for pairs of stimulation. The data had been extracted from the preferences of the specialists in relation to objects of knowledge, attributing weights to the cognitive elements.

Evaluation of Knowledge's Objects using the artificial neural network (ANN) (2): Evaluation for the method Categorical Judgments' Laws (1): The data had been extracted from the preferences of the specialists in relation to objects of knowledge,who revealed their preferences for pairs of stimulation, attributing weights to the cognitive elements.

Evaluation of Knowledge's Objects using the artificial neural network (ANN) (2): In this application, the layer of the entrance data possess 15 neurons corresponding the 15 variables referring to objects of knowledge (technology). The intermediate layer possesses 7 neurons, and the exit layer possesses 1 corresponding neuron in a scale value determined for the ANN. The process of learning supervised based in the Back propagation algorithm applying software Easy NN determines automatically the weights between the layers of entrance and intermediate, and between the intermediate and exit. The training process was finished when the weights between the connections had allowed minimizing the error of learning. For this, it was necessary to identify which configuration that would present the best results varying the taxes of learning and moment. After diverse configurations have been tested, the net of that presented better results with tax of an equal learning 0,37 and equal moment 0,88. The data had been divided in two groups, where to each period of training one third of the data is used for training of net and the remaining is applied for verification of the results. After some topologies of networks, and parameters, the network that showed better results was presented. The network was trained for the attainment of two result groups to compare the best-determined scale for the networks. In the first test the total of the judgment of the agents was adopted, however only in as test was gotten better scales, next of represented for method of the categorical judgments. With this, the last stage of the modeling in ANN consisted of testing the data of sequential entrance or random form, this process presented more satisfactory results. The results can be observed in Figure 3 that follows. The reached results proved satisfactory, emphasizing the subjective importance of the scale methods to treat questions that involve high degree of subjectivity and complexity. With regards to the topologies of the used networks, the results obtained some configurations of the ANN and compared with the CJT, it was observed that ANN 1, is the one that best approached the classification obtained for the CJT. It is interesting to highlight that the CJL method, as it considers a variable involving a high degree of subjective and complexity and because it works with probabilities in the intensity of preferences, considers the learning of new elements of knowledge. Thus, it can be said that for typology of application, as presented here, it is sufficiently indicated.

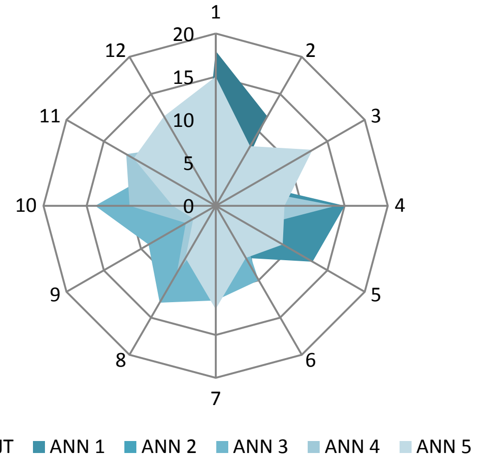

Fig. 2: Priority of Knowledge's Objects - ANN and CJT

Thus, the integration of these variables in the Neurofuzzy model results in a unique value which is the performance of the integration of the technology to the product. This enables to verify whether the procedure of integration was or not successful. The first 15 classified variables were used. The results showed a great efficiency rate of integration of the technology to the product equal to 0,89. With this result is plausible to state that, to some degree, there is efficiency in the management of those NPD planning in this category of companies. To illustrate this, assuming that the study-object company demonstrate the following optimal efficiency rates (efficiency rate of integration of the technology to the product): T1 – 0.8955; T2-0.5322; T3-0.84574; T4-0.4156; and T5-0.6213 (Figure 3).

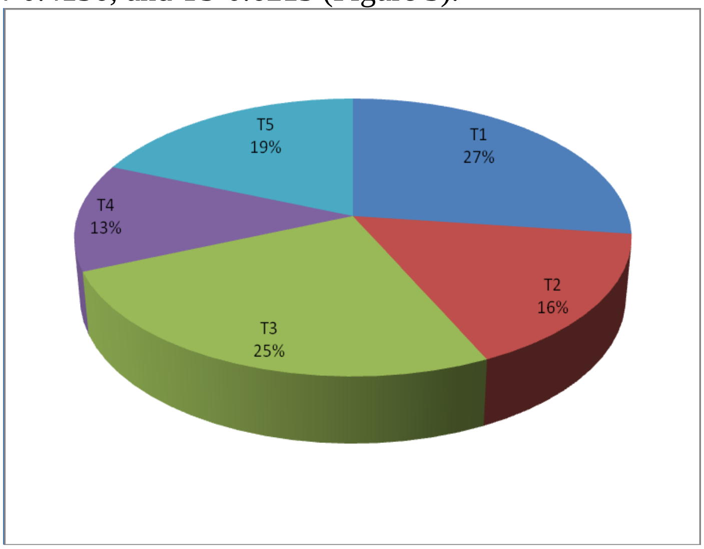

Fig. 3: efficiency rate of integration of the technology to the product

The best performance of the integration of technology process to the product T1 (0,8955)

Conclusion and Implications

This article aims to contribute to a new planning policy in the innovative products development. To do so, it presents a new modeling proposal to integrate technological innovation and new product development (NPD) in Ti-6Al-4V Alloy Treated With Pulsed Laser Nd:YAG for turbines for Aerospace Industry. The performance of the integration was based on the knowledge (IV - input variables) of the Neurofuzzy model. The performance is the result produced by the integration and convergence of the IV to a unique value (output variable - OV), called performance rate of the integration of the technology to the product. The result enables to improve the planning policy to the development of new products, and set new strategies to the process of integration of technological innovations and the development of products. The results obtained with the application of the proposed model show that this technology is adequate for supporting decision-making, due mainly to its low level of complexity and to its flexibility that allows the input and output of variables. Trough this method a more pragmatic and efficient guidance is sought, assisting the guidelines for long-term to integrate technological innovation and new product development in high tech environments, hence assuring this segment's competitiveness. Extensive and systematic procedures should be pursued that are capable of uniting the most diverse dimensions of planning of innovative products, surpassing the non-scientific practice often pervading some of the works. This proposal focuses on highlighting unexplored questions in this complex design. However, it evidently does not intend to be a "forced" methodology, but intends to render some contribution, even through independent course of actions. In the near future, we aim to demonstrate the suitability and feasibility of the proposed modeling framework, priority researches must be permanently and recurrently applied. Thus, this methodological support does not intend to be complete, but it is our intent to make it a generator of strategic elements for the development of new products development projects. A study was developed for Brazilian high tech company in a static context, which may represent a limiting factor. Therefore, it is recommended to reproduce and replicate the model in companies from other countries in order to confirm the results. It is also recommended that the dimensions of the integration of the technology to the product should be extracted from the state of the art, but strongly confirmed by the state of practice, by the judgment of other experts (from other countries), taking into account that values, beliefs, cultures and experiences are determinants in the assessment, which can overturn the effects on the results. It is also underscored that the methodologies and technical basis of this modeling should undergo evaluation by a multidisciplinary team of specialists permanently and periodically, hence proposing possible additions or adjustments to these methodologies. And also replace some of the technical implementations used herein by others, in order to provide a similar role to verify the robustness of the model. Nevertheless, the new products development will have to be anchored in efficient planning policies. One can argue that Brazil's high-tech industry still has a long way to go and also has tremendous growth potential. Hopefully Brazil can become a technological and competitive nation.

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