EUREKA PROJECT E!2819- FACTORY ECOPLAST

1. General description

Project	E! 2819- FACTORY ECOPLAST	**Status**	Finished- 05-May-2006
Title	**Development And Characterisation Of Eco-Friendly Thermoplastics**		
Class	Sub-Umbrella	**Technological area**	New Materials
Start date	30-Sep-2002	**End date**	30-Sep-2005
Duration	36months	**Total cost**	2.2Meuro
Partner sought	No		

Summary The Project Goal Is To Develop Eco-Friendly Thermoplastics As A Composite Of Polymers And Natural Fibres Like Wood, Flax, Jute, Etc. The Application Guidelines Will Describe Parts Properties And Injection Moulding Process Parameters.

Budget and duration

Phase	Budget(Meuro)	Duration (Months)
Definition phase	0.62	10
Implementation phase	1.58	26
Total	**2.2**	**36**

Member contribution

Member	Contribution	Position	Since
Slovenia	**42.57%**	**Notified Finished**	**05-May-2006**
Portugal	20.36%	Notified Finished	05-May-2006
Hungary	20.94%	Notified Finished	05-May-2006
Croatia	4.89%	Notified Finished	05-May-2006

Participants

Company	Country	Type	Role
Isokon Plastics Manufacture Ltd.	**Slovenia**	**SME**	**Main**
University Of Ljubljana / Faculty Of Mechanical Engineering	Slovenia	University	Partner
Tecos - Slovenian Tool And Die Development Centre	Slovenia	Research Institute	Partner
Zagreb University/Mechanical/Naval Architecture Fac. (Famena)	Croatia	University	Partner
Tiszai Vegyi Kombinat Rt.	Hungary	Large company	Partner
Inteplastico - Industrias Tec. Plasticos S.A.	Portugal	Large company	Partner
Piep Associacao - Polo De Inovacao Em Engenharia De Polimeros	Portugal	Research Institute	Partner

2. Project outline

Project description

With an expanding world population and parallel with the increase in their purchasing potentials, the need for materials to satisfy demand on the world market is rapidly growing. In times when we cannot expect polymer prices to be reduced, but consumption is still growing, we need to develop new materials that would be cheaper and at the same time offer equal or better properties. The oil supply is getting smaller every day and the pressure to become more independent from oil derivatives is at an all-time high, therefore there are multiple reasons to maximise the use of renewable resources. On the other hand we have enough natural resources like wood, flax, hemp, jute, etc. For these reasons a big challenge arises namely to make completely new types of composite materials by combining different resources.
One of the biggest new areas of research in this field is in combining natural fibres with thermoplastics. The research objective will therefore combine two or more resources in such a way that a synergism between components results in a new material which is much better than any of the individual components. Usage of natural resources in the polymer industry does not only assure regular supplies but it also helps to stimulate economic development.
Appropriate fusion is a palletized compound suitable for injection moulding and extrusion process. Such a material also reduces environmental impacts because it is simpler to recycle. A patent protection for the results arising from this project will be applied for.
Keywords: polymer, eco-friendly, injection moulding.

Technological development envisaged

1. The technological determination of compounding conditions
Natural fibres demand a specific manufacturing process, we will develop the necessary screw geometry for an extruder that will assure maximal dispersion of wood fibre but still have a very low shear force in the machine that can disintegrate our filler.
2. Determination of palletizing process
One cannot palletize bio-polymer materials with the most common processes known to the general industry. We will determine conditions and processes under which this can be achieved.
3. Rheological properties determination
We will perform all necessary tests for the injection moulding process planning and control and, when needed, define new standards for characterisation of new developed bio-polymer materials.
4. Development of new wood fibre types
Size, type and uniformity of wood fibres can have a high influence on compound properties. We shall determine this in the frame of proposed projects and select the most suitable species.
5. Compatibility
Compatibility between polar and non-polar substances will be researched and evaluated in such a way that mechanical values of newly developed materials will be increased.
6. Transfer from real to virtual world
We intend to perform 3D computer-aided simulations for new composite materials to study and define technological windows assuring stable production. We shall also study and define relations between the process parameters and product complexity. Doing this we intend to set up conditions for final product development and with them to help a wide range of consumers for a quicker and reliable implementation of new developed materials.
7. Injection moulding tests
Injection moulding tests will be performed with a goal to determine special (material, process, parts shape) conditions under which the material must be processed. As a result of this we will be able to offer our customers completely defined and approved production data.
8. Injection moulding cycle time reduction
One of the project goals will also be to develop materials and to define process conditions that will lead to a reduction in cycle time. This cycle shortening will increase productivity and reduce production costs.
Project objectives are very promising because we already have tested the idea under a Slovene national project and reached positive and stimulating results. The project consortium is very advantageous for it does not include competitive risks and all partners are respectable companies with many years of experience in technological and commercial fields. The project will benefit greatly from synergy effects and that is in fact one of EUREKA's goals.

Markets application and exploitation

The market is becoming aware of strong public emphasis and high governmental support when using environment friendly materials. The presented project will also have a high probability of broad commercial success due to this attribute. In the preparatory phase of the project we performed some market studies. Among them we found that the U.S. market has already seen an enormous increase in the usage of extruded bio-polymer materials since six years. From these findings it can be expected that new materials for injection moulding could have similar growth intensity in Europe.
The potential areas of usage are in:
* Furniture industry
* Building industry
* Automotive industry
* Packing applications.
Undertaking commercial activities we plan a multi-level promotion:
* Fair K in Duesseldorf
* Expert conferences
* Special seminars for potential users, architects and designers
* Edition of material manual, web presentation and open e-communication with web page visitors.
For Slovenian customers, a special seminar on this topic has already been done presenting new possibilities and testing market replies. Reactions were very positive and stimulating. For this reason we plan to permanently inform all the public interested about project achievements and at the same time to carefully analyse their suggestions and ideas to enrich the project.

Project codes

BSI

BNF/BNJ	mechanical testing
BO/BW	chemical analysis and testing
DYM/DYN	thermoplastic polymers
MY	computer applications
N	mechanical engineering

NACE

2414	Manufacture of other organic basic chemicals
25	Manufacture of rubber and plastic products
2521	Manufacture of plastic plates, sheets, tubes and profiles
2524	Manufacture of other plastic products

3. Main participant

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Organisation type	SME
Participant role	Main

Contribution to project

The company has over 14 years of experience in compounding any type of filler and extruding it into sheet forms. We will use this knowledge to determine necessary production process parameters, allowing us to us natural fibres in poliolefin matrices. We will participate in the development of screw geometries suitable for goods dispersion and production of homogeneous compounds. We shall carry out all production tests and fine-tuning of the production processes. We will install, when necessary, a laboratory line on which samples needed for other tests will be manufactured on a separate level. The technology transfer from laboratory conditions to production level will also be performed by us. We intend to undertake all necessary commercial activities, assuring that the project and products will be accepted by a broader industrial audience. By providing customers with all the necessary information and test and demo samples, we intent to build solid ground for starting sales activities after finishing the project. In the project we see a big potential for developing new real materials and products, therefore we shall apply for patent protection of the findings and results.

Expertise

Established in the 70s, ISOKON began with the production of extruded and pressure moulded poliolefin materials. Along with our growth, we always had an open mind for new ideas by not only supporting our customers but also offering them new independent solutions. Since being bought by the company ISOSPORT from AUSTRIA, we have additionally benefited from the development sector. Now we can offer (together with the mother company) a team of highly educated experts with many years of experience in the field of polymer processing and products development (innovative products for building, sports, textile and automotive industry). In compounding wood fibres we already learned that this is a product of the future and we are one of the few experienced in this very promising field. We are already designing our own machinery and home-made specific solutions for production improvements. 80% of our market is represented by partners from the E.U., therefore we have strong connections with other E.U. companies and we have a reliable overview of the E.U. market situation and trends. ISOKON is involved also in some national projects researching possibilities of implementing natural fibres as materials for injection moulding technologies.

4. Partner

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Organisation type University
Participant role Partner

Contribution to project

The core contribution of FS-LAP will be injection moulding tests of newly developed materials. There are so many limitations and constraints when connecting desired parts functionalities with material specifications and moulding process parameters, therefore an experimental evaluation is necessary. Biomaterial content influences the course of the process and internal characteristics, such as orientation, frozen layer thickness, residual stress and degree of crystallisation. In use, however, only the macroscopic properties of a moulding count. These external properties are determined by its internal structure, regardless of the process course by which it was achieved. External quality of a mould can be drawn from its internal structure. Figure 1 depicts the events as a series of causes and effects, where the biomaterial has a great influence. The process parameters are results of the production parameters set in the machine; they are physical values that determine the physical state of the process while the part is being formed. The internal properties are a function of the process parameters. It is known that different process parameters can in some cases produce similar structural properties. The internal properties determine the external properties, that is, the mechanical behaviour of the mould. Fig 1.: Effect of production settings on process parameters and part properties 1. PRODUCTION SETTINGS - hydraulic pressure - heated band temperature - time - screw velocity 2. PROCESS PARAMETERS - melt pressure - pressure gradient - time - melt velocity - shear stress - temperature gradient 3. INTERNAL PROPERTIES - orientations - frozen layer - degree of crystallisation - residual stress 4. EXTERNAL PROPERTIES - tensile strength - warpage - modulus - impact strength - strain to fracture FS-LAP will study the production settings and process parameters of biomaterials on external properties of computer supported injection moulding systems. For this purpose some tests will be performed to study and experimentally evaluate some promising market ideas and products and to define technological limitations of new materials. With a special experimental tool for injection moulding standard test specimens, ASTM type I will be manufactured. FS-LAP personnel are highly skilled and experienced in the field of using modern CAE tools as well in running and controlling real injection moulding production. There is also a good technical support for tool manufacture and modifications as well for instrumentation at the Faculty and by TECOS industrial members.

Expertise

The Forming laboratory (LAP) at the Faculty for mechanical engineering (FS) has long-lasting experience in polymer processing. During working with Slovenian industry and offering special courses for undergraduate and especially for postgraduate students, a lot of research and development projects have been elaborated. The basic goal of the laboratory is a permanent combination of virtual and real production environments. As virtual manufacturing has many privileges (time, costs, variant approach, sensitivity analysis) it could also

lead to some misunderstandings if results have not previously been compared with real ones. A combination virtual/ real is ideal because results obtained by carefully analysing real experiments can later be used for fine-tuning of numerical codes. LAP is internationally well-known and recognised. Its members published their reports in different high-ranking international journals; they were also invited to present their experiences during lectures at foreign universities and conferences. LAP participated in some European projects like TEMPUS (JEP-1925), INCO COPERNICUS (RASHTOOL and ENFORM) and EUREKA (E! 2336-Stresscycling), bilaterally with HUNGARY, GERMANY and CROATIA.

4. Partner

Company	**Tecos - Slovenian Tool And Die Development Centre** Kidriceva, 25 3000 Celje Slovenia Tel +386 3 490 09 20 Fax +386 3 426 46 11 www.tecos.si
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Organisation type	Research Institute
Participant role	Partner

Contribution to project

TECOS, as a technology transfer centre, intends to design injection moulding tools followed by virtual injection moulding process evaluations. To perform the stated goals with high reliability, a lot of knowledge and experience is needed. The virtual work will be integrated into a complex CAE environment, where special codes (FEM, FDM, CVM) will be used. Analysis is composed of three parts: part properties and shape accuracy analysis, tool design with special kinematics and heat control (generation and transfer) and process cycle evaluation and optimisation. The numerical simulation of injection moulding processes demands adequate material data. Data for materials available on the market is often defined experimentally by material producers or delivered to software developers. For new materials the situation is different, there is no adequate rheology data available, therefore the processes are simulated with parameters expected/ estimated to be as equal as possible to the real ones. In the family of similar materials one can use, for the first estimation, the similarities between rheological and mechanical material characteristics. TECOS intends to focus its efforts on building up a reliable material database, which will be obtained by a combination of final part properties, mechanical testing of specially prepared samples and with on-line injection moulding process monitoring. Numerical tools like backward computing and neuronal networks will help us to describe the rheology of investigated materials. As a result of studying injection moulding of newly developed eco-friendly polymers, TECOS will perform a series of systematically planned virtual manufacturing processes (before fine tuned by experiments). The results obtained will be used to define process technological windows and to write guidelines (together with other project partners) for potential users and designers.

Expertise

TECOS was established by the Slovene Government as a technology transfer centre, as a link between Slovene science, education and the Slovene tool making sector. Slovene tool making companies are mostly SMEs, therefore they can't afford modern computer aided tools and highly skilled workers to design tools and processes which are essential for a fast, reliable and cost efficient response to the market demands. A team of experts and some postgraduate students are permanently involved in analysing complex forming processes (cold, warm and hot metal working, sheet metal forming), but the most successful (with some hundred finished CAE industrial projects) are those in the field of polymer injection moulding process design and/ or evaluations. Here it needs to be stressed again that both parties gain a lot from this cooperation, SMEs gain optimised solutions, TECOS industrial experience, enrichments of knowledge and suggestions/ directions for further work. TECOS has participated in several Slovene and international projects. It is already involved in several E.U. projects like 4.FP, INCO-COPERNICUS (ENFORM as coordinator), BRITE EURAM, EUREKA (E! 1764, E! 1869, E! 2382 - coordinator).

4. Partner

Company	**Zagreb University/Mechanical/Naval Architecture Fac. (Famena)** Ivana Lucica, 5 100 00 Zagreb Croatia Tel +385 1 61 68 222 Fax +385 1 61 56 940 www.fsb.hr
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Organisation type	University
Participant role	Partner

Contribution to project

1. Systemic construction of moulds and dies for processing of biodegradable polymers. 2. Optimisation of parameters for processing of biodegradable polymers. 3. Analysis of recycling possibilities of biodegradable polymers.

Expertise

* CHAIR FOR POLYMER PROCESSING Polymers and their processing have been studied at the FACULTY OF MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE for more than sixty years. The syllabus includes polymers and wood as well as their processing and treatment procedures. The course on Non-Metal Processing, now Polymer Processing, was founded in 1971. Currently, the syllabus is included in the general module of the study of mechanical engineering, aeronautical engineering and naval architecture, and within the course of Production Engineering and the course of Processing and Mounting. There is a postgraduate course on the Manufacture of Polymeric Products, as part of the course of Technology in Engineering Production, founded in 1980. A large part of the instruction is carried out in industry, and practical work also involves experts from the field. Students studying general subjects regularly visit companies in Zagreb, and students in higher semesters of specifically oriented studies visit companies in DALMATIA, SLAVONIA,

SLOVENIA and AUSTRIA. Professionals from companies provide a special contribution in assisting in work for seminars and diploma papers. Such co-operation has created strong links between the industry and the Faculty. This is a permanent social task since the Section educates future experts in the field of the Croatian plastic and rubber industry. Since its foundation, 254 students have completed the study leading to a Bachelor of Engineering. The final paper was written by a total of 62 students at Post-secondary College. Twenty-three Master's theses and two Doctoral dissertations have been defended. * LABORATORY FOR POLYMER PROCESSING The Laboratory for Polymer Processing was founded in 1979. The Laboratory is also used as a lecturing room. The equipment, among other things, includes manual injection moulding machine for the manufacture of injection-moulded parts and a Brabender rheometer, a device for testing the flow properties of polymeric materials. The Laboratory for Polymer Processing is involved in solving practical problems such as the identification of materials, selection of the most suitable material, recommendations in selecting polymer processing equipment, participation in the development of products and moulds. Rheological, mechanical and thermal calculations are conducted at the Laboratory, as well as price calculations for moulded parts, simulations of filling the mould cavity, development of design documentation, etc. Also, the Laboratory participates in the certification of polymeric products. Owing to the foundation of the UNIVERSITY CENTRE FOR POLYMERS (SVECIPOL) and INA-donated equipment, students have the possibility to carry out the practical part of instruction.

4. Partner

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Organisation type	Large company
Participant role	Partner

Contribution to project

With our extended knowledge and highly sophisticated laboratory equipment, we will help with developing or selecting appropriate matrix material for the compound. Material needed for tests will be supplied by TVK. We will do all laboratory tests needed for determination of rheological properties of the compound material and when necessary develop new standards for testing bio-polymer materials. The study of compatibility between polar and non-polar substances will be researched by TVK.

Expertise

The Tiszaojvaros-based TISZAI VEGYI KOMBINAT RT comprises a group of more than 30 companies. The parent company is a leading petrochemical producer in Central Europe, and at present, it has more than 20% of production capacity in the region. TVK RT. is the largest chemical complex and sole gas oil company. Today, TVK is one of the major chemical polyolefins producers in HUNGARY. It manufactures ethylene, propylene, polyethylene and polypropylene from naphtha and complexes and is the sole polyolefins producer in HUNGARY and it represents almost 20% of petrochemical capacities in Central Europe. TVK RT. is an

integrated production company that manufactures ethylene and propylene from naphtha and gas oil and converts these into low, medium and high density polyethylene and polypropylene in its high-tech processes. Our Olefin plant, with other 360 Kt/y capacity, is a modern and safe unit. As a result of expansion projects implemented in the past decades, our polymer production capacity has increased to 600 Kt/y, a significant volume by European standards. Indicative of our leading domestic role, the customers purchasing our products cover 70-80% of the domestic plastics processing industry. Our exports represent 65% of our sales on a yearly basis. Eighty percent of this volume goes to Western customers, but exports to Central and Eastern European regions also have a rapidly increasing share. We place particular emphasis on the quality of our services associated with supplies in order to fully satisfy customer-specific requirements. More than 82% of our European sales are executed through TVK foreign sales networks. TVK RT. processes ethylene and propylene into the following polyolefin products and supplies these to domestic and foreign markets: - Various low density polyethylene grades (LDPE), marketed as TIPOLEN, are manufactured by ICI autoclave and BASF tubular processes. Density range: 0.918-0.924 g/cm3. - Medium and high density polyethylene (MDPE and HDPE) grades, or TIPELIN, are manufactured in a low pressure catalytic process, a slurry polymerisation technology under license from PHILLIPS PETROLEUM COMPANY. Co-polymers with hexene-1 co-monomer and homopolymers are in the density range of 0.932-0.967 g/cm3. - Isotactic polypropylene, or TIPPLEN, is a high purity and even quality polymer. Our product portfolio contains homopolymers, random and high impact copolymers as well.

4. Partner

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Organisation type	Large company
Participant role	Partner

Contribution to project

1. From raw material to product: - selection of a target application - development of new product, or find existing products for injection moulding - design of a prototype part - development of a prototype. 2. Non-conventional injection moulding techniques: - special techniques for bimaterial processing (N2 atmosphere) - two-material moulding.

Expertise

Injection of plastic materials.

4. Partner

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Organisation type Research Institute
Participant role Partner

Contribution to project

1. From raw material to product: - selection of a target application - development of new product, or find existing products for injection moulding - design of a prototype part - development of a prototype. 2. Non-conventional injection moulding techniques: - special techniques for bimaterial processing (N2 atmosphere) - two-material moulding.

Expertise

- Compounding, processing and characterisation of polymeric systems. - Product development.