MODULAR DESIGN FOR STORAGE OF LUGGAGE IN PASSENGER TRAINS

Lucian CUCU[1], Ionel SIMION[2], Gina Florica STOICA[1], Sorin CĂNĂNĂU[1]

This paper presents a study of different luggage volumes transport and proposes its improvement through a modular system design. It proposes a module able to optimize passenger baggage storage, as well as dynamic aspects of the train coupling system, residence times, the time required for embarkation and disembarkation of passengers leads to the necessity of designing a modular system, self-contained, for luggage. This line of research involves developing an innovative product with high-impact, which would improve services in the railway industry in complete safety.

The approach presented in this paper requires rethinking the structure of the train in terms of storage space for luggage. They will be relocated outside the train, through a modular design solution able to solve the lack of such storage without influencing the behaviour of the train and its structure.

The study is a new direction for the rail industry and it is applicable for other means of transport and represents an important step in the new conditions imposed for baggage transport security.

Keywords: modular design, modularisation design, modular luggage storage, exoskeleton.

1. Introduction

The transportation of mixed volumes is used in aviation and shipping services for luggage, not being developed for other means of transport (rail and road).

Existing work deals with transporting luggage, but sometimes sensitive issues like the stagnation area and the limitation of volumes delivery (luggage) from point A to point B are not treated. Rail passenger transport is the movement of passengers using railway vehicles between the place of embarkation and place of disembarkation. Meanwhile, rail ensures the movement of passengers, their baggage, with greater safety, continuously and with a default chart. [1]

[1] Machine Design and Tribology Mechanical Engineering and Mechatronics, University POLITEHNICA of Bucharest, 313 Splaiul Independentei, Bucharest, Romania, e-mail: lucian.cucu@upb.ro

[2] Engineering Graphics and Industrial Design- Aerospace Engineering, University POLITEHNICA of Bucharest, 313 Splaiul Independentei, Bucharest, Romania, e-mail: ionel.simion@upb.ro

Passenger's luggage transport by rail was treated very little in the speciall literature. Passenger's claims on comfort are constantly increasing. They grow directly with the resources invested by railway service providers. Providing comfort builds on consumer interest in this topic.

2. Aspects of modularization in luggage transportation on the railway infrastructure

The modularization implies that all parts are independent and, at the same time, interconnected within the life cycle of the product. Modularization confers functional independence and represents a major objective in product design. Products can be modularized to be feasible / reliable in order to meet the customer's demands. Modularity is the degree to which system components can be separated and recombined creating a subassembly or an assembly operation. The evolution of market demand for passenger rail trail leads to the need to improve transport luggage, as a factor of increasing comfort.

Efficient transport of luggage requires several conditions:

- keeping the number of passenger seats;
- minimal changes in the structure of the wagon;
- improving the user experience for those travelling by train services;
- promote a comfortable journey by train to the detriment of the car;
- promote green travel.

Transport of luggage as well as optimization of these services can be achieved in compliance with these goals and options available.

In general, the product systems "modulation" can be decomposed into a number of components. These can occupy various positions resulting in a variety of configurations. Components can connect, interact, and exchange energy and information through their adherence to a standardized interface.

Fig. 1 Modular design components

The design of modular elements can be made from whole or starting the modular element constituents can achieve sub-elements and overall. [2]

The modular design and modularization design is an approach that divides the system into smaller parts (modules or skids) that can be performed independently and then combined so as to have more functionality.

The modular system is generally characterized by:

1. Partitioning distinct functional modules consisting of functional elements isolated, independent;

2. Using defined modular interfaces;

3. Ease amendment to ensure interchangeable interfaces.

The disadvantage of modularisation (depending on the degree of modularity) is that modular systems have high index of performance. This is due to the complex method of combining and optimizing components. Luggage storage modularization in railway transportation has a modest development although the number of people who use public transport services increases at the expense of road transport. Giving up his own car and gradually increase the use of public transport is largely due to fuel price increases and promotion of ecological means of transport.

This migration between rail and combined transport railway and road creates problems in the rail infrastructure.

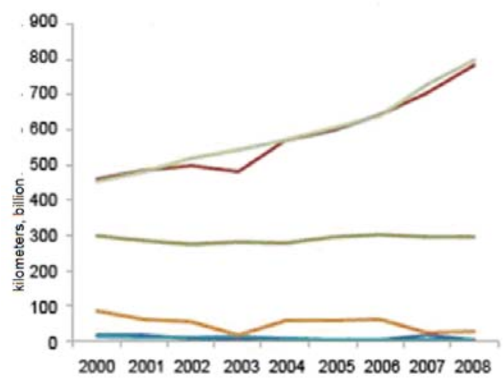

Fig. 2 Railway passenger growth

The increased flow of people using the railway infrastructure leads to increaseing luggage storage spaces, wich remained unchanged.

Since the space stations are more or less imposed, creating a "dynamic storage" would solve some problems and also will allow checking the baggage's in terms of antiterrorist protection. Issues are rising from the embarkation and disembarkation of luggage while traveling, leading to confusing situations even in a well-organized route.

The analysis of the architecture of a wagon train leads to the conclusion that the interior storage space is insufficient for a proper performance of the function of storage required for the increased passenger numbers and diversity of types and number of luggage. A large number of users of this service are traveling with large luggage’s along with other smaller ones simultaneously. Existing storage capacity in a car does not provide enough room for heavy duty luggage. Storing such large luggage is usually the clearway of the wagon, crowding it, making movement difficult, and creating discomfort and difficult access to storage spaces.

It highlights issues related to "traditional" safety, price, punctuality, time travel, accessibility. Boarding the train with large bags increases the time required for the train to depart. Reconfiguring the architecture of a wagon train in order to create new storage involves restructuring costs, planning, and loss of a number of passenger seats, including a long time spent in the service station to change.

3. Passenger wagon reconfiguration solution

The solution involved by the study of a possible reconfiguration was relocating the storage space to the exterior of the wagon train. Admitted compliance gauges for the railway track permitted the development of a storage only on the longitudinal axis of the train.

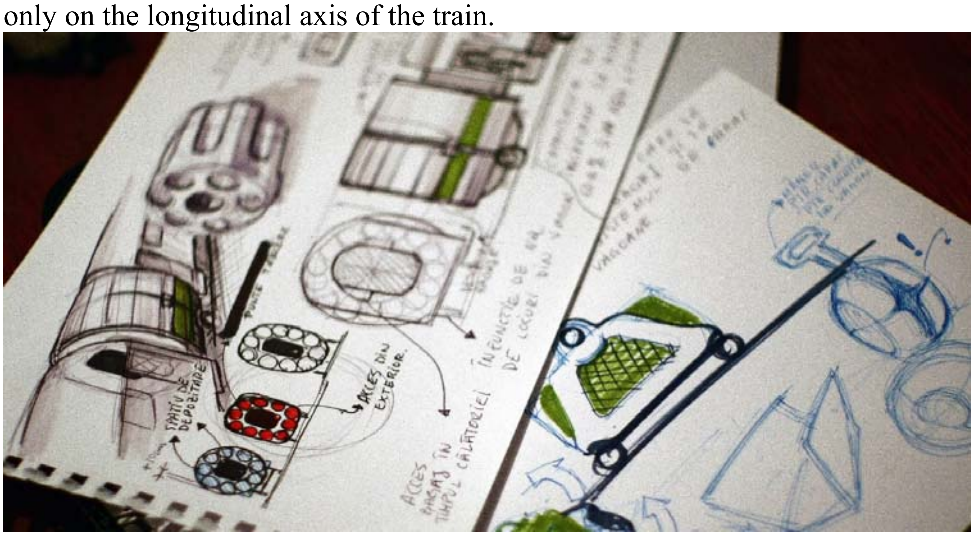

Fig. 3 Preliminary iterations of the concept

The proposed solution must maintain the smooth operation of the train, and therefore must comply with the conditions of rail service providers. To meet these requirements, the concept gradually developed through trial and error, influenced by the morphology of the train, the various aspects of station parking platform, train station architecture and how the user interacts with it.

It has been conducted a series of iterations, graphics and scenarios of modules, thus revealing potential problems and solving them by adapting the concept to the conditions required in order to offer proper accessibility and ergonomics . [3]
The charging architecture of the Revolver type gun best describes correctly the optimal solution for the proposed system of transport and luggage storage. This system allows loading and unloading luggage on both sides of the train depending on the architecture of the platform when stationary and allows access to luggage from inside, while on the move.

4. Study iterations of the storage spaces

The study started from the existing baggage storage system on some passenger trains, from the European Union, which have attached a specially designed wagon for transporting luggage, placed after the locomotive. This variant is using an automated loading and unloading baggage system, implemented in a standard sized car. A brief analysis led to the conclusion that this solution does not satisfy the requirement related to the downtime of the train, access is difficult for passengers in the last wagon.
The concept itself fulfilled the requirement of automation and feasibility on the stability of the train, but do not address the issue of efficiency of the entire system.
Alternatively, the study led to a smaller car located between the train cars which has the charging system of "revolver". This iteration meet the requirement of automation and streamlining the residence times, access is fast, but does not answer the feasibility condition, the carriage being to small leading to instability phenomena of the train while on the move.[4]

Concept development and interaction between user and system:

The interaction between the user and system

User/ module interaction study is based on a complex scenario in the context of this module is mounted on a train set and communication interface between the train and railway service provider is working.
Scenario analysis has implemented the dwell typing luggage and age of the user.
Access to storage capsule is made when buying the ticket specifying the intention to use this luggage service that once implemented requires a ticket surcharge.

Assigning a capsule is made by software developed specifically for this service, analysing the availability of spaces and destination stations, avoiding overcrowding the modules (it will follow a uniform distribution and proper user / baggage / module / destination).

Hence, if multiple users on the same destination will be distributed in different cars and wagons default corresponding modules to streamline the debarkation.

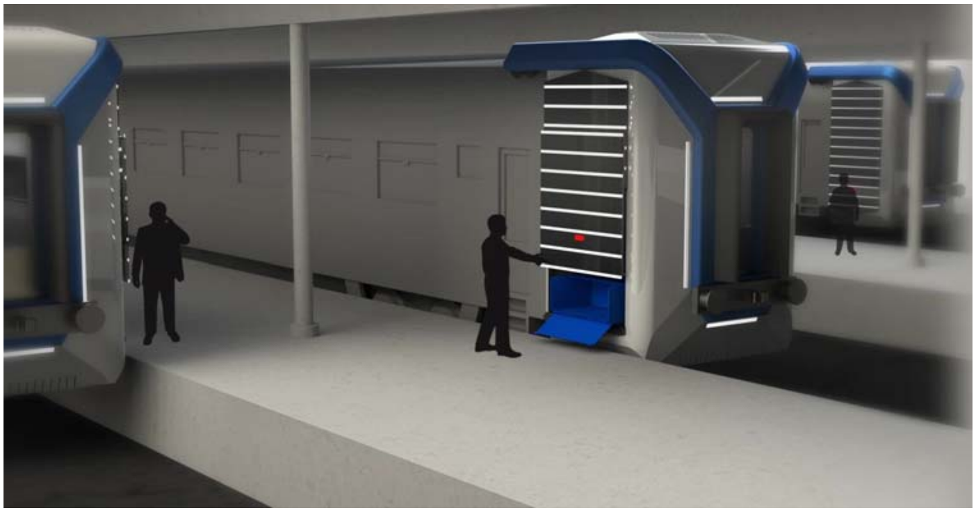

Fig. 4 Context implementation of the dynamic module

Access to the capsule is made by scanning the bar code printed on the purchased ticket. Scanning the ticket sends a command to how to select a capsule reserved by the software, bringing it to the user to enter the baggage. The capsule takes the luggage inside, while another capsule is preparing for the next user.

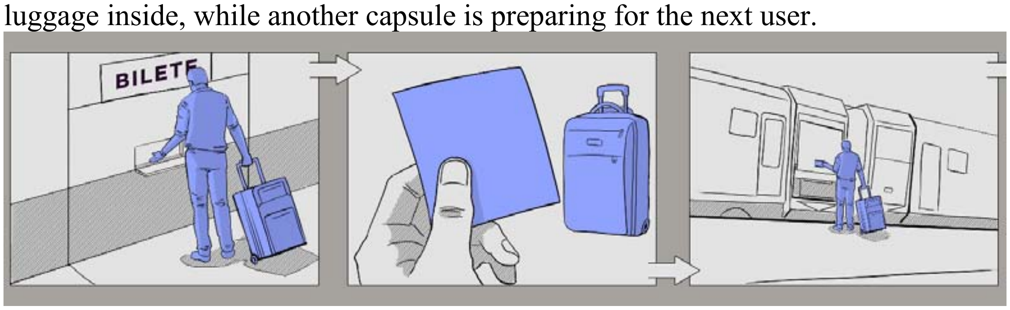

Fig. 6 Utilization scenario -stage 1

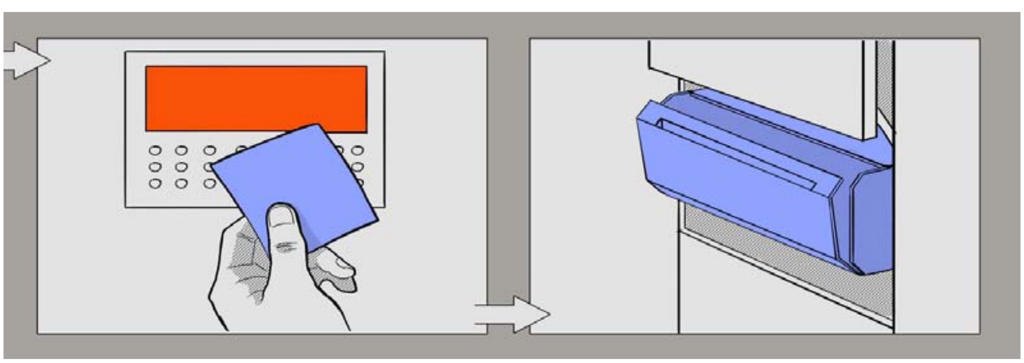

Fig. 5 Utilization scenario -stage 2

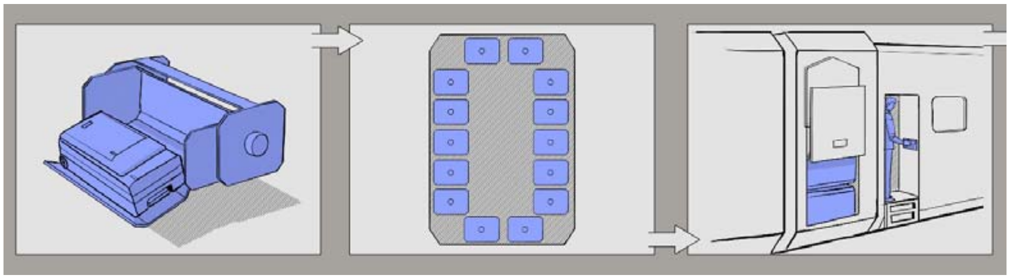

Fig. 7 Usage scenario -stage 3

To recover the luggage, at the destination station, the user will scan the ticket inside of the car off to a scanner located inside the wagon space immediately adjacent to the access door. Placing the scanner in this area organizes and streamlines the access to module, wagon door in this context forming a "funnel" allowing people to get off the train one by one.

The time required for positioning the capsules for download coincide with the time starting with scanning of the ticket by the user until he reaches the front of the module (2-5 seconds).

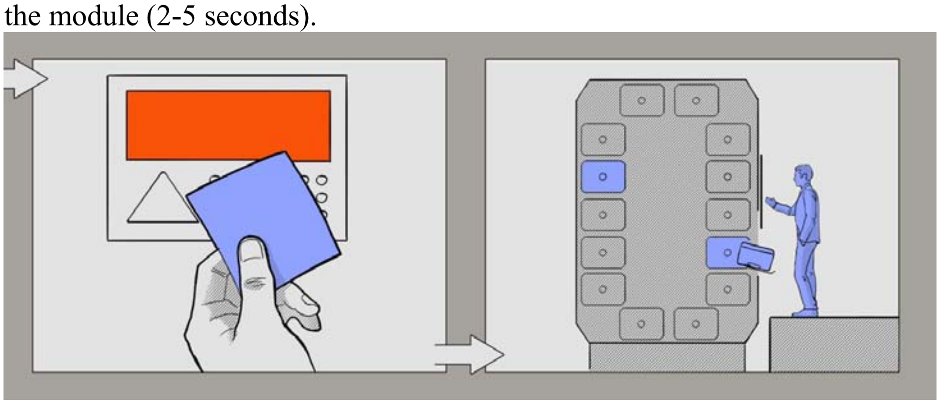

Fig. 8 Utilization scenario -stage 4

5. The proposed modular luggage storage at the end of the train

The solution provided meets all requirements for feasibility. The concept finally took the first studies of morphology and functionality, solutions optimization, usability, user interaction, finding a feasible way to train dynamics problem. The proposed solution is an independent structure, which is integral with the car after it is mounted in the train.

Luggage storage module in component wagon train consists of five components:

1. Metal inner structure; 2. The set of 14 capsules; 3. Structure of external protection; 4. "Exoskeleton" grip; 5. Arm grip and coupling.

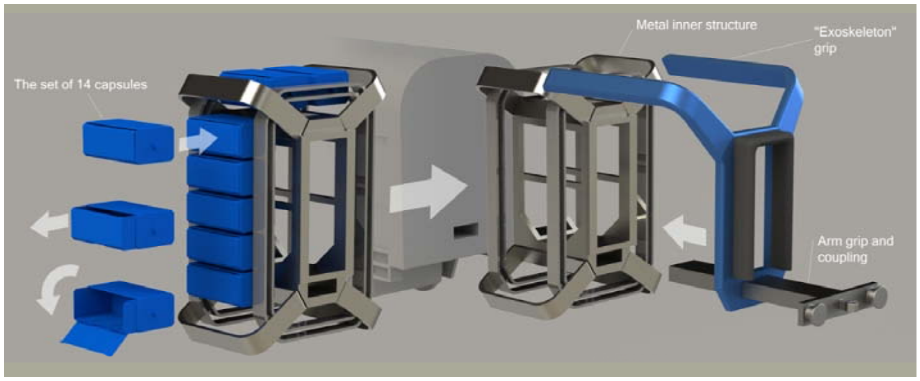

Fig. 9 Internal structure of the dynamic module

Inner structure is made of metal, inside which is a set of 14 capsules mounted on a conveyor belt capable of operating capsules in different conditions imposed by the structure of the stationary train station.

Internal structure is designed to allow users' movement from one car to another. At the same time, it allows the user to access the appropriate luggage inside the car. At the bottom, under the clearway, is a shaft that crosses the entire structure, enabling the module to be fixed by the bracket, using the original coupling construction of the train.

This beam structure must withstand a load applied to the whole set of capsules, mechanically inside. The module does not take the loads transmitted by the movement of the train, the coupling being independent without dispersion taken from the dynamic forces of the train structure [5].

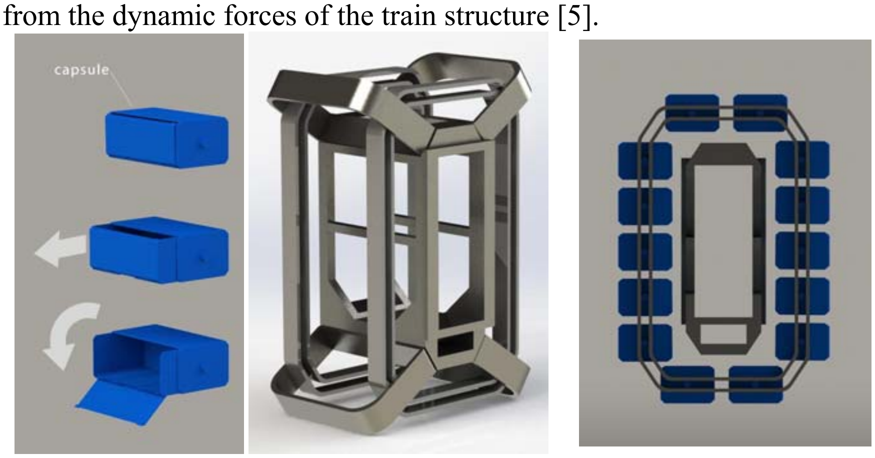

Fig. 10 Internal steel structure and capsules

Capsule assembly is driven by an electric transportation system, able to take and deliver luggage by positioning capsules imposed on a route. Each capsule has dimensions LxWxH = 1190x720x500mm, characterizing an optimal volume that may comprise the largest sized luggage normalized on the market. Opening and closing system provides user access on both sides depending on the positioning of the train to the platform. The locking system is composed of this elements:

1. Background - made catching transport system module;
2. Drawer - slide half of its length in both directions;
3. Door - formed in the open position, a ramp to enter the capsule luggage easier.

Capsule material must be resistant to moisture, shock, wear and tear. The proposed material is a polymer capsule (polycarbonate type) with reduced weight and easy to maintain. It can provide strength, is lightweight, relatively simple technology, with minimal wear and maintenance during the storage of luggages. Capsule morphology development was based on standard size luggage and drive system. The functional model of the capsule was determined by analysis of circulation space inside the module and the need to be accessed by the user on both sides.

Outer protective structure

It covers and protects the capsules and whole mechanism inside to the outside environment.

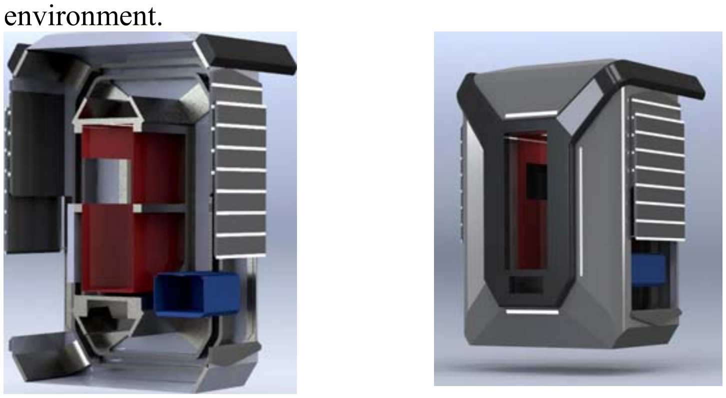

Fig. 11 Dynamic module cross section and exterior

The shell doors are mounted vertically with a sliding function when the train is stationary. This allows access to the capsule and the scanner bar code which transmits information related to how the requested capsule.

The retainer Design Module wagon

Clamping the module to the carriage is done via a subset called "exoskeleton", mounted outside due to limited space inside. Positioning facilitates assembly catching on the outside and avoid clutter components inside. "Exoskeleton" dress giving support to the module, assuming the role of a protective cage.

The bracket and coupling

The core clamping integralise with the coupling system of the train. It fixes all the wagon module, forming a whole, and also serving as a coupling system to the wagons. This system has the advantage of a multifunctionality clamping arm responsible for coupling the wagons which do not involve major structural changes to the wagon, keeping the same type of standard coupling and a simple solution for mounting the module. Thus it is an attachment that can be removed if not needed for use, without requiring changes wagon for recommissioning after removing the module [6].

Fig. 12 Retainer structure

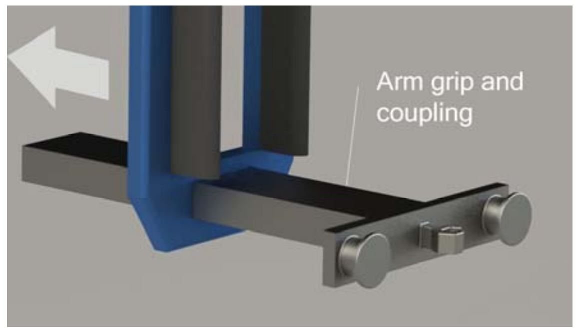

Fig. 13 The bracket and coupling structure

6. Conclusions and directions for research

In current conditions that require maximum security, baggage transport is a very important element in rail transport.

The proposed model is original and propose a solution that does not substantially alter trains.

Control of baggage, emergency, can be done easily because they are stored at the end of the wagon.

Modern storage space is easily accessible and provides added comfort without increasing the cost of the trip very much.

R E F E R E N C E S

[1] *Johan Woxenius*- Utilising more of the loading space in intermodal line trains – Measures and decision support, Department of Business Administration, Industrial and Financial Management & Logistics, ISSN- 0166-3615, 2013.

[2] *J. Rinderle*-Function and form relationships : a basis for preliminary design, Carnegie Mellon University Engineering Design Research Centre, Pittsburgh, PA. 15213, 1987.

[3] *John Gill* –Accessibility for Visitors , RNIB, 105 Judd Street, London WC1H 9NE, ISBN 1 86048 033 0, 2007

[4] *I. Chen, Wai-Fah*- Principles of structural design / edited by *Wai-Fah Chen, Eric M. Lui*. p. cm. Includes bibliographical references and index. ISBN 0-8493-7235-6 (alk. paper) Structural design. 1936- II.

[5] *Michael F. Ashby* - Materials selection mechanical design - Department of Engineering, Cambridge University, ISBN 0 7506 4357 9, England, 1999.

[6] *Mario Sergio Salerno Anna Valeria Carneiro Dias* -Product design modularity, modular production, modular organization : the evolution of modular concepts, Politecnica USP Produção Sao Paulo - Brazil.