DEVELOPMENT OF AN AUTOMATIC GUIDED CHASSIS

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ABSTRACT: Studying and implementing the latest technologies on the market is a priority for many companies, given the benefits that new technologies offer. The current trend of flexibly automating the production process comes in direct response to market demand. to be able to offer a wide range of products, manufactured in different time regimes, in different batches, with different particularities. Most of the time, the time and quality of the production process study of feasibility to be able to identify its degree of applicability.

KEYWORDS: Industry 4.0, automation, robots

1. Introduction

Industry 4.0 is constantly evolving, so the goal of this research is to automate the transportation process with the help of an AGV robot. The development direction of the research is the development of a chassis with optimal control, which will minimize costs and be able to withstand high demands and withstand the external environment. The flexibility of automatically guided robots is their ability to move in certain directions at certain speeds. A very important aspect in the operation of these robots is not only the actual transport of materials but also the way they transfer and pick up transported objects. The loading and unloading of the robot with materials is done automatically, while the operator can handle the processing of parts on production lines.

Taking all this into account, we can see that the automation of a process requires attention special analysis, an analysis of the current situation in which automation is desired and then, data analysis, identifying how automation can or cannot be implemented.

2. Business strategy

In order to understand what the customer wants and how these desires are reflected in the characteristics / functions of the new product, research was conducted on the analysis of the needs. For this, a questionnaire was applied for a sample of 50 companies with various fields of activity. The reference data in the following table have

Table 1. Need analysis

Willingness expressed	Parameter	Value
I want it to be resilient	Material	Aluminium
I want it to have great battery life	Autonomy	12V-40Ah
I want it to charge quickly and easily.	Charging time	2-3 h
I want it to have a preset route	Number of routs	2-3
I want to be able to order it from my phone	Planificare traseu	1-2 min
I want to increase my work speed	Speed	2 m/s
Identifying and circumventing obstacles	Device with sensor	2 m
To have a small overall size	L x l	max.608 x 312 mm

Once the user's expectations of the product were set, a clear picture of the market in which the product was to be launched followed. This was done by studying the range of AGVs currently on the market, by the manufacturers of AGVs and by defining the target customer for our product presented below [5-7]:

1. Field of activity: Storage companies, sorting of components and products, consumer goods
2. Possibly interested markets: EMAG, UNILEVER, NESTLE, FAN COURIER, DECHATLON, IKEA
3. Number of employees in charge of transport: 1-5
4. Decision makers price, product quality, credibility, service.
5. Desires: adaptable product, from fragile load to Heavy-duty,
6. The reason why you buy to increase productivity and reduce costs;
7. Possible purchase objections: maximum load.

3. Functional analysis

Through the functional analysis, a research was carried out on the functions that must be performed fulfill the product. These were characterized and subsequently ranked according to the degree of importance.

FPI-To support and transport objects,
FCO-Self-guided,
FCI-To adapt to various work surfaces. external,
FC2-To be resistant to the environment
FC3-To be esthetic
FC4-To allow storage in confined spaces,
FCS-To abide by the rules and regulations.
FC6-To adapt to the charging source,
FC7-To be harmless with objects

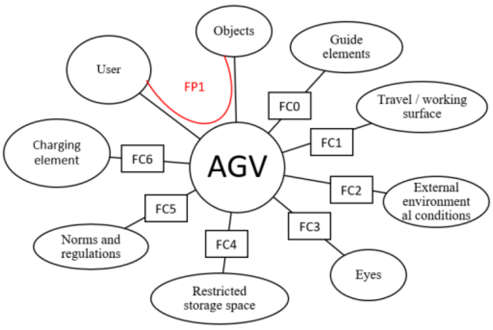

Fig. 1. The relationship of the system with the environmental elements

Based on the interactions of the system with the elements of the external environment for the life phase it was realized functional analysis presented in table 1, where one can observe a main function and seven functions constraints for which the target level and their flexibility were analyzed [14].

Tabel 1. Functional analysis

Function	Targetlevel	Flexibility
FP1	Max 100 kg	Imperativ
FC0	Independent	Imperativ
FC1	Adaptable	Impertiv
FC2	To be airtight	Mandatory
FC3	Product shape	Intermediate
FC4	Product size	Mandatory
FC5	100%	Imperativ
FC6	Adaptable	Mandatory
FC7	Seating surface	Imperativ

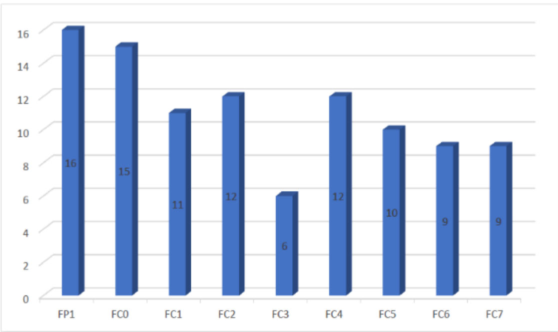

Fig. 2 Diagram

The functional analysis functions have been defined to be implemented on the new concept. The functions of "supporting and transporting objects" "and guiding oneself" turned out to be the most important. Analyzing the period of time that the product spends on the market, a life cycle for the proposed product was made and all the use scenarios that it has been analyzed.

Analyzing the time period that the product spends on the market a life cycle was achieved for the proposed product and all possible usage scenarios have been analyzed.

4. Concept development

To ensure the loading and unloading of loads that the AGV carries were developed more concepts. Only 2 of the 7 developed concepts are presented in this research [6].

The first concept in Fig. 2 is the use of roller transfer devices. For this purpose, the vehicle and the fixed structure of the unloading loading station shall provide roller horses. When unloading, the rollers are actuated on the vehicle. The friction force between the blade and the rollers pushes the blade on the roller track of the fixed station. When loading, proceed in reverse, operating the rollers of the horse in the fixed position. It must therefore be possible to operate both the rollers on the vehicle and those on the fixed station.

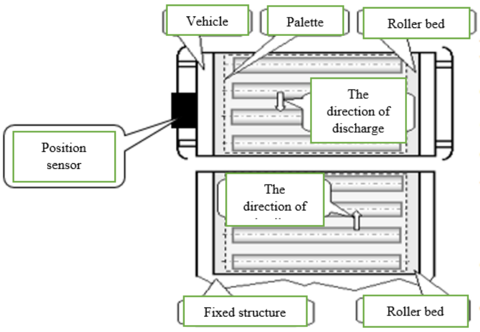

Fig. 3 Roller platform

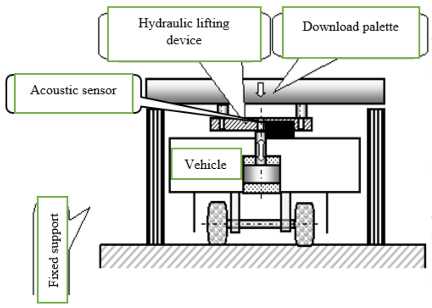

Fig. 4 Lifting platform

The following concept in Fig. 4. is equipped with a self-actuating lifting device. The load is supported by the support pads of the lifting device. After stopping the vehicle in the unloading-loading station, the lifting device lowers the load on the support of the fixed structure, after which the unloaded vehicle leaves the station. When loading the empty vehicle stops in the station, the buffers of the lifting device skip the load, then the loaded vehicle leaves the station. In this chapter two concepts have been specified. These were made taking into account the functions of the functional analysis and the customer's need expressed by the product request, identified in the chapter previous The concept to be developed in the following chapters is the lifting platform because they meet the required criteria, namely the cost and the workload.

5. Development of technical solution and prototyping

The developed product was designed to meet the functional analysis required for the development of technical solutions. It is divided into three subsystems, namely, the mechanical, electrical and software subsystem. They are represented in the following figures in the order of the constructive evolution of the product and in figure 5 is presented the unloading-loading position. [1], [2]. [3]

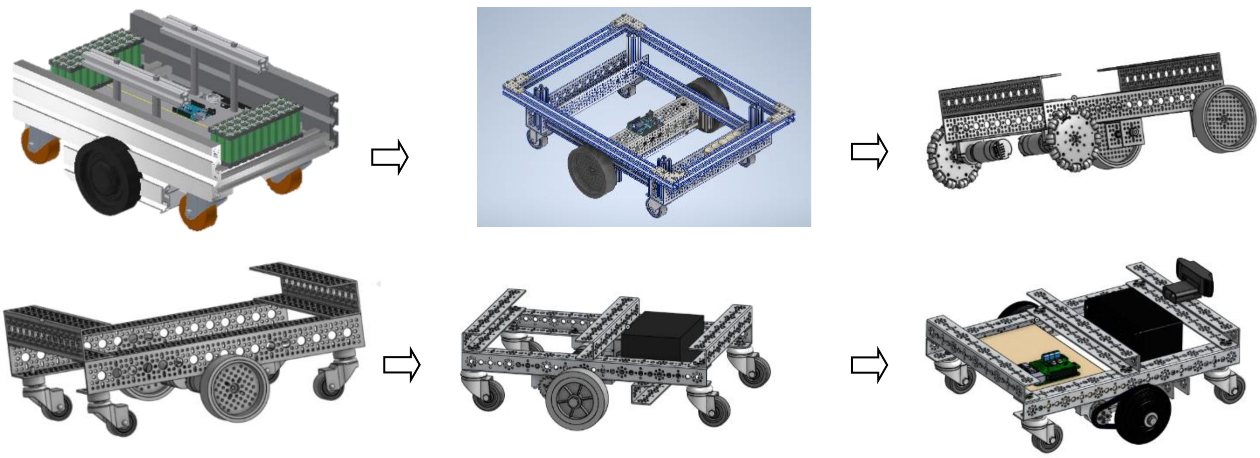

Fig. 5. The soft design developing of AGV prototype iterations

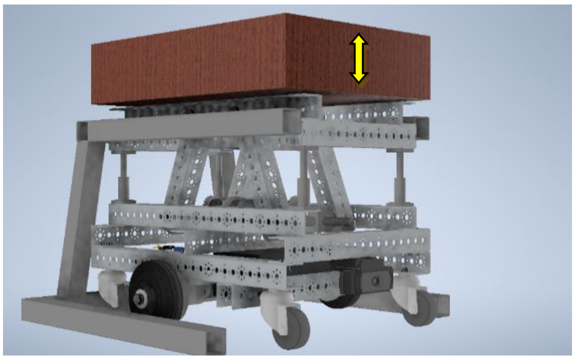

Fig. 6 AGV prototype with lifting and unloading mechanism with electric and mechanical actuation on the U platform

The first stage was the construction of the metal shaft: For a low weight but also a good resistance to the demands of the chassis, it was decided to use U-type profiles that have the dimensions of 32 x 32 mm and the thickness of the material of 2 mm of aluminum. therefore, the redesign of the chassis was necessary to be able to carry a mass of maximum 100 Kg. The new design being more compact and easier to assemble.

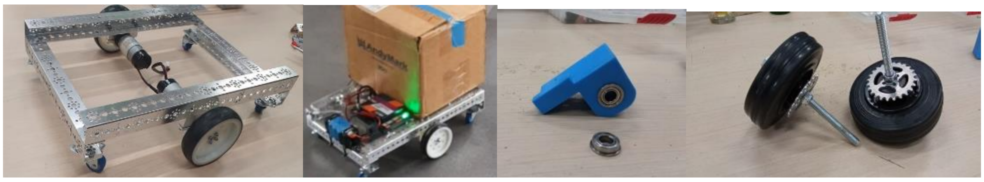

Fig. 7 Switching from wheel locations directly on the drive shaft to the use of a gear and chain gear

The power supply for the motors and electronic components is given by a 12 V NiMh type battery and 3000 mAh initially located in the back of the AGV.

The solution by which the maximum load mass of 100 Kg will be reached during transport according to the product specifications, is by using a wheel axle with a diameter larger than the original one of 6 mm. need and use of flange bearing bearings The bearing was obtained by printing with PLA and a density of 100% for a very good resistance to compression and pressing of bearings in bores

For the drive of the wheels was introduced as a whole a sprocket with z-14 driven by an electric motor with a torque of 2.47 Nm. The torque given by the motor is amplified by the reduction created with the second sprocket which has z-32. Thus, moving with a higher mass load will be more efficient. Along with the use of drive wheels with a diameter of 100 mm, the pivoting wheels that can be required up to 50 Kgf each have also been replaced. The diameter of the rollers is 50 mm. The location of the wheel pivot has been shifted so that the radius of rotation of the roller does not protrude beyond the chassis to avoid accidents during use. The location of the battery in the central part of the chassis for a better agility in corners was necessary. This positioning had the advantages of smaller connectors but that came with another problem, namely how it will be powered or how it will change since it is under the chassy in the central part. The solution is to recharge it through a connector.

Another component that is important in product development and helps with functionality is the program through which the robot operates. It is written in the memory of the raspberry pi 4 8 GB card from component of the machine, using the Baleno program and is in the form of Pyton code.

Also, the module Pololu engine control is installed on the board. The subsystem located at the top has the function of loading and unloading products. By operating the electric motors and rotating the threaded shafts the 4 connecting rods change their angle, so the mechanism produces the translation of the platform on the axis za of the structure. During the unloading of the products the mechanism is raised so that it can enter the unloading area and by lowering the product will result in a placement on the flat surface of the U-type platform, the loading being the opposite of this operation.

After the physical realization of the chassis, a deformation analysis was performed by using the 3D Inventor professional design software and more precisely the analysis menu (Analysis) had as first step the updating of the 3D drawing in its last form. have a structural role in the analysis by placing a weight in the upper part of the chassis being the loading area. The rest of the electronic components and support of the electric motor, including the motor, were extracted from the analysis drawing in order to simplify both visually and in terms of processing the results, finally obtaining a shorter charging time. To this simplification I later added pin type contacts in the places where the fixing is done with screws for the same reasons. 10 kgf Thus we obtained on the one hand a confirmation of the appropriate location of the contacts and constraints but also a result of the analysis in which it can be seen that the aluminum profiles were not subjected to cold plastic deformation confirmed by safety coefficient with higher scale value [7]. [10]

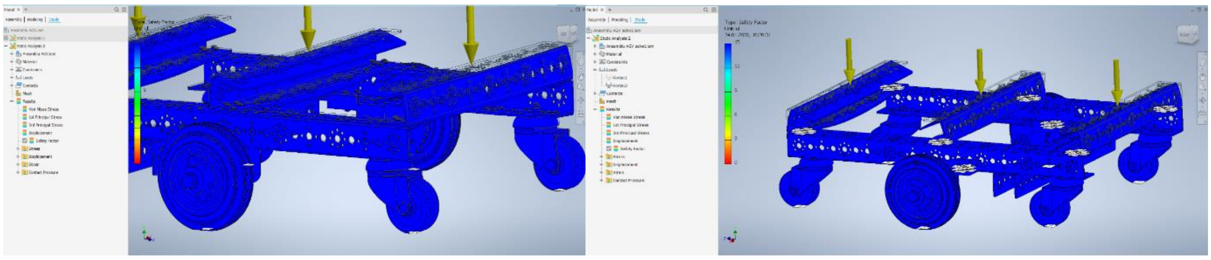

Fig. 8 Selection of parameters and surfaces to be subjected to deformation analysis

In the following test a higher value close to the one proposed in the specifications of the AGV type robot was used, namely 90 Kgf. After obtaining the results, it was found that in this variant the safety factor is somewhere on the scale of number 2, so deformations appear at the level of the profiles, the bottom contact surface pushed inwards.

Logically, this situation is not the real one because the assembly does not contain the loading surface represented in reality by a sheet metal strip of a certain thickness. This would have a greater influence on the deformation of the profiles being a factor that increases the rigidity of the assembly. In order to verify this hypothesis, the component that represents the loading surface but at a considerably smaller thickness was introduced in the analysis, as it is represented by a plan. Thus, the analysis of the structure became more plausible by the fact that the respective sheet raised the safety coefficient in the evening to a value of over 3.74 and the profiles did not deform excessively inwards. The most deformed line is the one that joins the centers of the profile bores.

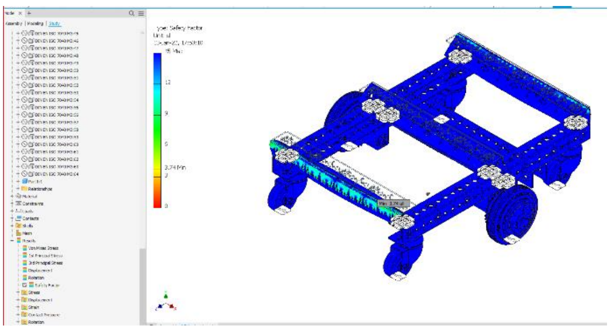

Fig. 9 The result of the deformation analysis and the representation of the required points

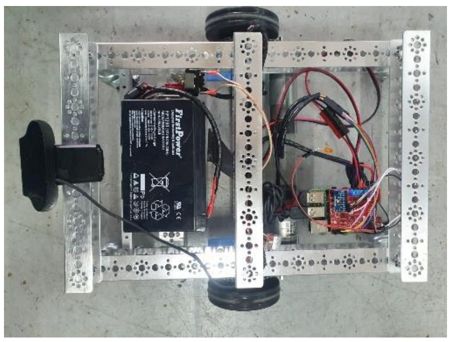

Fig. 10 AGV prototype with Raspberry Pi control board Pololu motor control module MAP sensor

Following the assembly of the hardware components and the installation of the software codes of the AGV type robot, much better results were obtained compared to the first prototype. For all criteria except battery life where a solution has been implemented by using a larger and rechargeable battery, but which is economically advantageous. The new battery can store 3 on more electricity with a capacity of 12 V with 9000 mAh Autonomy in working mode reaching the initial specifications set out in the product data sheet. A first step in the operation of the AGV was to test the engine, chassis, battery system. To perform this step, they were temporarily mounted and connected to the chassis engines, the battery and a pleasant wi-fi capable of being able to transmit commands to the engines for moving in two directions, forward or backward.

To test the product, we connected to the wi fi board (Raspberry Pi) via a phone through its wi fi function, in the phone we connected a joystick controller.

From the first test it was observed that the engines are capable of performing the transport function, different weights were placed on the chassis to observe both its mode and behavior and the Rejes engine and weaknesses such as the fact that the battery is not suitable, the motor shaft takes up a very large part of the weight of the load.

Another step was to make the left / right turn, for this we used the engine encoders, when you want to turn left the engine on the right keeps its speed and the one on the left decreases speed, the same thing happens for the right turn, but the engine that keeps its speed is the one on the left and the one that decreases its speed is the one on the right. In the improvement of the autonomous robot cartre, we replaced its control, the control is done now through online platforms. Correction of space travel of traction losses through the addition of engine rotations will be done with the help of the MAP-9250 accelerometer sensor and the camera web video located on the front [3]. [11]

A simulation was performed in the Tecnomatix Plant Simulation program: In this simulation it is presented a well-defined workspace consisting of the next route to be completed by AGV

The AGV starts from the first working point (CNC LABCENTER 260), point where it was loaded with the necessary parts for transport to the second point (DRILLING MACHINE MG 16), the parts transported by AGV are unloaded at this point following that it is move to the third point (LOADING STATION) until the next tasks are transmitted to it. At this moment the second simulation is performed in proportion of 60%, the AGV starting from the rest point (charging station) to point A (CNC LABCENTER 260) where it takes over the parts transport to point B (DRILLING MACHINE) is required, transport to be carried out later. At this moment in the simulation there is no return of the AGV in point C, loading point, following in the future through several interactions and changes of constancy in the program overcoming this problem and performing a complete simulation.

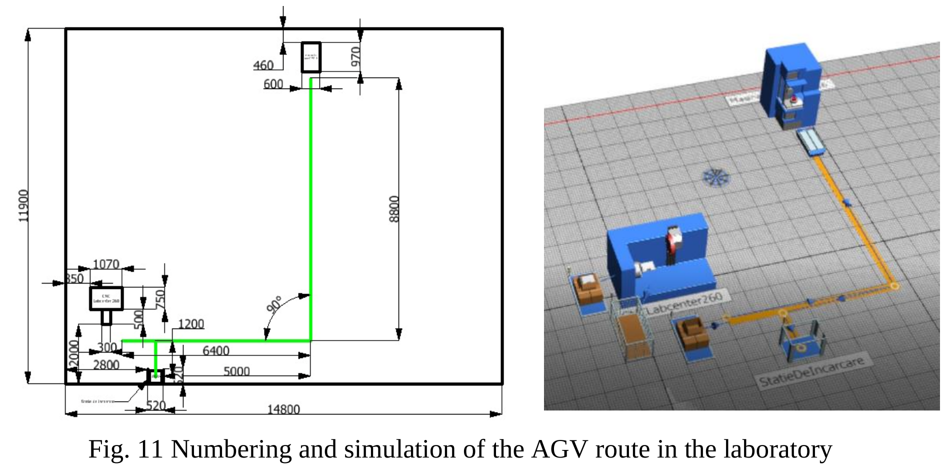

Fig. 11 Numbering and simulation of the AGV route in the laboratory

In the case of an autonomous robot, it works according to a well-defined route, a route that is possible make in the next figure.

The route was defined both physically within the faculty lab and numerically through the Autodesk Inventor design program. The projected sketch is made on a scale of 1.1. the sketch data coincides with the dimensions of the work front followed by the robot. Various transport cycles between the 2 stations (CNC Labcenter 260- Drilling Machine MG 16) and loading station will be further simulated, taking into account various parameters specific to the route between the 2 workstations that will help to dimension the parameters. odometry and navigation of the robot.

6. Economics analysis

The cost of production is the cost of purchasing materials and consumables, processing costs of raw materials for processing into a finished product.

The Table 2 shows the selling price of the AGV product for which the expenses related to the jobs, the salary expenses, the maintenance expenses, the expenses with the necessary materials and others were taken into account [12,13].

Table 2. Costs

	Value	**Measure unit**
Annual fixesd costs	2364932	lei/year
Variable unit costs	970	lei/unit
Total unit costs	2862	lei/unit
Selling price	4000	lei
Sale price with TVA	4768	lei

The break-even point is the point at which the proceeds from the sale of the production fully cover the variable costs of that production and the fixed costs, so that the enterprise derives neither profit nor loss.

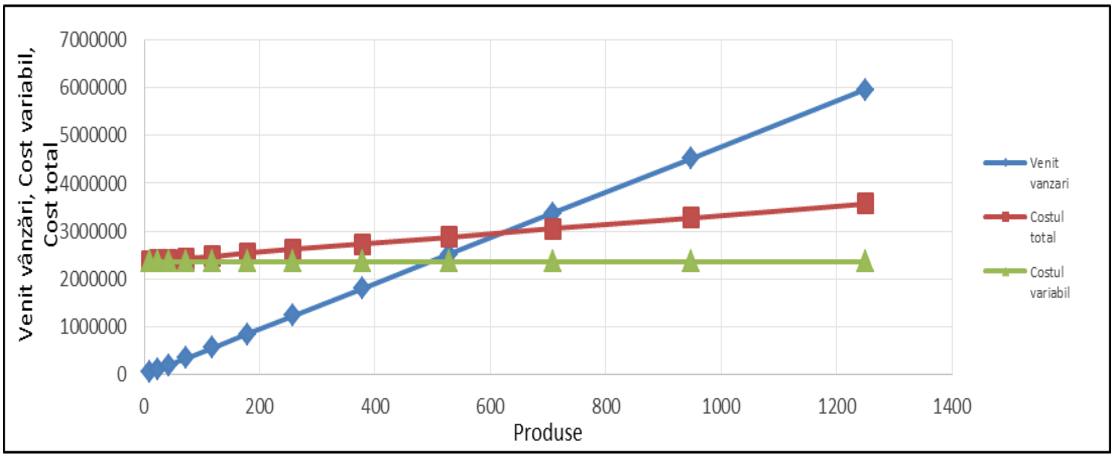

Fig. 12. Calculation and arrangement of results to determine the break-even point.

Following the calculations made it can be seen in Fig 12 that after the sale of 623 products from the reaches the break-even point After about 10 months of production, the break-even point is reached, which means that at the end of October we will make a profit.

7. Conclusions

Today's robotic applications are becoming more numerous, and all have as their main goal the reduction of the operational costs related to the industry. Also, the current trend is to replace the people who perform these operations, in order to obtain constant results. A criterion analysis was performed for each product. The needs expressed on based on a questionnaire applied to a sample of 50 enterprises and the new characteristics for choosing a concept were defined.

Through the newcomer analysis, a research was carried out for the development of the product in order to understand what the customer wants and how these desires are reflected in the characteristics / functions of the new product. By segmenting the market and choosing the target segment, the customer profile was created. Through the functional analysis, the functions to be implemented on the new concept were defined.

Functions "support and transport objects and take objects and transport them from the storage space" they turned out to be the most important. Analyzing the time, the product spends on the market a life cycle for the proposed product has been completed and all usage scenarios have been analyzed which we may have.

Two concepts have been developed. These were made taking into account the functions of the functional analysis and the customer's need expressed by the product request, identified in the previous chapter. These chassis concepts have different characteristics based on some criteria; a hierarchy was made to observe the degree of importance. of chassis. Thus, with each new prototype, improvements have been made at the construction level, so that the demands arising from a transport of 90 Kgf do not affect essential components such as engines in terms of premature wear.

One more performance has been added by using a high-capacity battery but also by programming the engine speeds for low speed and efficient travel. Regarding the deformations of the resistance structure, namely the set of U-type profiles fixed with screws, we obtained from the analysis at software level values that did not allow the definition of the loading limits of the AGV type robot, namely 90-100kg All components were analyzed and depending on the cost, so as to result in a price as low as possible with the raw materials for a total cost of the reduced product

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