COLEÇÃO

DESAFIOS DAS ENGENHARIAS:

ENGENHARIA DE PRODUÇÃO 2

CARLOS EDUARDO SANCHES DE ANDRADE
(ORGANIZADOR)

Atena Editora
Ano 2021

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Coleção desafios das engenharias: engenharia de produção 2

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Dados Internacionais de Catalogação na Publicação (CIP)

C691 Coleção desafios das engenharias: engenharia de produção 2 / Organizador Carlos Eduardo Sanches de Andrade. – Ponta Grossa - PR: Atena, 2021.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-5983-570-6
DOI: https://doi.org/10.22533/at.ed.706211910

1. Engenharia de produção. I. Andrade, Carlos Eduardo Sanches de (Organizador). II. Título.

CDD 670

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

Atena Editora
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APRESENTAÇÃO

A obra “Desafios da Engenharia: Engenharia de Produção 2” publicada pela Atena Editora apresenta, em seus 18 capítulos, estudos sobre diversos aspectos que mostram como a Engenharia de Produção pode atender as novas demandas de um mundo globalizado e competitivo.

A evolução da sociedade e da tecnologia no mundo atual impõe novos desafios, tornando urgente a busca de soluções adequadas a esse novo ambiente. O desenvolvimento econômico das cidades e a qualidade de vida das pessoas dependem da eficiência e eficácia dos processos produtivos, objeto dos estudos realizados na Engenharia de Produção.

No contexto brasileiro, num período pós pandemia, a crise econômica se agrava e é necessário procurar novos caminhos para alavancar o crescimento econômico. Assim a Engenharia de Produção pode ser um elemento importante para enfrentar esses novos desafios.

Os trabalhos compilados nessa obra abrangem diferentes perspectivas da Engenharia de Produção.

A gestão de processos e a gestão financeira são abordadas. Diversos outros temas, em português, espanhol e inglês são também abordados, como os impactos ambientais e epidemiológicos do processo produtivo.

Agradecemos aos autores dos diversos capítulos apresentados e esperamos que essa compilação seja proveitosa para os leitores.

Carlos Eduardo Sanches de Andrade

SUMÁRIO

CAPÍTULO 13

PROPOSAL FOR A REPLACEABLE HIGH PRECISION SERUM PERFUSION SYSTEM

Data de aceite: 01/10/2021
Data de submissão: 30/07/2021

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RESUMO: Neste trabalho de pesquisa é feita uma proposta de um sistema substituível de perfusão de soro de alta precisão, através da utilização de mecanismos de estrangulação de fluxo e sistemas digitais de precisão. A metodologia utilizada para realizar a análise e seleção do modelo baseia-se no programa Células de Inovação da Confederação de Câmaras Industriais dos Estados Unidos Mexicanos (CONCAMIN), Na qual participa a empresa Aarson Produtos Hospitalarios e o Instituto Tecnológico de Hermosillo. Como produto final, é apresentado um conceito com características de inovação do mercado local.
PALAVRAS - CHAVE: Perfusão sérica, precisão, sistema substituível, células inovadoras.

PROPOSTA DE UM SISTEMA SUBSTITUÍVEL DE PERFUSÃO DE SORO DE ALTA PRECISÃO

ABSTRACT: In this research work, a proposal is made for a high precision replaceable serum perfusion system, through the use of flow throttling mechanisms and precision digital systems. The methodology used to carry out the analysis and selection of the model is based on the Innovation Cells program of the Confederation of Industrial Chambers of the United Mexican States (CONCAMIN), in which the company Aarson Productos Hospitalarios and the Technological Institute of Hermosillo participate. As a final product, a concept with local market innovation characteristics is presented.
KEYWORDS: Serum perfusion, precision, replaceable system, innovation cells.

1 I INTRODUCTION

A parental route for drug administration is intravenously, through the use of needles or probes inserted into the vein, allowing quick and immediate access of the liquid to the

bloodstream (ADAM, 2021). As a background, intravenous drug delivery was discovered in the eighteenth century, as a procedure in the delivery of drugs on an experimental basis, and it was until 1656 that Christopher Wren injected wine and beer into the veins of a dog to observe its results (BALLÓN, 2016).

Existing methods for intravenous drug administration are usually applied in two ways, one is to introduce the drug alone or diluted directly (bolus form) through the use of syringes, and the other method is by intravenous drip, channeling a venous line, the latter is used the most, in a wide variety of cases, the infusion times must be prolonged (for example, in cases of treatments for asthmatic attacks, colic, etc.), or for more appropriate hospital referral (Dorta Bottle, 2004).

Since its discovery in the 18th century, to the present day, the state of the art in matters of intravenous drug infusion technology has gone from being purely mechanical devices, to systems with the introduction of electronic and mechatronic systems, ranging from the introduction of medication, to automated flow control for insulin injection in diabetic people (HERMOSO; BAHÍLLO, 2007), and more precision systems, for the delivery of anesthesia on the micron scale, through computer assistants (CANDÍA; RATTI, 2001), to integrated systems with smart supply pumps (BATISTON, 2018).

Although the systems and devices used in the area of medicine have the objective of improving the quality of life of patients with continuous innovations, the FDA (Food and Drug Administration) establishes that 60% of deaths and / or injuries serious in treated humans, are due to operating errors of the instruments or medications used (OLVERA, 2013). That is why the need arises to develop easy-to-use technology and interaction between the human-system-device, with a high level of precision, especially in the area of medicine.

2 | METHOD DESCRIPTION

For the proposal of the non-invasive glucose meter, the Innovation Cells methodology was applied, coordinated by CONCAMIN, through a structured process that allows putting into practice skills, methodologies and innovation tools in solving real problems of companies or entrepreneurs. The Innovation Cells program is shown in Figure 1 and consists of ten methodological stages (HERRERA, 2018).

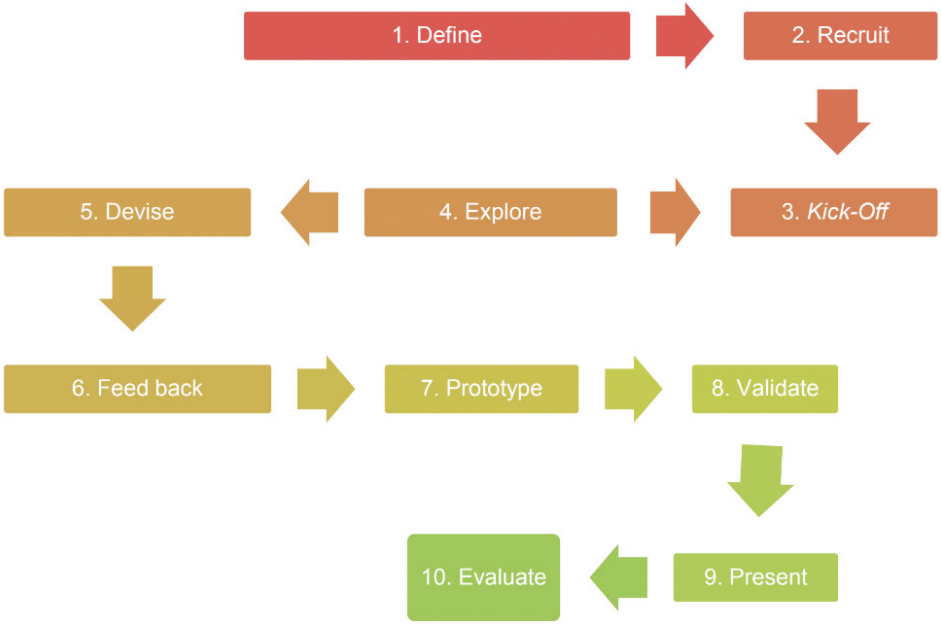

Figure 1. Stages of the methodology used in this research.

1. Stage 1. Define: the objective of this stage is to attract innovation projects from companies and support them in clearly defining an innovation challenge and the profiles required for its development.

2. Stage 2. Recruit: attract university students with desirable profiles based on the definition of the challenge.

3. Stage 3. Kick off: program start; coexistence between student-company where work roles are discussed and known.

4. Stage 4. Explore: Teams discover, design, and implement exploration tools and techniques to generate valuable information.

5. Stage 5. Devise: teams discover, design and put into practice creativity tools and techniques to generate a large number of solution proposals to their challenge.

6. Stage 6. Feedback: event in which teams present their solution proposals to a large number of people to provide feedback and select the best solutions.

7. Stage 7. Prototyping: teams discover, design and put into practice prototyping tools and techniques to materialize and be able to show their solutions.

8. Stage 8. Validate: teams discover, design and put into practice validation and experimentation tools and techniques to evaluate the relevance of their solutions and improve them.

9. Stage 9. Final presentation: event in which the teams present the final results of the process and show their prototypes or concepts.

10. Stage 10. Evaluate: evaluation of the performance at the team level and at the individual level of all the participants. Identification of the next steps of the project.

3 | RESULTS

Based on the proposed methodology, the results were the following.

Stage 1. The company Aarson Productos Hospitalarios de Hermosillo Sonora, together with the Technological Institute of Hermosillo, launched the challenge of proposing a biomedical device with significant impact on the national and international market.

Stage 2. An interdisciplinary group of students from the Hermosillo Technological Institute was formed, made up of two biomedical engineering students, one mechatronics engineering student and one business management engineering student, accompanied by a teacher from the area of metal mechanics with a profile in mechatronics.

Stage 3. A visit was made to the company Aarson Hospital Products by the students and advisor, where the general aspects of the program, the scope and limitations of the proposed challenge and a global analysis of the problem were discussed.

Stage 4. The basic information collected in this stage were the following.

The parts that make up a conventional perfusion system (see figure 2) are shown in table 1.

Parte	Descripción
AWL	It is used to penetrate the material of the cap of the medicine container.
Drip chamber or drop counter	Container in which the medicine falls "drop by drop", it is used to visualize the quantity of drops that flow into the system in a unit of time.
Extension	Flexible tube that starts from the drip chamber and ends in connection at the punch.
Regulating key	Regulates the flow of perfusion.
Injection port	Through them, medicine can be injected without having to disconnect the system (only some systems have it).

Table 1. Description of the parts that make up a conventional perfusion system. Adapted from BOTELLA (2004).

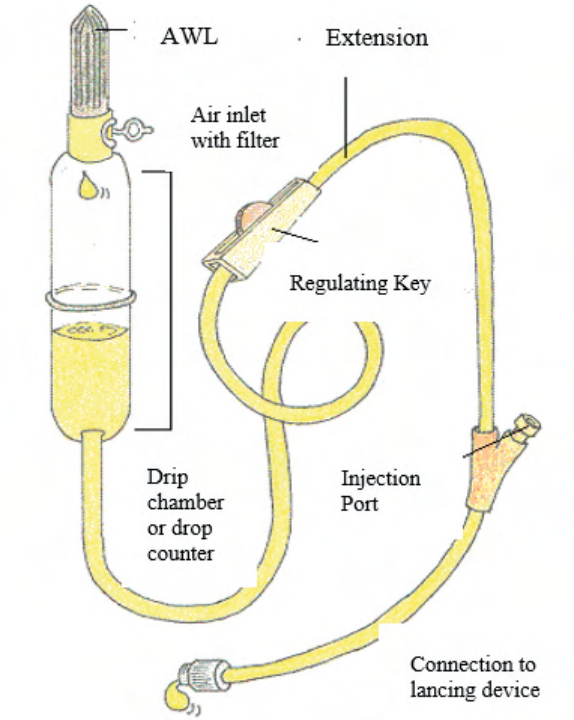

Figure 2. Schematization of the parts that make up a conventional perfusion system. Source: Dorta Bottle, (2004).

A flowmeter (flow sensor) can be implemented, to measure the particles or quantity of flow that moves within a closed duct, linking the measurement in real time to a screen or indicator. The types of flowmeters according to MILLER (1996) can be speed, volume, density or mass. Commercially there are many types of flow sensors for measuring flow in a section in a given time. The position of the flowmeter would be posterior to the AWL, inside the drip chamber, in order to count in real time, the amount of medicine supplied.

In the regulating valve, a choke solenoid valve can be implemented, linked directly to the controller (a microprocessor), so that the system operator can program the exact amount of medicine to be dispensed in a specific time.

Stage 5. In this stage, three different concepts were presented as possible solutions to the problem and each of them were described. Table 2 shows the description of the chosen model.

Stage 6. The concept with the most relevant characteristics was chosen; analysis of the competition map or existing solutions (see figure 3), specification of the concept (see table 3), map of innovation opportunities (see figure 4) and design matrix (see table 4).

In the analysis of the competition map, the values obtained by potential customers

are shown, through a perception survey of the three proposed models.

It is observed that the P2 model (in blue) and the P3 model (in green), present a score of 22 in the measurable characteristics.

In the analysis of the specification of the concept in table 3, it can be seen that the P3 model has a higher score, with a total of 60, followed by the P2 model with 48 and finally the P1 model with 36 points.

Target segment	Concept details
Who?: Hospitals and health centers (public and private) What characteristics does it have?: It is a small mechanical throttle valve, which regulates the flow rate with high precision, in such a way that an indicator (number) indicates the number of drops and total milliliters supplied to the patient. Life flows through your veins. Stabilize the flow of your intravenous medications with high efficiency systems and advanced technology at the best cost Value proposition statement	What does it contain or what is it about: A flow regulator by means of throttling How will it be bought or acquired ?: It can be sold in pharmacies or supermarkets. Another option is online sales on request. How is it packed and delivered? Plastic bag individually. Cardboard box with shock absorption in batch. How is it used? It is placed over the flow conducting hose before reaching the catheter. A knob regulates throttling and flow. The same knob indicates quantity in drops or ML.
Unique selling proposition (USP) and benefits for users	USP and customer benefits
Why does the user need and will buy the product?: Unlike other regulators, this is outside the hoses, so it can be reused, other products are discarded. What positioning or differentiation will it have with respect to the competition?: High precision, lower price and it is not discarded.	Why will suppliers or partners support or sell this product?: Because it is the best option in terms of flow regulation by mechanical means. Why will others recommend this product?: Because it is easy to use, practical and convenient. What positioning or differentiation will it have with respect to the competition?: Its comfortable and easy to use. Its precise functionality and ergonomic design.
Promotion, distribution and allies	Business impact
Branding and promotion? You can campaign on the Internet (YouTube, Facebook and Twitter), showing the benefits of the product and user experience. Co-branding? Due to the design and mode of use, an alliance could be made with Apple, since its products have related concepts. It could be integrated into Apple Watch marketing in some way. Distribution? Collaboration for delivery? Collaboration with shipping companies, Amazon.com, Mercadolibre.com and other stores on the Web to facilitate access to the product.	Positioning, market share, contribution, income, profits: If the technology is patented, it will have a great competitive advantage over other products on the market. Depending on the sale price, it could have a market of up to 5% of the diabetic population (350 million people) due to the great convenience represented by the use of a product with these qualities.

Table 2. Description of the chosen model.

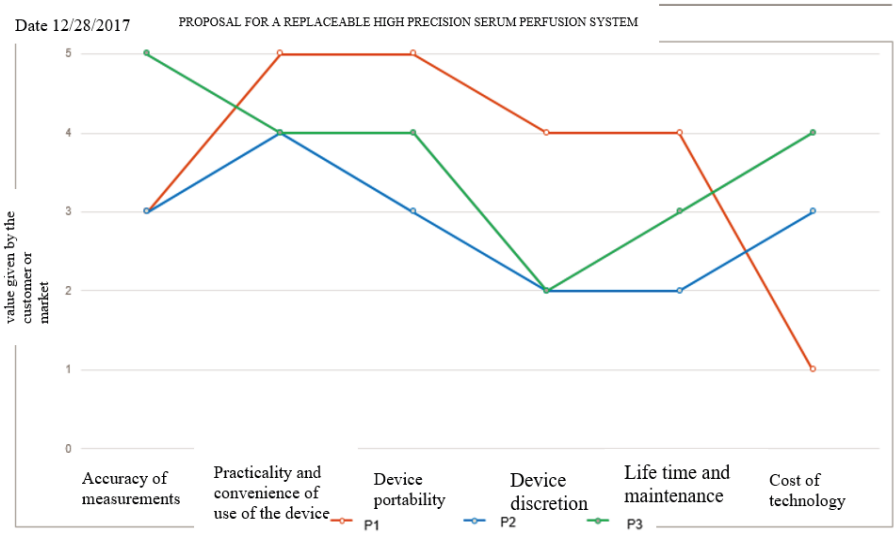

Figure 3. Map of existing competencies or solutions.

Area	Concept criteria	User or client requirements	P1	P2	P3
Product reliability	A. Accuracy of measurements	The highest possible precision is required for the user to make the correct decisions based on the information obtained. The FDA requires a margin of error of 1% of the true value.	9	9	9
Device functionality	B. Practicality and convenience of use of the device	It must be easy to use and the information must be displayed clearly and concisely. Measurements should be taken in a short time with just simple tasks. The information must be able to be digitized and displayed on a screen.	9	4	14
	C. Device portability	You need a small, lightweight, battery-operated device. That does not weigh more than a cell phone. It must fit in your pocket. It is battery operated and energized for at least 24 hours.	9	9	9
	D. Device discretion	It is important that the device is not too scandalous (in appearance and use) so that the user is not discouraged from using it in public.	7	4	10
Concept feasibility	E. Life time and maintenance of the device or its components	The life times and maintenance cycles compete with current glucometers (3 month calibration, life times of 2 years or more - do not take disposable items into account).	7	4	10
	F. Cost of technology	Production costs must be low so that the product is accessible to the largest possible population.	7	6	8

Table 3. Design specification.

In the diagram in Figure 4, you can see the opportunities for innovation, listed below from highest to lowest:

B. Practicality and convenience of use of the device

D. Device discretion

E. Life time and maintenance of the device or its components

F. Cost of technology

A. Accuracy of measurements

C. Device portability

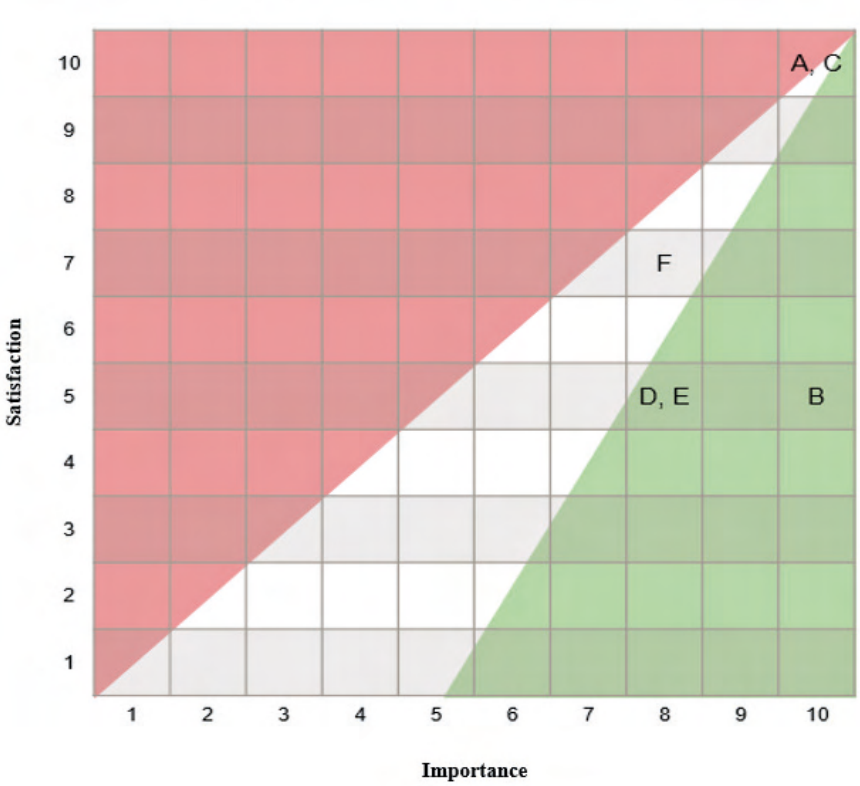

Figure 4. Map of innovation opportunities. Note: Opportunity Score = Importance + (Importance - Satisfaction) / The amount in parentheses should never be zero.

Elements or variables	A	B	C	D
Measurement technology	Solenoid valves			
Physical form of the product	Cylinder	Rectangular prism		
Material	PVC	Plastic	FDA approved polymers	
Maintenance	Electronic	Electric	Mechanical	Continuous calibration
Alarms	Sonorous	Visual	Both	
Display	LCD			
Packing	Box	Plastic		
Controls	Buttons			

Table 4. Design matrix.

4 | CONCLUSIONS

Multidisciplinary teams of diverse engineering, in cooperation with school academy and industry, can solve problems of a great diversity of branches, for example, those belonging to the health branch, based on well-structured, proven and well-founded methodologies.

In the biomedical sector, the areas of opportunity for innovation and patenting of new products open up to a wide panorama of possibilities, with the characteristic that it is possible to work in synergy with engineers from various disciplines, who can be biomedical, mechatronic and engineering in business management (to name a few), to result in value propositions for the industry, which can later be converted into products or patents. It is proposed, in future research, to complement stages 7 and 8, to validate the proposed model.

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