FUNCTIONAL STRUCTURE OF A GENERATOR OF SELF-PROPELLED AEROSOL FOR APPLICATION OF INSECTICIDE AGAINST MOSQUITOES

BAUMHARDT, Ulisses Benedetti, ulissesbb@brturbo.com.br
ALONÇO, Airton dos Santos, alonco@ccr.ufsm.br
Universidade Federal de Santa Maria – UFSM, LASERG, Campus da Universidade Federal de Santa Maria, Bairro Camobi, Santa Maria – RS, Brasil, CEP: 97105-900

DIAS, Vilnei de Oliveira, vilneidias@yahoo.com.br
Universidade Federal de Santa Maria – UFSM

GASSEN, José Renê de Freitas, jrgassen@gmail.com
Universidade Federal de Santa Maria – UFSM

AVELINE, Letícia, leticia@aveline.com.br
Universidade Federal de Santa Maria – UFSM

SILVEIRA, Hendrigo Alberto Torchelsen da, hendrigo.eng@gmail.com
Universidade Federal de Santa Maria – UFSM

Abstract. *This paper describes the development of the structure of functions of a generator of self-propelled aerosol developed to combat in scale of adult mosquitoes. This product will implement the control through the space application of insecticides in the ambient. The demand of this work was based on the low efficiency obtained in the process, together with the super sizing of the systems available for such purpose and the actual need of the control of epidemics. The guiding methodology of the project was the Development Process of Agricultural Machinery - PDMA, following basically 5 steps: 1) identification of potential customers / users of the product; 2) development of the needs of the selected public, through the collecting of information with help of questionnaires; 3) transformation of customer/users needs into project requirements, this is, the characteristics that have to be present on the machine to attend the requested needs; 4) development of the technical specifications of project, by assigning desired values goals to each item; 5) development of the structure of functions of the product, starting in global function, which expresses the relationship between the inputs and the outputs of all the involved quantities, as the flow of energy, material and signal, and dismember it later in partial functions and finally elementary functions. It was used tools like the first matrix of the house of quality - QFD. The organizational structure developed presented the following global function " Move in ways inhabited making the application of formulated product efficiently to the control of mosquitoes, safety and ergonomics with the people involved" needed to be split into six partial functions "to generate aerosol, to control the generate aerosol, to provide safe movement, to control the displacement of the machine, to accommodate the operator with safety and ergonomics and to protect the people involved" and from those derive forty-two elementary functions. Can be check the importance of correct development of the structure of functions of the product under study, with knowledge that it is through it that are designed the principles of solutions, that subsequent selected and grouped together form the concept of the machine.*

Keywords*: project of the product, ultra low volume - ULV, agricultural machines*

1. INTRODUCTION

Brazilian society have their health affected by insecurity or lack of sanitation, causing many diseases. Among these diseases, some become public calamities, such as diseases transmitted by mosquitoes. Among them, dengue deserves special prominence, its vector the Aedes aegypti, which was eradicated in most countries of America in 1950, nowadays has be expanded dramatically, starting in major cities and also reaching the rural areas (WHO, 2000).

The World Health Organization (WHO) estimates that annually between 50 and 100 million people are infected in over 100 countries, of these, approximately 550 thousand patients require hospitalization and 20 thousand die as a result of dengue (PNCD, 2007).

The strategies of fight are based on the use of chemicals and biological agents through the focal and perifocal treatments, and space application of insecticides, as well as in integrated controls with environmental management programs (BRASIL, 2001; LUNA et al., 2004).

Among the mentioned treatments, the spatial or treatment of the ambient is the only one that aims the combat of the mosquito when in flight through the contact of the drop of insecticide, suspended in air, and the body of the target. This method presents itself as a valuable tool for vector control services in emergency situations, where it is needed quickly

reduce the population of vectors, holding or restraining an epidemic to manageable levels (NELSON, 1986; REZENDE et al., 2004).

The demand of the product under study is based on the absence of a machine specifically developed for the treatment in scale of the ambient in the control of the mosquitoes together with the low efficiency obtained in the intra-domicile by the equipments adapted that perform this function, the "heavy UBV's", as a study by Paixão (2007).

This paper had as objective the development of the structure of functions of a generator of self-propelled aerosol developed to combat in scale of adult mosquitoes. This product will implement the control through the space application of insecticides in the ambient.

2. MATERIAL AND METHODS

The methodology used was based on the Process of Development of Agricultural Machinery - PDAM, written by Romano (2003). This choice was reasoned on the product under study, where although its use can be both in the city as in rural areas, it is characterized as an agricultural machine, because aims the application of pesticide to control pests. As for activities developed, these were based on five steps:

1) Identification of potential customers/users of the product;

Through observations and interviews it was sought identify the direct and indirect users of the product of this study. Back et al. (2008) define the direct users as the people and organizations that are influenced directly by the product, the indirect users don't possess such evident bond with the product.

2) Development of the needs of the selected public;

This activity aimed to realize tasks to identify the wishes and expectations of customers/users in relation to the product that is being designed. For this task, was made a technical visit and the application of questionnaires. A technical visit was realized in the Center for Control of Zoonosis - CCZ in the city of Palmas, capital of Tocantins, where were made observations, registration of images and semi-structured interviews with some of the equipment operators.

Were elaborated structured questionnaires through the discussions and solutions raised during the meetings of the team project. The information obtained were called as original information of the customers/users (ROMANO, 2003). After was produced a list of the needs of customers/users.

3) Transformation of customer/users needs into project requirements;

This activity has been made through two tasks, the definition of the requirements of project considering the general attributes, taking as objective the transformation of the requirements of users in a technical language, with measurable parameters, called the project requirements. After it was elaborated the hierarchization of the requirements of project, aiming to organize the efforts of the team of development of the product and to avoid spending much time in the elaboration of conceptions that meet to the requirements of project of little importance to the market (ROMANO, 2003). Thus, the tool used was QFD, that according with Back et al. (2008), is based on concern that the products must be designed to reflect the wishes, tastes and expectations of users. The authors emphasize that QFD is a method of elicitation of requirements, but is used for documentation and visualization of the needs raised by previous methods, assisting in the processing of these and its successive changes in requirements of user and of project, prioritization of the requirements of project and its final transformation into project specifications.

4) Development of the technical specifications of project;

The specifications of the project are the final result of the process of transformation of the users' needs and they are frequently mentioned as the most important part of the development of the product (BACK et al., 2008). This activity refers to the objectives that the agricultural machine to be projected should assist (ROMANO, 2003).

Seeking to compare the values goal attributed in the specification of the project with the values goal of the available machines in the market (ROMANO, 2003). Initially, those were identified and registered technical information’s of generator of aerosol manufactured for allocation on vehicles, product that more resembles to the that is being projected. After this rising, with the help of an electronic spreadsheet, the project specifications were analyzed and quantified so that these values could serve as parameter for the attribution of the measurable values (goals). Then, for each project requirement were identified the evaluation forms and the inherent risks of the implementation of the requirement.

5) Development of structure of functions of the product.

The first task of this activity was the elaboration of the global function of the product based in the project specifications, considering the interfaces with other technical systems and the environment. Then, the sub-functions were identified and dismembered in partial and elementary, in order to facilitate the search of beginnings of solutions and a larger understanding of the operation of the machine (PAHL et al., 2005).

For the search of the referred functions, during the team meetings, the guided abstraction was used, that, in agreement with Pahl et al. (2005), it consists of analyzing the list of specifications regarding the demanded function and to the main variables, seeking to emphasize the nucleus of the subject more clearly. For this analysis, the authors suggest:

a) To suppress wills mentally;

b) Only to consider requirements to affect directly the functions;

c) To convert quantitative data in qualitative, in that conversion, to reduce them to essential assertions;
d) To enlarge in an appropriate way what it be noticed;
e) To formulate the problem in a neutral way as for the solution.

For the authors, some steps can be suppressed, depending of the task or of the extension of the list, what happened in this work.

Regarding the composition of the identified functions, this happened through a predicate composed by a verb and a noun, as for example, to generate flow of air, to signal displacement, among others.

3. RESULTS AND DISCUSSION

Deliveries of this work are presented in accordance with the activity developed.

1) Users of the product;

Among the main direct users of the equipment now employed for the control in scale of adult mosquitoes, they are the operators of the generator of aerosol, drivers of the vehicles "heavy UBV", employees of the maintenance, personal of the technical delivery, companies that work with scraps and recycling of the components of the equipment, manufacturers of the equipment, government and city halls. The indirect users are the population in general, more specifically, the pedestrians, drivers and inhabitants of the atmosphere that it is being treated.

2) Customers/users needs;

The first information said as "originals" were collected seeking to ascertain what the external customers/users, specifically those that have direct link with the UBV heavy, would like on a machine built specifically for the control of mosquitoes. Were collected 81 questionnaires, of these, 33 were answered by drivers of vehicles carrying the nebulizer (UBV heavy), 31 by operators of the nebulizer and 17 by researchers, coordinators and others who have understanding in the area. According to Back et al. (2008), a number of 20 or 30 interviews in a homogeneous group of users can ensure that 90% or more of the needs are identified. After collection, this information were worked, aiming to grouping the similar and elaborate the list of needs of customers/users (Tab. 1).

Table 1. Customer/users needs of the generator of self-propelled aerosol

N°	Customer/users needs
1	Be cheap
2	Be economical
3	Be efficient
4	Be resistant
5	Safe and comfortable to the involved
6	Easy to use and regulation
7	Have quick and simple maintenance
8	Not break in use
9	Have good autonomy
10	Inform the public when in operation
11	Have agility

3) Requirements of project;

Totaled up 65 requirements of project, which after the use of QFD could be classified according to the degree of importance to the project, being presented in three thirds, the top (Tab. 2), the medium and the lower.

Table 2. Upper third of the hierarchized requirements of project

Ord.	QFD	REQUIREMENTS FOR PROJECT	Unid.	Dir.
1º	4702	Cost of Production	R$	-
2º	3264	Number of information for monitoring the conditions of use of the machine	n	+
3º	3071	Percentage of usual processes of fabrication	%	+
4º	3061	Percentage of simple tools for assembly of the machine	%	+
5º	3058	Cost of maintenance	R$ a. a.	-
6º	2835	Power required to trigger the blower	kW	-
7º	2820	Reach of the range of application	m	+
8º	2705	Cost of operation	R$ a.m.	-
9º	2696	Total power of trigger (propulsion, air flow, cooling and controls)	kW	-
10º	2673	Generate air flow in the nebulizer mouthpiece to simulate the wind speed in the application	m/s	+

11º	2510	Number of commands of the nebulizer available to the operator	n	+
12º	2484	Time of corrective maintenance and predictive	h	-
13º	2353	Total net mass	kg	-
14º	2332	The time required to preventive maintenance	h	-
15º	2330	Time between preventive maintenance	h	+
16º	2314	Percentage of pieces easily found in market	%	+
17º	2080	Ability to generate air flow to break the liquid	$m^3 s^{-1}$	+
18º	2029	Parts to be recycled or remanufactured	%	+
19º	2022	Number of schemes and corresponding speeds	n	+
20º	2011	Number of alerts of bad operation	n	+
21º	1906	System of impacts damping	XX	XX
22º	1871	Course of horizontal displacement of the nebulizer mouthpiece	m	+
23º	1871	Course of vertical displacement of the nebulizer mouthpiece	m	+

It should be emphasized that this hierarchization aimed to the priorities to be considered in decision making throughout the process of achievement of project, which does not mean that the requirements of project that received lower scores are not met.

4) Technical specifications of project;

Knowing that the project specifications are the objectives that the machine needs to assist, and that these should establish something that is necessary, verifiable and attainable (BACK et al., 2008), some existent parameters were sought, more precisely in the generator of aerosol, manufactured for allocation on vehicles (BAUMHARDT et al., 2008).

They were identified 40 models, supplied by 13 companies in 5 countries (Brazil, USA, China, Germany and Turkey). Due to the absence of information regarding some of the appraised requirements, 6 models were excluded of the analysis, announcing only 34 products.

The select parameters aided in the development of the project specifications linked to the process of generation of drops. For the others, analogies of existent systems were used, preliminary calculations with base in collected information, and in some cases estimates, due to absence of defined parameters for a more detailed approach. In the Table 3, can be visualized some project specifications obeying the order of importance attributed to the project requirements.

Table 3. Some technical specifications of project

	Project requirements (hierarchized)	**Unit**	**Value Goal**	**Form of Evaluation**	**Aspects to be avoided**
1	Production cost *1	R$	< 100.000,00	Economical-financial analysis	Compromising of the quality
2	Number of information to monitor the conditions of use of the machine	n	3 (Rotation and temperature of the motor, level of fuel)	Analysis and quantification	Operational difficulty; High production cost
3	Percentile of usual processes of production	%	> 60	Analysis and quantification	Need of high investments
4	Percentile of simple tools for assembly of the machine	%	> 80	Analysis and quantification	Operational complexity of the maintenance
5	Cost of Maintenance	R$ a. a.	< 4.000	Analysis and quantification	Compromising with the quality of the maintenance and with the high production cost
6	Necessary potency to work the blower	kW	13,42	Test in dynamometer	To avoid potency excess in the blower
7	Reach of the application strip	m	50	Test of deposition of drops; Test biological	Uniformity lack in the width of the application strip

*1 It doesn't include structure for the manufacture.

5) Structure functional of the generator of self-propelled aerosol

According to Menegatti (2004), before beginning the search for solutions for the project problem, it's necessary to define which the function or functions that product should accomplish.

Initially, the global function was developed, characterizing the "larger" problem of the project, and after it was defined the sub-functions. The Global Function should express the relationships between the entrance greatness and exit of the product, bringing a summary of what to wait in functional terms (REIS, 2003).

For Andrade et al. (2005), this activity makes possible a larger understanding of the project as a whole and a better visualization of which the points that should be resolved in the project.

Knowing the global function, with base in the project specifications, the development team dismembered this function in sub-functions, in way to verify the existence of solutions for those. As identified, there was the need to accomplish a new division of this, characterizing her in elementary functions. The Figure 1 illustrate the functional structure of the product "generator of self-propelled aerosol".

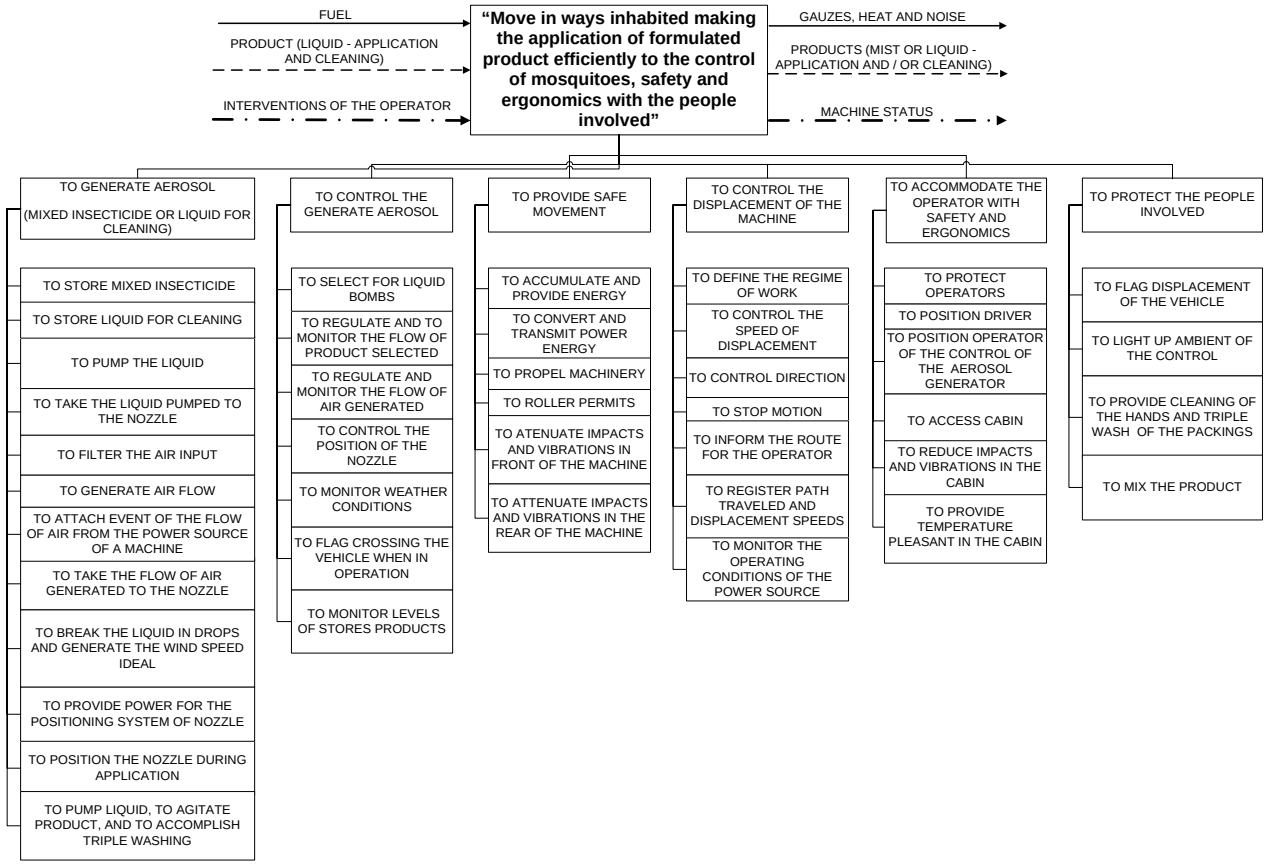

Figure 1. Structure functional of the generator of self-propelled aerosol

4. CONCLUSIONS

The Process of Development of Agricultural Machines (PDMA) it was an efficient and appropriate methodology for the elaboration of the agricultural machine in study, the "generator of self-propelled aerosol";

After the development of the structure of functions of the product in study, will be possible the identification of at least a solution beginning for each one of the identified functions. That will aid in the development of larger number of variants of the product, and consequently, the probability of the formulation of a conception that best assists the needs of the customers/users of the product;

The use of questionnaires for the obtaining of the customers/users needs, as well as to discover opinions regarding the characteristics inserted in the product, it was an efficient tool;

Finally, this study will allow the development of the other activities and phases along the process of development of the project, seeking the creation of a specific machine to combat the mosquitoes.

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5. RESPONSIBILITY NOTICE

We, BAUMHARDT, Ulisses Benedetti; ALONÇO, Airton dos Santos; DIAS, Vilnei de Oliveira; GASSEN, José Renê de Freitas; AVELINE, Letícia; SILVEIRA, Hendrigo Alberto Torchelsen da; took the responsibility for the content and authenticity of the work entitled "FUNCTIONAL STRUCTURE OF A GENERATOR OF SELF-PROPELLED AEROSOL FOR APPLICATION OF INSECTICIDE AGAINST MOSQUITOES".