Project no.: 017958

Project acronym: **CRIOSINTER**

Project title:

Development of an innovative recycling process based *in cryogenic and water jet grinding and sintering techniques for extending the use of recycled rubber in the development of high quality products*

Instrument: *Cooperative Research Project*

Thematic Priority: *Frame Work 6*

Publishable Final Activity Report

Period covered: from 1st to 26th month

Date of preparation: 13/03/2008

Start date of project: October 2005 Duration: 26 Month

Project coordinator name: Enrique Alcántara

Project coordinator organisation name: **IBV** Revision [Final]

1. PROJECT EXECUTION

Nowadays, an enormous quantity of used tyres is landfilled which is one of the main environmental problems worldwide. Estimates are that 250,000,000 used tyres are accumulated each year in the countries of the 15 EU**.** This could supply 45% of European virgin rubber uptake. Only 24% of used tyres is recycled, mostly in low demanding, low price products, that yield low economical profit, stopping R&D investment (most companies along the recycled rubber supply chain are SMEs). As a consequence, the main use of tyres is as fuel substituting one environmental problem for another due to emissions.

In this sense, several efforts have been made in finding new high demanding applications for recycled rubber, but with low success. This is mainly due to the approach followed. Attempts have aimed at mass low demanding applications as asphalt infill, instead of trying to solve the main barriers for the application of rubber in high demanding products: lower mechanical properties and an inferior market perception of recycled rubber.

Tyre recycling is an SME's market formed by tyre collectors and grinders, which supply powder for several applications. These companies face a very complicated situation as 2006 EU directive (199/31/EC) establishes zero tyres landfilling. Present situation is far from this goal and drastic measures are needed.

Today, 27 % of tyres still go to landfill (Figure 1) and, of the rest only 24% are recycled, whereas 27% are used as fuel (Figure 2). The later is expected to decrease due to more strict regulation on contaminant emissions. In this way, around 250,000,000 used tyres are accumulated each year in the countries of the former 15 EU to the 1,000,000,000 tyres already stocked. This situation is very worrying and if nothing is done, it will lead to whole tyre recycling industry collapse and, of course to a serious environmental and industrial problem.

Figure 1- Landfill site on fire.

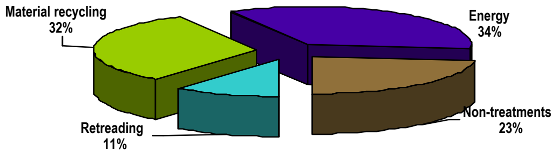

Figure 2- Applications of used rubber.

On the other hand, most of the recycled rubber is used in low profit applications, which stops R&D investments. Near 70% is used for artificial turf infill, a very low price application for a single market, which results a highly unstable situation for tyre grinders. Actually, attempts looking for new applications of recycled rubber are based in a similar approach: finding low quality and great uptake uses (asphalt infill). Hence, there is a clear demand for new markets with a higher profit margin.

At the same time, SMEs manufacturers of rubber products are highly interested in reducing their dependence on virgin rubber, which is increasingly a problem as prices and supply are highly unstable. The fact is that used tyres could supply 45% of EU rubber needs.

However, up to now, efforts to substitute virgin by recycled rubber have failed. This is mainly due to the fact that currently, mechanical properties of recycled rubber do no reach specifications of competitor materials, and that there is a general perception in the market that recycled products have a lower quality.

Attempts to improve mechanical properties of recycled rubber have failed first of all because they have worked separately on only one step of the recycling process, either on grinding or transformation, whereas both: raw material properties and transformation process variables influence in final properties. Besides, the influence of these parameters in final mechanical properties has not been addressed and the current recycling process is little controlled. On the other hand, emotional barriers have never been addressed before. Thus, there is a clear need for a project with a holistic approach to identify the influence of all these variables in final properties and include emotional aspects.

PROJECT OBJECTIVES

The main goal of this project was to develop an innovative recycling process for producing recycled raw rubber with enough quality for competing with virgin rubber in high demanding products. It will be achieved by integrating emerging grinding technologies, new transformation processes and new materials design technologies. Emotional engineering techniques will be also used to improve customers’ perception of recycled products. Products considered in the project are shoes, floorings and automotive applications. The partial goals are scheduled:

- Studying the possibility of the optimisation of cryogenic and mechanical technology by controlling the morphology or another grain characterization property such as size in order to be able to optimize the obtained properties.
- Development of procedures for optimising pressure-temperature sintering.
- Development a use-oriented material design methodology allowing translation of product requirements into product properties.
- Identifying emotional requirements to be translated into recycled products.
- Integration of above results in a process for producing high added value products from scrap tyres.

PARTNERS

The consortium in this project responds to the need for multidisciplinary approach including renamed RTD performers and companies with sound knowledge and experience in different fields as materials, recycling, biomechanics, emotional engineering, press manufacture, sintering and injection moulding along the vertical supply chain from the used tyres to final products. In this sense, the consortium joins partners from seven different European countries including highly complementary RTD experts in product development, biomechanics and emotional engineering (IBV) and materials and recycling technology (RAPRA and AIMPLAS). Also companies using new grinding techniques as RECIPNEU (Cryogenic), a novel mechanical optimized process as RUBBER RESOURCES and the traditional one (ADRIA) for comparison, as well as press and mould manufacturers with different applications (REP, FONTIJNE, and CAUCHO INDUSTRIAL VERDÚ). Finally, end rubber users as product manufacturers (ANALCO-Shoe Soles, Rubber Resources-Automotive Components and AMSA-Flooring) and The European Association of Tyre Recyclers (ETRA) for dissemination.

The Partners who take part into the project:

RTD Partners:

- INSTITUTO DE BIOMECÁNICA DE VALENCIA (IBV)

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  Project web sits & other access points:
  http://www.criosinter-project.net

- RAPRA TECHNOLOGY (UK)
- TECHNOLOGICAL INSTITUTE OF PLASTICS (AIMPLAS)

Industrial Partners:

- FONTIJNE
- REP INTERNACIONAL
- ADRIA
- ANALCO
- AMSA
- RECIPNEU
- CAUCHO INDUSTRIAL VERDÚ
- RUBBER RESOURCES

End Users:

- THE EUROPEAN TYRE RECYCLING ASSOCIATION (ETRA)

RESULTS ACHIEVED

The project objectives followed two approaches (Figure 3). The first comes from the raw material knowledge and the sintering process while the second approach comes from the end user and market expectation.

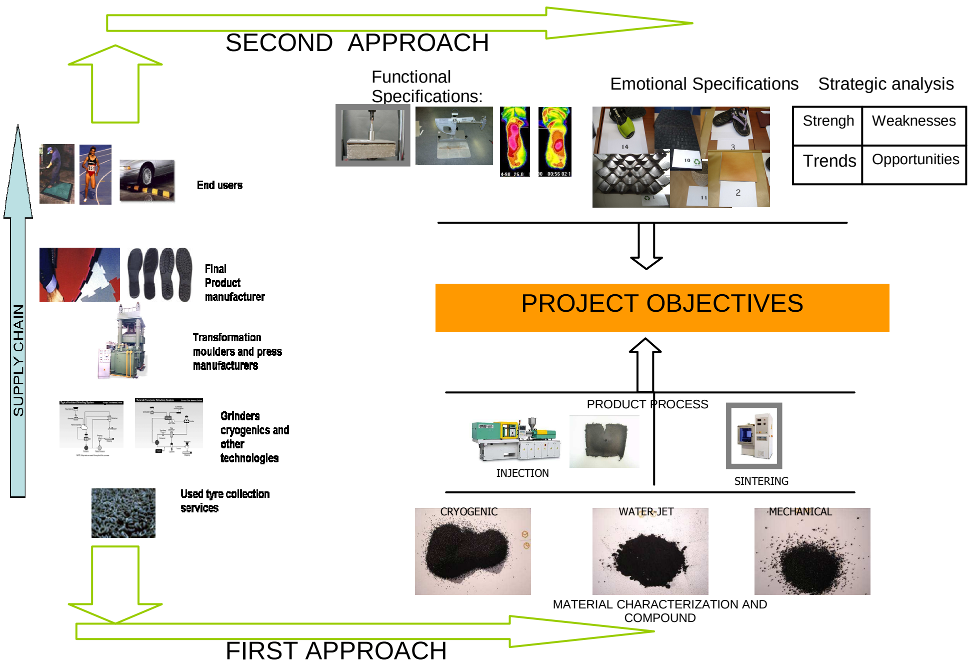

Figure 3- Project Overview diagram.

A full characterization of grain rubber coming from the two processes studied: cryogenic and mechanical grinding has allowed us to determine control parameters for a pre-sintering compound that have to be used in order to get a specific value of a determined property. Figure 4 shows the morphology of recycled rubber particles.

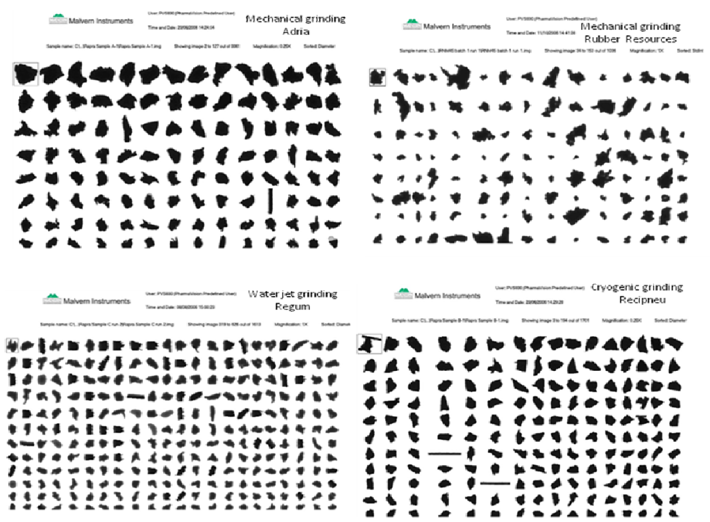

Figure 4- Morphology of recycled rubber particles.

The injection- compression sintering process has been studied and a rubber-injection moulding machine (Figure 5) has been employed in order to do the scale up of the injection compression process.

The HTPS sintering process has been fully characterized and the description of control parameters for the sintering process has been performed.

Figure 5- Image if the injector machine

Knowing the control parameters of a pre-sintering compound and the control parameters of the sintering process, a optimization of the sintering procedure has been carried out obtaining as a result an Expert System (Figure 6) which is able to optimize the resources involved in order to obtain a sintering rubber with the selected level of properties achievement depending on the final application where it is going to be used.

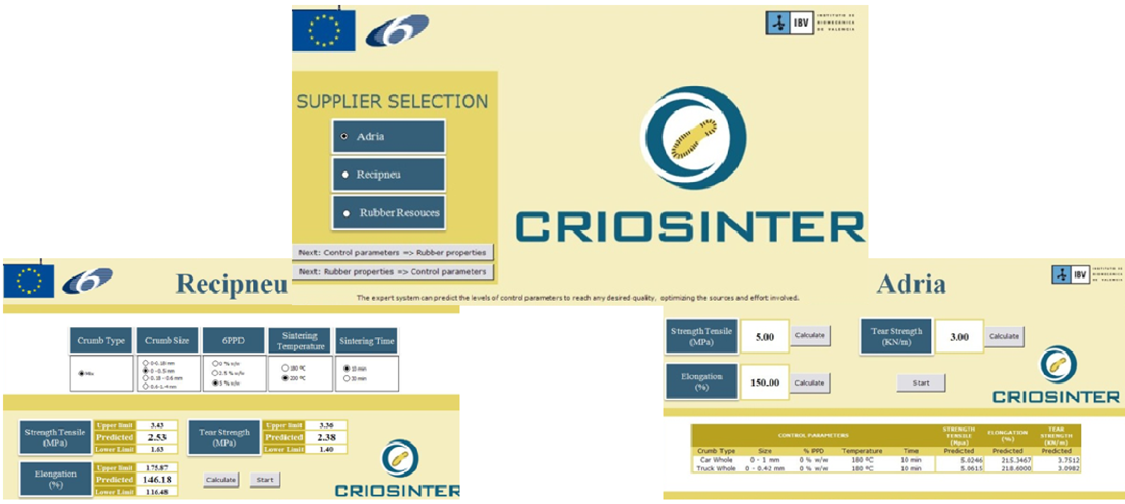

Figure 6- Expert system interfaces.

Technical Specifications for target application products and priority characterization into three levels: Basic, Linear and Overquality specifications have been obtained taking in account a holistic approach to the product as can be observed in Figure 7. Then the House of Quality for each of the selected market application was obtained.

In this context, a strategic plan for raw recycled products and supply chain was developed and the SWOT analysis: Strength, Weaknesses, Opportunities and Treads of the supply chain obtained.

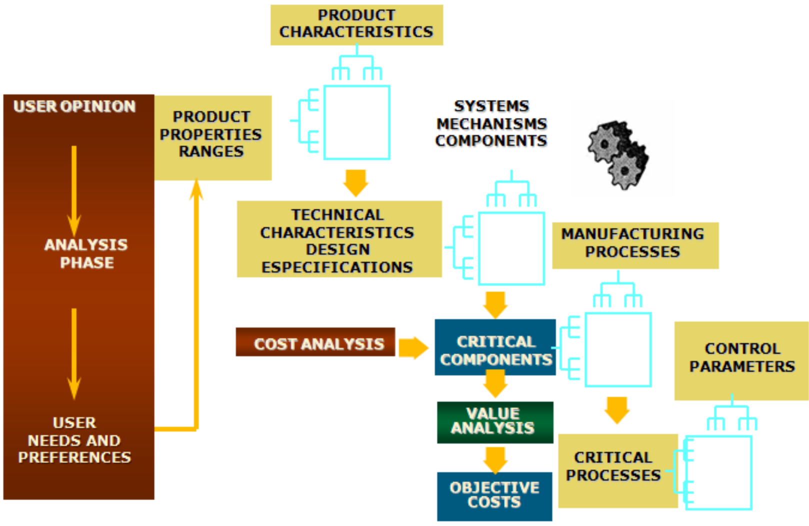

Figure 7- Product flow chart.

Emotional engineering has also been taken into account for solving the existent barriers that recycled products find in its introduction into a high demanding sector. Here, the affected perception concepts and actions to solve the detected weaknesses were studied and the importance of communication was detected because the purchase decision for the recycled products become balanced against the non- recycled ones by introducing a label which informs that the product is a recycled one. It can be seen in Figure 8.

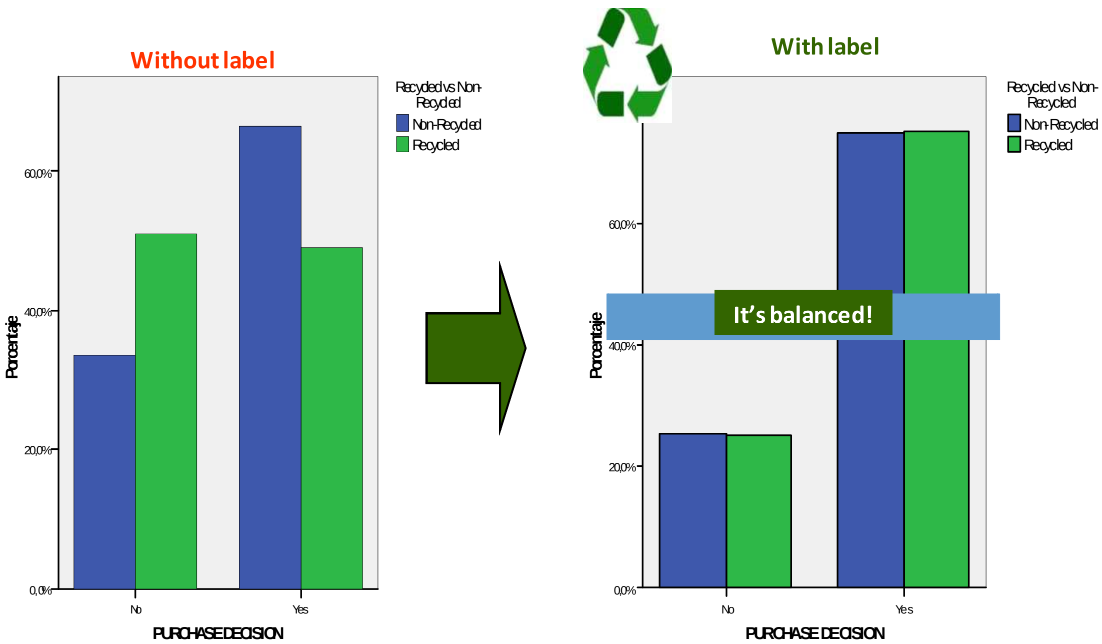

Figure 8- Bar chart of purchase decision for recycled vs. non recycled.

For this reason in order to aid the product introduction, a label (Figure 9 and Figure 10) that outlines the advantages of the recycled rubber has been developed.

Figure 9. Draft label placed on the shoe prototype.

Figure 10- Draft label developed.

In addition, to improve the user perception, further improvements should consider an odour elimination strategy. Due to the fact that an attempt to improve the odour has been performed, and we have find that the cryogenic rubber has obtained better results. However, adding some fragrance to the rubber do not manage the desired perception from the user

In this point of knowledge, three end products of the following high demanding sectors: shoes, floors, and automotive components have been developed. They have been submitted to a battery of test in order to determine its requirements achievement in order to be introduced into a high demanding market and we are glad to say that the results have been very promising. Figure 11 and Figure 12 show some of the obtained prototypes.

Figure 11 - Shoe prototype.

Figure 12- Flooring prototype.

CRIOSINTER

http://www.criosinter-project.net/

Figure 13- Logo and web designed for CRIOSINTER Project. (Intranet is only available for CRIOSINTER partners)

2. DISSEMINATION AND USE

EXPLOITABLE KNOWLEDGE

Exploitable knowledge emerged from the project is divided in two main groups: knowledge having a future potential for further research activities which will permit industrial application, and knowledge transferred to the SMEs involved in the project, that will be exploited throughout their commercial routes and channels.

It is important to remark that, the results obtained have been very promising. During this project, a new use of recycled rubber has been obtained, introducing it into high demanding products.

We would like to highlight that some of the SMEs involved in the project have initiating negotiation with its clients in order to make a 100% recycled product, to use recycled rubber as urban furniture or to take advantage of the CRIOSINTER results in order to promote their products.

DISSEMINATION OF THE KNOWLEDGE

Dissemination will continue addressing 'take-up' actions within European manufacturers (particularly SMEs) to promote the growth of the technology developed into new and existing application areas. Attention will continue being focused on the dissemination of the technological, market and product benefits and case study results, the results of the economic and environmental studies, technological transfer, and the transfer of best practices and process control methodologies. Developments within the project, particularly with regards to market intelligence, will continue supporting the focus of dissemination in order to achieve maximum impact.

When selecting the issue for disseminating the requirements of reusability, accuracy, generality and innovation will continue being considered.

During all the project duration, the public side of the web site has been used as a dissemination platform. In addition, the project has been presented in different European forums, as European congresses such as the European Tyre Recycling Association conference (2006 and 2007) or the ECOMONDO Fair where a poster of CRIOSINTER (Figure 14) was placed on the ETRA stand.

Besides these specific actions, the participation of the Information and Communication Area of the IBV has been essential to disseminate the project to the general public, taking advantage of their previous experience and contact within pres media.

Major dissemination activities developed are the following ones (apart form the ones already described):

- More than 20 articles, press releases were published in mass media.
- Different articles were published in specialized press, such as one appearing in “The Parliament Magazine”

The poster (Figure 14) presented on ECOMONDO Fair will continue being used for dissemination purposes.

Figure 14- CRIOSINTER Poster.