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# THE DESIGN PROCESS AND THE NEEDED DIGITAL TOOLS FOR MATERIAL SELECTION

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## ABSTRACT

The aim of this study is to analyze the methods and the digital tools for materials selection in the different stages of the design process. It is also envisaged the establishment of successful routes for materials selection and the improvements to be done in the existent digital tools for a better intersection with the design process.

An in-depth analysis of material selection by digital tools was carried out with the examination of three hundred databases, websites references and other software. A substantial amount of information regarding the more relevant databases and software, around one hundred, was collected.

Through one chosen case study, the different stages of the design process and the type of methodologies and digital tools that can be successfully applied in each stage are illustrated. Although Ashby and Johnson [1] and Kesteren [2], proposed a methodology that allows an interactive selection of materials during all the design process, it is shown, in this work, that the materials selection can be refined if more than one selecting methods and digital tools are applied along the different design stages. The required development of digital tools for a better interaction between the design process and the materials selection will be discussed.

## 1. INTRODUCTION - DESIGN AND MATERIAL SELECTION PROCESSES

The architect Blaine Brownell [3], author of publications such as “Transmaterial”, considers that there are materials, products, and processes that are redefining our physical surroundings and the Universe of available materials. Brownell, while observing the current scenario of architecture and design, considers that the majority of designers still give privilege to conventional materials, as opposed to the most recent ones.
We can refer that it all depends on the importance that designers give to the materials selection.

Several authors have included the material selection in their design process, as either a phase or a "step" to go and achieve a stage in the design process.
Munari [4] draws a linear model, with a stage dedicated to the materials selection and technologies.
However, most studies mention the materials selection as a "step" to go on in a certain stage of the design process. Later, Ashby, Johnson and Kesteren, scholars associated with the design and material selection, made revealing studies about material selection process and its pertinence to the design process.

Considering the most common linear models, we can say that the design process is a sequence of events completed by an order. Each of them has several procedures to follow, with a goal to achieve a solution to the original problem.

Design processes are difficult to standardize, not only due to the countless and different types of processes, but ”in part because of the iterative non-linear nature, and also because the needs of clients and users are so different. In addition, real life, with its changing market conditions and customer preferences, is much more dynamic, chaotic and fuzzy than any standard model can fully accommodate and often, stages of the design process overlap“[5].

Blessing [6] defines four categories of design models:-stages serial (linear); activities cyclic (elliptical); -stages and activities (spiral) and stages and activities and solution concentric (spiral concentric).

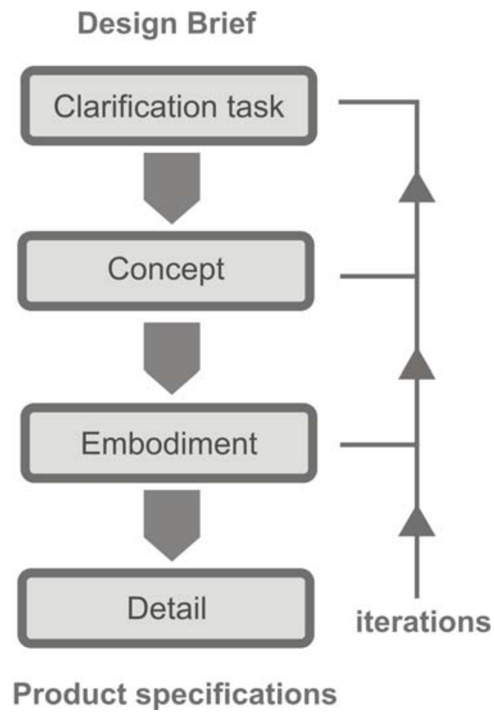
The linear format that were very common, was criticised for suggesting that a problem could be solved in one go, so revised models that incorporated loops and iterative phases were developed.

Most authors accept that there is no best practice in design process. However, there is agreement that could be some commonalities across processes used, and that these typically consist of four main phases.
A Design Council research [7] echoes this understanding. They created the double Diamond, a process formed from four distinct phases, which are Discover, Define, Develop and Deliver. Each of the phases consists of a series of iterative loops where exploration and testing of ideas can happen. The process name, double diamond, stands for its double lozenge format.

One of the most well-known of stage-based models was proposed by Pahl and Beitz [8] for mechanical design, figure 1. This model was consensual and it was used as a canon for Ashby and Kesteren studies on the connections between design and materials selection process.

Ashby [9] conceives a design flow chart, showing how design tools and materials selection enter the procedure. Information about materials is

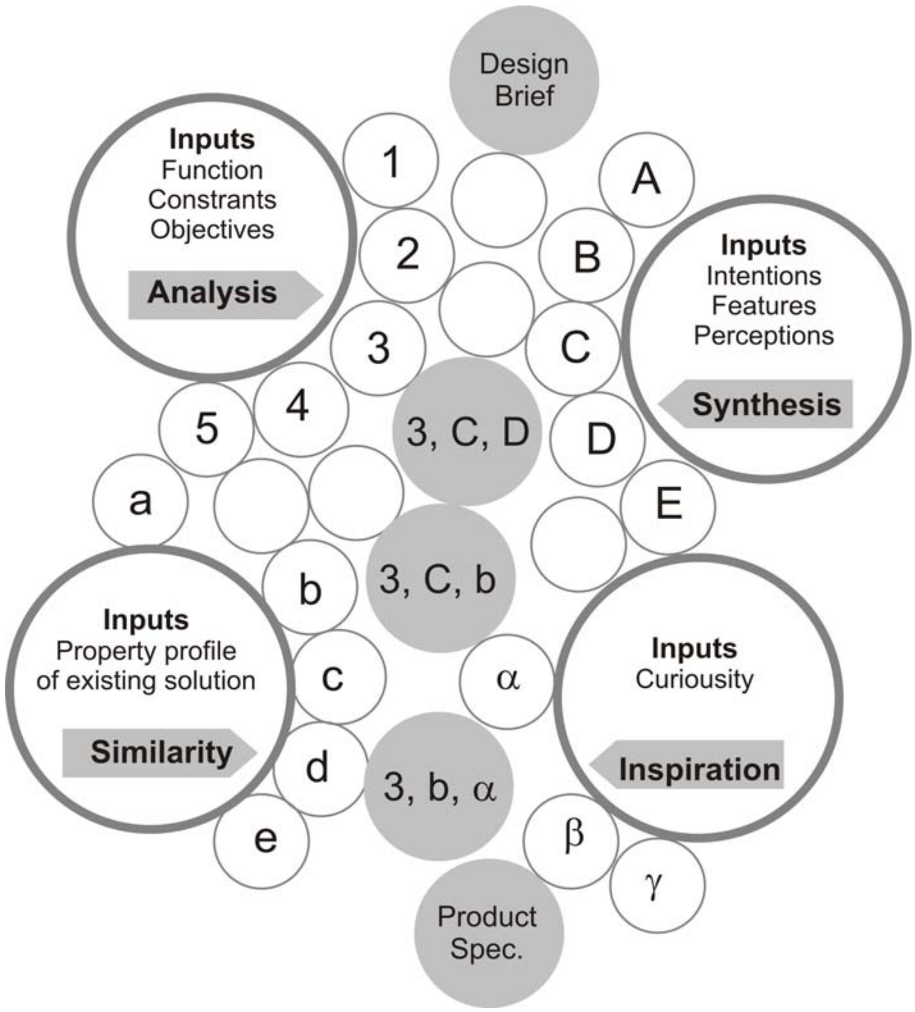
**FIG.1 DESIGN METHODOLOGIE, PAHL & BEITZ, 1996**




needed at each stage, but at very different levels of breadth and precision. The phases of the design process are similar to Pahl and Beitz model. The materials selection is a parallel process that enters each stage of the design. The nature of the data needed is different for each design stage. In the concept stage, the designer needs low precision data about all materials, whereas in the embodiment design stage, he needs a higher data precision about a subset of materials that might fit the solution. The final stage of detailed design requires a still higher level of precision and detail, but for only one or very few materials.

Later in 2002, Ashby and Johnson [1] worked in a Path of Material Selection, in which the materials selection is seen as a journey from design brief to the product specification, figure 2. The traveller is assisted, in varying degrees, by the tools of analysis, synthesis, similarity and inspiration (large circles), generating successively refined solutions as the journey proceeds. This method is a combination of analysis, synthesis, similarity and inspiration. In it, the selection methods are seen in large bubbles; their job is to generate possible solutions for the design brief.

**FIG.2 THE PATH OF MATERIAL SELECTION, ASHBY AND JOHNSON, 2002**




Each generates a population of little bubbles – the solutions that have survived or merged from the technique – containing information about a material combination.

It is a more complete and close to the real practice of a designer than the previous one [9].

Ilse Kesteren [2] developed the MSA model in her PhD thesis. It is of iterative nature and it shows the importance of user-interaction aspects in the materials selection, figure 3.

Materials Selection Activities (MAS) model includes the preliminary selection of candidate materials in the analysis phase of the design processes, and the main idea is helping to cut the Materials selection process into understandable pieces.

## 2. METHODS FOR MATERIAL SELECTION

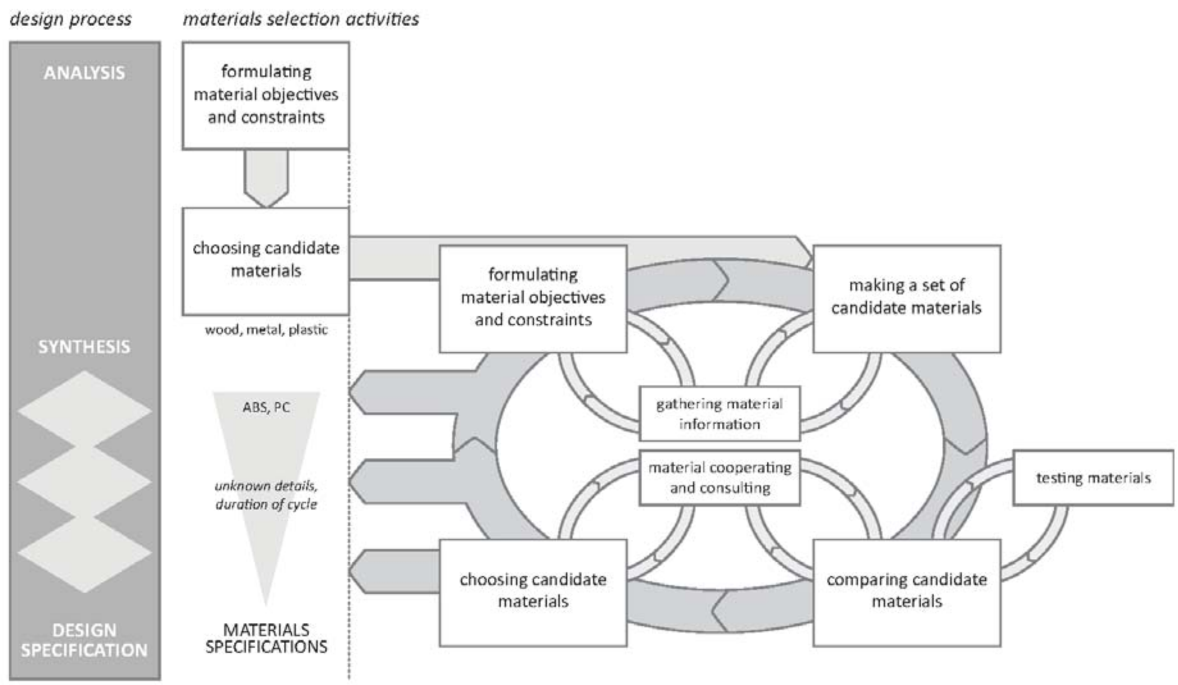
Studies of problem-solving, which were developed by Ashby & Johnson [1], distinguish two reasoning processes, deductive and inductive reasoning. They are the basis of selection by analysis, synthesis and similarity.

In addition, many good ideas are triggered by accident, an unplanned encounter. The encounter is “inspiring”, meaning that it provokes creative thinking. “The selection by inspiration comes by immersion: by exploring ideas almost at random, like delving in a treasure chest, the scientific methods of no help here” [1].

Ashby & Johnson [1] describe four methods used on the material selection by designers, as follows:

a) **Selection by analysis (deductive reasoning):** it uses specific information and

**FIG.3 MATERIALS SELECTION ACTIVITIES MODEL, KESTEREN, 2008**




precise selection methods; the procedures of this method undergo four steps described ahead.

**b) Selection by synthesis (inductive reasoning):** it is based on a past experience and on an analogy, searching for a connection between the intended requirements, intentions, perception, aesthetics and design solutions documented under a database of case studies on products.

**c) Selection by similarity:** it seeks material with similar features to those we intend to substitute.

**d) Selection by inspiration:** it makes the searching of ideas randomly possible, images of materials, samples and products. This method stands on a mental index (through images, books, computer files). These methods are not directly related to software for material selection, but we can find them in the majority of digital tools.

In the case study, we will address from a situation-problem, which could represent a project with which a designer may come across during his/her work.

Materials selection is performed through a process similar to the selection by **analysis (deductive reasoning)**, since it is the most complete and consistent process, which comprises of four basic steps:

1-Translate the needs of design into specifications for materials and processes.
2-Identify the materials that do not fulfil the requirements and specifications of design.
3-Build a classification scheme of materials that might satisfy the needs, identifying those with more potential.
4-Show or indicate ways of getting information about the candidates with more potential. [11]

During the research process, we will be impartial when solving the case studies; we will give no special preference to a database, only to those that could give us a wider universe in terms of available materials for selection, because in the initial stages of the design process we should consider all Universes of materials.

## 3. SOFTWARE AND DATABASES

From the knowledge of the stages required for material selection, we can begin the selection; although we have many resources from which we can start making it, the most common are:
-technical manuals;
-manufacturers catalogs;
-materials exhibition and samples;
-databases;

-software.
Since the last two resources are the least known in Portugal, we decided to hold a research on databases and software, also because of their recent development in the United States and Europe.

The first task to be carried out was gathering information about the material selection on books and scientific magazines. We pursued a bibliographic research in several national libraries, a research on documental databases from national and international libraries, different publishers, scientific magazines, and a range of internet search engines.
Throughout the bibliographic and web research, we registered a few notes of the significant results about the material selection and, in some cases, summary texts were executed. It was from the bibliography, scientific articles, web portals and search engines that we found references for material selection tools and the theoretical contextualization of the present study.
After referencing approximately three hundred tools, all of them were analysed, and only one hundred was considered relevant for the investigation.
The selection criteria of relevant databases and software for the investigation process were as follows: -Extended character of the tool (very specific databases or software were not considered); -Possibility of selecting materials;
-Minimum and significant number of materials (were not include databases with a number inferior to 12 materials); -The usefulness for the problem solving of the designing activity.
In case the website of the selection tool representative did not allow the demonstration version, a solicitation contact would be done. If at the end of this process there would still be reservations about it, we would contact the software representatives again in order to place more questions.
This procedure was applied to all the tools, but, even so, there were still some uncertainties towards some of these tools when the temporary access to databases and demonstration versions was denied.
During the research on selection tools, we adopted the criterion of grouping them according to the following aspects:
-General databases.
-Manufacturers databases.
-Software.
Arnold van Bezooyen [10] identified two groups of different tools for material selection, during his report "Material Explorer - Material Selection Tool for Designers":
**Information software:** They make technical information about materials available.
**Inspiration software:** They make information about different types of materials available and also exhibit visual information for inspiration.

On the other hand, during our study we came to the conclusion that the way how databases and software for material selection work depends on each tool, namely if we are working with a **general database**, **manufacturer's database** or **software**. This was the main reason that led us to divide the different digital tools into these three groups.
The assembly of "general databases" implies the existence of a tool with information regarding one or several "materials families" and their properties may be referenced to different material manufacturers.
In the resolution of the case study that we will develop, the majority of digital tools used were selected from the general databases table **(Annex A)**

The one hundred databases and respective software were all analysed according to the following items: -name/designation; -associate institution or company; -characterising text; -web portal address; -total number of materials/(total number of processes); -modality of use;-available materials; -selection methods; -properties for selection;-type of result/ information; -notes.

## 4. CASE STUDIE - CREATION OF A NEW PRODUCT - CAMPING TENT AND MOUNTAIN CLIMBING STAKE

### 4.1 Introduction

With the first case study, it is intended that one selects a material for the creation of a camping tent stake and, to the extent possible, with a solution superior to others already adopted, of galvanized steel with anti-oxidation treatment by galvanization covered with a melted zinc bath.

## 4.2 Requirements

The new product must have the following requirements:
The product to be developed implies the use of a material that:
- Resists to oxidation, because the galvanized steel stake begins to oxidise, after a few uses and superficial scratches.
- The design and material for the new stake must allow a consistent placement on rocky and sandy soil, and also with snow.
- The material must be light, since it is a demand for alpinism and mountain climbing sportsmen.
- The predictable cost increase with the new stakes cannot make the profit and competition to other manufacturers impracticable.

## 4.3 Selection

We started using the interactive charts, based on the work of Michael Ashby, from the web portal **"Information on material selection and processing"** [12], in order to know how many materials families would correspond to the formulated requirements:
-Strength/Density (in order to identify the materials with high resistance conjugated with little weight)
-Young's Modulus/Cost (to identify stiff but economic materials)
-Strength/Cost (in order to identify the materials with high resistance, but yet, economic, figure 1).
On the web portal "Information on material selection and processing", the Young's Modulus-Density chart was not available, so it was consulted on page 57 of Ashby's book [9]. This chart allowed the visualization of stiff, tenacious, and at the same time, light materials.
The first chart to be consulted was the one which showed the connection between the Young's Modulus-Density, which allowed to consider the families of composites, metals, and engineering ceramics, the most stiff and tenacious, in relation to weight or density. Despite the fact that some polymers show reasonable interactions, this materials "family" was not considered, because there are already stakes made of polymeric materials, with a weak performance on rocky soil and a much reduced durability. Because they are frail, and considering that any stake can be subjected to hammer impacts, the ceramic materials were also a solution put aside. Therefore, this first selection jots down to composites and metals classes. Our choice was confirmed with the interactive chart of Strength/Density, which allowed identifying the materials with traction resistance on little weight. With this chart, it was possible to identify the class of resins strengthened with carbon fibre, within the composites family. Within the metals family, aluminium alloys and magnesium conjugate these requirements in a more fulfilling way.

Afterwards, the **Young's Modulus-Cost** and **Strength-Cost** charts were consulted (in order to identify the resistant and stiff, yet economic materials). After being analysed in terms of similar mechanical resistance, charts present substantially different costs:
-Aluminium alloys between 1.3€ and 5.9€ per kg
-Magnesium alloys between 4.4€ and 13.2€ per kg
-Resins strengthened with carbon fibre between 43.9€ and 73.1€ per kg
However, this **price/weight** relation is a relative reference; the amount of necessary material to manufacture the project depends on the mechanical characteristics and properties of each material.

The aluminium alloys, in terms of the requirements/cost relation, are starting to noticeably stand out. On the other hand, the idea of creating a different stake makes possible for tool a good adherence on sandy and snowy soils, and it was possible to obtain more accurate information about the adequate type of aluminium alloys. The design has preponderance on the choice of the stake material, but considering a traditional or even innovative solution, we consolidated the idea that an aluminium alloy is the best choice, because of its costs and oxidation resistance, which was one of the main requirements throughout the whole process. While consulting the **Design InSite database** [13], it was possible to confirm the choice, since this tool links the materials, manufacturing processes and products.
It was possible to have the conception that the pressure die casting or forging can be the most adequate processes for the performing of aluminium, due to its shape, costs and amount of

**FIG.4 FLOW DIAGRAM FOR MATERIAL SELECTION IN THE CASE STUDY**

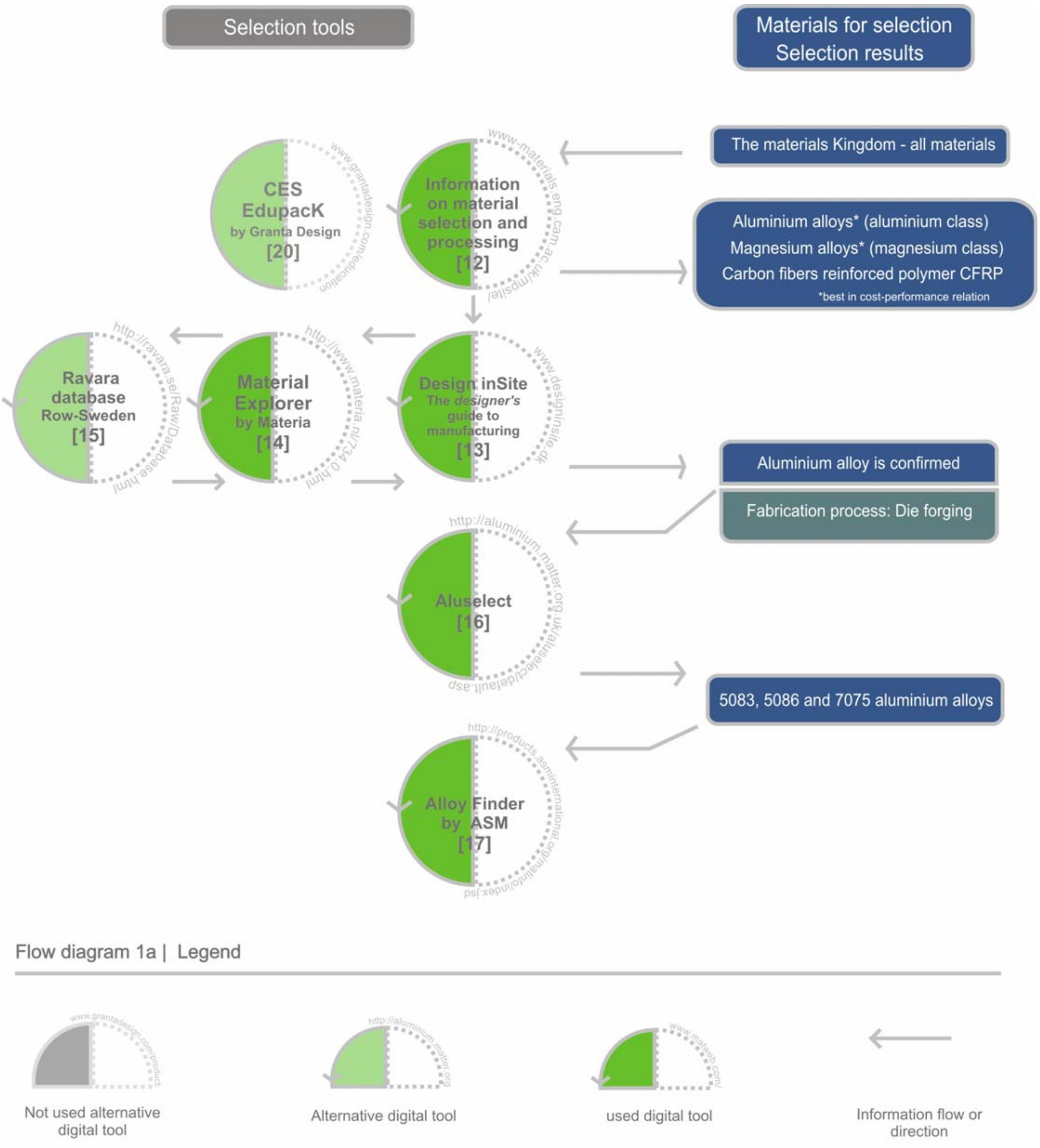
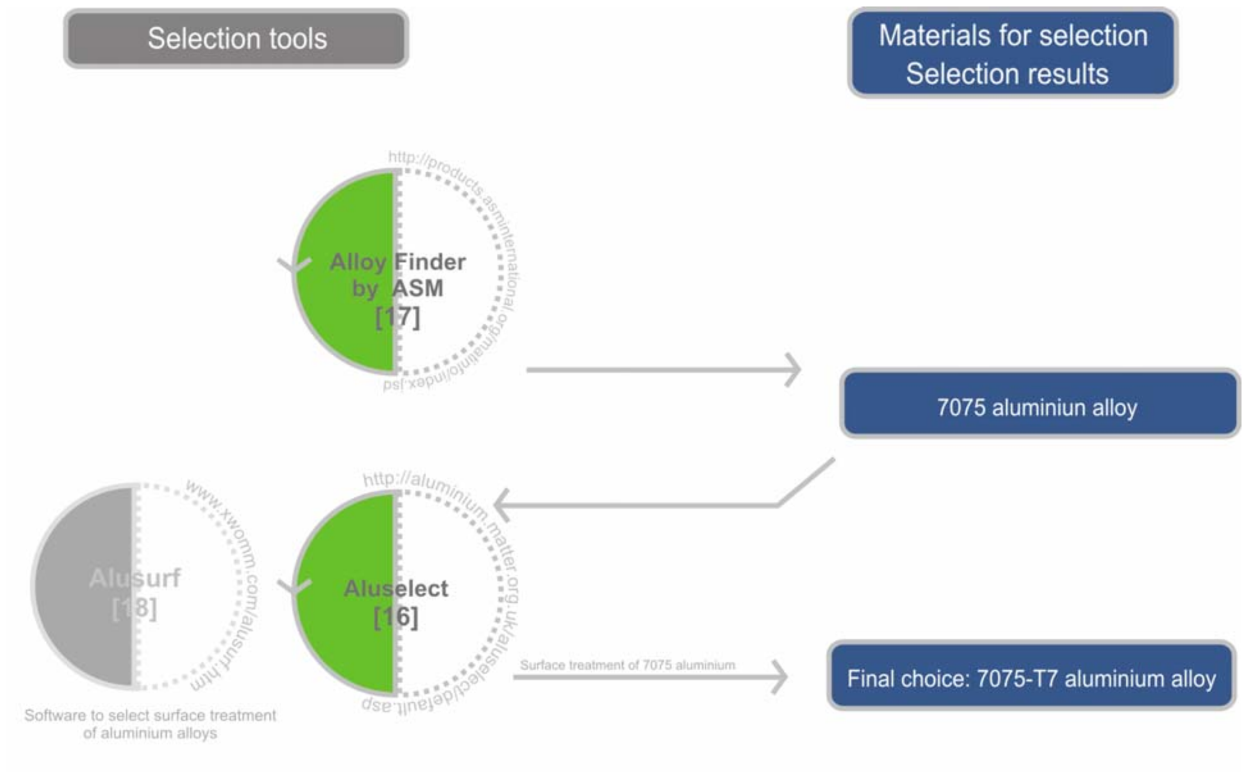


**FIG.5 CASE STUDIES FLOW DIAGRAM FOR MATERIAL SELECTION**




necessary pieces. We selected forged aluminium, because it is more economical and it allows a wider range of compositions.

We also searched in **Material Explorer** [14] and **Ravara database** [15] for adequate materials. Despite of being two of the best free tools for designers, we did not find useful to solve this concrete problem. Moreover, because these databases indicate the trade name rather than the technical name, this makes the search difficult.

Through the **Aluselect** database [16], with technical information on a large set of aluminium alloys, one performed a simple research of applications with similar requirements, as well as tools, and it was possible to obtain more accurate information about the adequate type of aluminium alloys. A set of eight alloys was selected, from which three offered more guarantees: 5083, 5086, and 7075.

In spite of the two first alloys allowing a bigger variety of superficial treatment and colours, the last alloy presented superior values of resistance and stiffness.

While testing the **Alloy Finder** [17] database from ASM International, we verified that we would have come to a similar conclusion if we had used this tool. The Alloy Finder is a database with paid access which belongs to the company that publishes the ASM Handbooks, and it allows the access to very complete technical sheets, with more alternatives within the same aluminium alloy.

### 4.4 Results

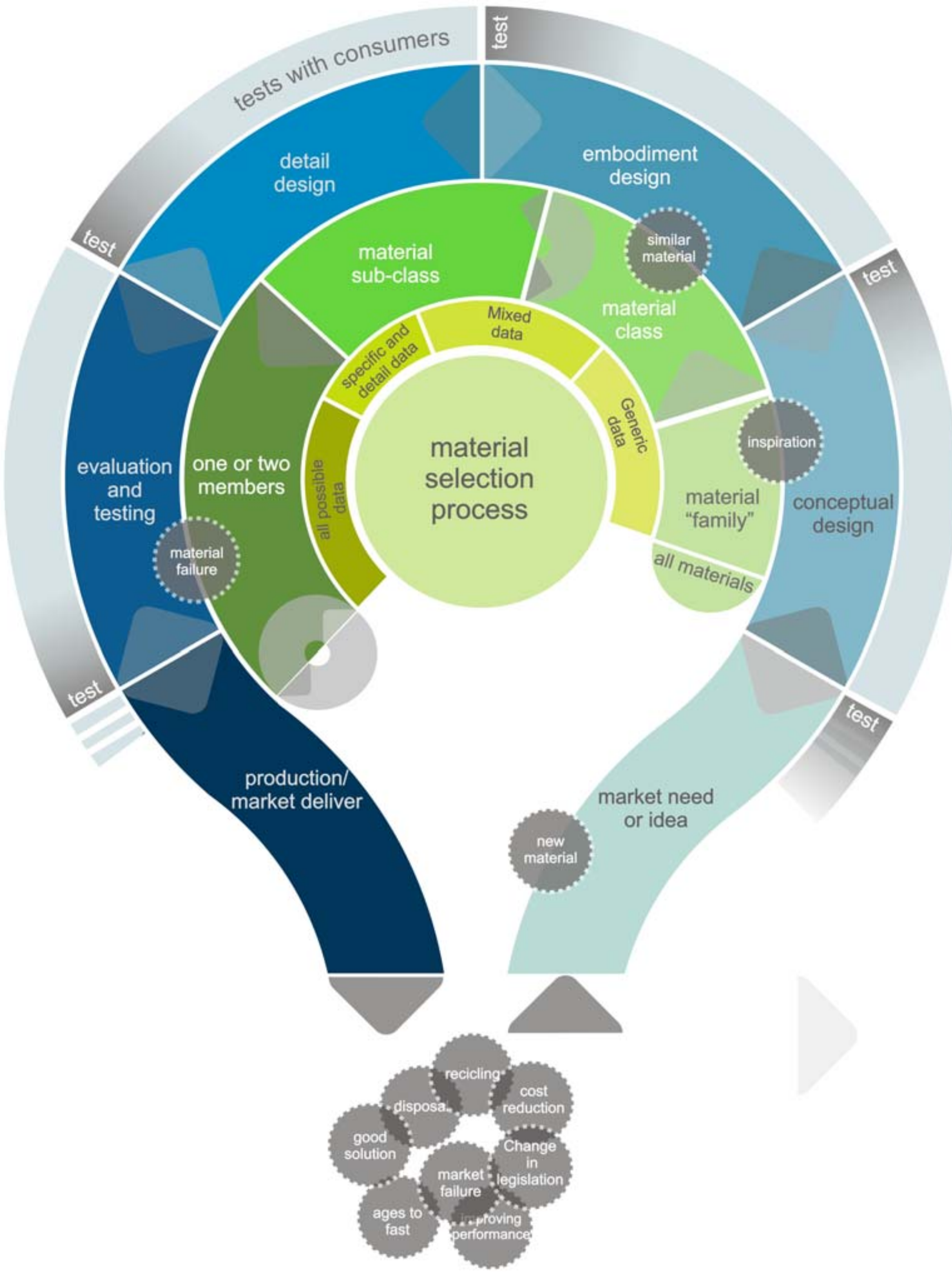
With the **Aluselect** database [16], it is possible to be acquainted with the thermal treatment compatible with aluminium 7075, which allows enhancing its mechanical resistance, as well as to corrosion. This is a thermal and stabilizing treatment called tempera, with classification T7.

There is a software application that chooses the superficial treatment of aluminium, which is **Alusurf** [18] from XWOMM multimedia.

We may refer that the material for the stake would be an aluminium 7075-T7. However, alloys 5053 and 5086 with the adequate superficial treatment would not be a bad choice. With **Alloy Finder** [17], it was also possible to access to a detailed technical sheet of all aluminium alloys.

The use of several databases was very functional, as we were defining the project's design.

**FIG.6 RELIGHT PROCESS FOR MATERIAL SELECTION, 2009**




With the evolution of the process, it was necessary to get more specific information and consequently more databases that were able to provide this information.

Through the **MatWeb** database [19], it was possible to get a faster outcome. Nonetheless, it would be necessary to place a set of maximum and minimum values that would correspond to different properties, which is not always easy, particularly during the initial stages of certain projects.

If we had used the **CES Edupack 2007** or the **CES Selector** [20], we could have achieved good results as well. Hence, the approach proposed by the CES software is more helpful, because it allows a good combination along with the design process. It provides the material selection in an evolutionary way, and combines several resources in a single tool. Also, it enables the selection of material candidates in a developmental way, from the entire "Universe" to few subclass members.

In this material selection process, the **analysis method** was extremely useful, following all the relevant steps towards a precise selection, but also the **selection method by synthesis**, where we compared the performance of other stakes and garden tools already developed with the stake that would be created.
During the resolution of this case study, we drew a model that we think that reflects well the experience of material selection, Figure 6. It is a model of combined steps and activities that is cyclical and interactive. It relates six stages of the design process with the steps of material selection. It starts by considering all materials, to a material "family", then only one class, to a subclass and ending in only one or two members.
Moreover, it also relates the stages with the type of information needed during the selection; initially, we need general information about the largest number possible of materials, and then we require mixed and diverse data, with more properties values.
Later on, we need precise and detailed information about a subclass of materials and we finished with all possible and precise information about one or two materials.
In this process, we also consider catalyst factors that can change the course of the process, which are represented by small gray circles that may cause the resumption of part or the whole process. We can mention as example, the appearance of a new material, a material failure, need for replacement by a similar material or the selection by inspiration. After the end of the process, there are other catalyst factors, such as recycling, disposal, changes in legislation, premature aging, need for reducing costs or improving performance. We name this model "Relight Process for Material Selection (RPMS)", because the format is identical to a lamp.

## 5. CONCLUSIONS

The material selection is an increasingly more complex task, not only for the diversity and availability of the offer, but also for the consequences implied by the selection itself, in the whole life cycle of the product.
Scholars from Charles et al [21], to Ashby et al [11], finishing in Bezooyen [10], consider that digital tools are the ones with more potentialities, not only in technical terms, but also because of the dynamic way by which they follow the evolution of the design process.
After this in-depth analysis of some of the most representative databases and from the experience acquired through these case study, one has concluded that:

-in spite of the access limitations to several databases and software, none situation-problem was left to be solved;
-the more represented materials families on databases are polymers and metals;
-in the majority of tools, the selection is carried out through mechanical, physical properties and also of manufacture.
-using the charts or CES software, the methods of Michael Ashby were crucial to reduce the universe of all materials in the beginning of the selection process, into a "family" or even a "class" of materials;
-most of the databases are poor on information about aesthetic properties, which limits them as inspiration sources. Also, the information about ecological properties was not yet generalized to the most part of digital tools, which tends to limit its use every time these aspects become of essence on the material selection.
-the universality and organization of the content of a database, along with the interface quality, are decisive aspects of the use and success of the digital tool;
-during the solving of this case study, it was possible to use almost all methods of material selection, by **analysis**, **synthesis** and **similarity**;
-There is little uniformity on the databases information and that implies the weak compatibility between the data of different digital tools;
-if, on one hand, inspiration tools make the user fall in love and become involved in the selection process, inspiring creative and innovative solutions, on the other, information at the "distance" of a simple input of values related to the properties may quickly unveil materials never used before on a certain task;
-we may conclude that the need and typology of the necessary selection tool changes along with the stage of design process. Thereby, when we are working on the concept, we have the need to look for a bigger and more general database. On the other way, when we get access again to

a database in a first draft or a detailed project phase, we try to find more precise tools, those which only select within a specific materials family;

-sometimes, in some information tools, one may find difficult to answer a few questions that make part of the questionnaire used to introduce data, with the need of particular values related to some properties. However, this apparently demanding and not very interactive process may eventually save a great amount of time.

Despite the need to be tested at all stages of the materials selection process, "Relight Process for Material Selection" (RPMS) seems to be a concise and applicable model.

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**ANNEX A**

**GENERAL DATABASES: WEB LINKS, USER CONDITIONS, NUMBER OF MATERIALS AND CLASSES**

| Database name | nº | Link | Using mode | | | | | Database materials | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Free | | Pay to use | | | | | | | | | | | | | | | | | | |
| Database name | nº | Link | Free | Demo software | Anual | By acess | Another | Nº of materials | Nº of fabrication processes | Ceramics | Composites | Metals | polymers | Glass | Naturals | Textiles | Fibers | "Smart" materials | Leather | Recicled | Aerogels | Nano | Others |
| MATWEB-Material Property Data | 1 | www.matweb.com | X | | $74,95 | | | "+69000" | | X | X | X | X | X | | | | | | | | | |
| REMATERIALISE-Eco Smart Materials | 2 | www.Kingston.AC.UK/~kx197 | X | | | | | 69 | 8 | | X | X | X | X | X | X | X | | | X | | | |
| DESIGN INSITE-The designer's guide to manufacturing | 3 | www.designinsite.dk | X | | | | | 120 | 100 | X | X | X | X | X | | X | X | X | | | | | |
| MATERIAL EXPLORER - MATERIA | 4 | http://www.materia.nl/734.0.h | X | | | | | "+1080" | | X | X | X | X | X | X | X | | | | | | | |
| MATÉRIO-Matériothèque | 5 | www.materio.com | | | 297 € | 100 € | 640 € | "+4000" | | X | X | X | X | X | X | X | | | | X | | | |
| MATERIAL CONNEXION | 6 | www.materialconnexion.com | | | $250 | | | "+4500" | | X | X | X | X | X | X | | | | | | | | |
| INNOVATHÈQUE | 7 | www.innovathequectba.com | | | 300 € | 100 € | 450 € | "1565" | | X | X | X | X | X | X | | | | X | | | | |
| IDEMAT - Online database | 8 | http://www.idemat.nl/ | | X | 350 € | | | "≃ 400" | | X | X | X | X | X | X | | X | | X | | | | |
| MATERIALS SELECTION AND PROCESSING | 9 | www-materials.eng.cam.ac.uk | X | | | | | "≃ 38" | 35 | X | X | X | X | | | | | | | | | | |
| MATERIALS DATA CENTER-THOMSOM | 10 | www.techstreet.com/asm-spec | | | | $25 | | | | X | X | X | X | | | | | | | | | | |
| TRANSSTUDIO-TRANSMATERIAL | 11 | www.transstudio.com// | X | | | | | | X | X | X | X | X | X | | | | X | | X | | | |
| MAS 2.0 | 12 | http://bmi.berkeley.edu/Me221 | X | | | | | 16 | 22 | X | | X | X | | X | | | | | | | | |
| EFUNDA, Engeneering Fundamentals | 13 | www.efunda.com/materials/piez | X | X | $60 | | $96 | | X | | X | X | X | X | X | | | | | | | | |
| ASM Materials Information | 14 | http://products.asminternation | | | X | | | | | X | X | X | X | | | | | | | | | | |
| TPSX-Material Properties Database (NASA) | 15 | http://tpsx.arc.nasa.gov/ | X | | | | | 1.500 | | X | X | X | X | X | X | | X | | | | X | X | |
| Prospect-The Wood Database | 16 | www.plants.ox.ac.uk/ofi/prosp | X | | | | | 1.500 | | | | | | | X | | | | | | | | |
| AZOM.COM | 17 | www.azom.com | X | | | | | | | X | X | X | X | | | | | | | | | | |
| Temperature Dependent Elastic & Thermal Propertie | 18 | http://www.jahm.com | X | | | | | "+2400" | | X | X | X | X | | X | | | | | | | | |
| NPL MIDAS (CES Software) | 19 | http://midas.npl.co.uk/midas/i | X | | | | | 17 | | | | | X | | | | | | | | | | |
| POLY INFO-Polymer Database | 20 | http://polymer.nims.go.jp/ | X | | | | | | | | | X | X | | | | | | | | | | |
| IDES PROSPECTOR | 21 | http://www.ides.com/demos/ | | X | 99 € | | | 80.000 | | | | | X | | | | | | | | | | |
| PLASTICS TECHNOLOGY-Databases | 22 | http://www.plasticstechnology | X | | | | | | 25 | | | | X | | | | | | | | | | |
| PLASTICS TECHNOLOGY-Materials database | 23 | http://66.192.79.234/ | X | | | | | | | | | | X | | | | | | | | | | |
| UK STEEL (CES Software) | 24 | www.steelspec.org.uk | | X | 90 € | | £164,5 | | | | | X | | | | | | | | | | | |
| KEY TO METALS - NONFERROUS | 25 | www.key-to-metals.com/ | | X | 490 € | | 790 € | | | | | X | | | | | | | | | | | |
| KEY TO METALS - STEEL | 26 | www.key-to-steel.com/ | | X | 490 € | | 790 € | "+"3500 | | | | X | | | | | | | | | | | |
| COOPER.org | 27 | http://www.copper.org/about/c | X | | | | | "+"440 | | | | X | | | | | | | | | | | |
| THE PGM DATABASE (CES Software) | 28 | www.platinummetalsreview.co | X | | | | | | | | | X | | | | | | | | | | | |
| COMPOSITE ABOUT.COM | 29 | http://composite.about.com | X | | | | | | | | X | | | | | | X | | | | | | |
| ARCH INFORM | 30 | http://eng.archinform.net/stich | X | | | | | "+111" | | X | X | X | X | X | X | X | X | X | | | | | |
| AluSelect | 31 | http://aluminium.matter.org.uk | X | | | | | 47 | | | | X | | | | | | | | | | | |
| Polymat | 32 | www.tds-herrlich.de/english/in | | | | ≥ 1€ | 400 € | 26.300 | | | X | | X | | | | | | | | | | |
| Polytrade | 33 | www.tds-herrlich.de/english/in | | | | ≥ 0,5€ | 110 € | 8.300 | | | X | | X | | | | | | | | | | |
| Materials Monthly | 34 | http://www.materialsmonthly.c | | | $200 | | | | | | | | | | X | | X | | | X | | | |
| WRAP (the Waste & Resources Action Programme) | 35 | www.wrap.org.uk/about_wrap/ | X | | | | | 8 | | | | | | | | | | | | X | | | |
| Woods of the world | 36 | www.azwoodman.com/woods- | | | | | $49,90 | 910 | | | | | | | X | | | | | | | | |
| The Wood Explorer | 37 | http://www.thewoodexplorer.co | | | | | $49,95 | 1.650 | | | | | | | X | | | | | | | | |
| BioMatNet | 38 | www.biomatnet.org/home.html | X | | | | € 7,50 | 8 | | | | | X | | X | | | | | X | | | |
| Biopolymer.net | 39 | www.biopolymer.net/ | X | | | | | "+ de 34" | | | | | X | | | | | | | | | | |
| Information | 40 | http://www.lboro.ac.uk/researc | X | | | | | 5 grups | | | | X | X | X | | | | X | | X | | | |
| Ravara Database | 41 | http://www.ravara.se/Raw/Data | X | | | | | 494 | 47 | X | X | X | X | X | | | | | | X | | | |
| Stylepark materials | 42 | http://www.materialworks.com | X | | | | from 240€ | 1.295 | | X | X | X | X | X | X | X | X | | | | | | |
| Technotheek | 43 | http://www.technotheek.nl/ | X | | | | | 442 | | X | X | X | X | X | X | X | X | | | X | | | |
| Raumprobe | 44 | http://www.raumprobe.de | X | | 29 € | | | 1.926 | | X | | X | X | X | X | X | | | | X | | | |
| Eco-materials pela MATREC | 45 | http://www.matrec.com.pt/lst_ | X | | | | | 64 | | X | | X | X | X | X | | | | | X | | | |
| Inventables | 46 | http://www.inventables.com/ | | | | | from €15 | "+3000" | | | X | X | X | X | | X | | | | | | X | |