CFC/IJSG/19 Jute Reinforced Polyolefines

Project Completion Report

Ir. M.J.A. van den Oever

Report 977

Colophon

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Author(s)	Ir. M.J.A. van den Oever
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Agrotechnology & Food Innovations B.V.
P.O. Box 17
NL-6700 AA Wageningen
Tel: +31 (0)317 475 024
E-mail: info.agrotechnologyandfood@wur.nl
Internet: www.agrotechnologyandfood.wur.nl

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Content

1 Project Summary

1. Title: CFC/IJSG/19 Jute Reinforced Polyolefines - Project Completion Report
2. Number: -
3. Project Executing Agency (PEA): Agrotechnology & Food Innovations B.V. (AFSG)
4. Location: Wageningen, The Netherlands
5. Starting date: 02 August 2004
6. Completion date: 31 December 2008
7. Financing:
    - Total Project Cost: USD 441,000

   of which:
    - CFC Financing (Grant): USD 390,000
    - Co-financing: USD 51,000 (of which: USD 10,000 grant by the Government of Bangladesh, USD 10,000 by the Government of India, USD 6,700 in-kind by Government of Bangladesh and USD 6,700 in-kind by Government of India) PEA Counterpart contribution: USD 18,000

For further financial details, see paragraph 2.4.

2 Background and Context in which Project was Conceived

2.1 Key commodity issues and relevance to strategy of sponsoring IJSG

Jute fibre is traditionally manufactured into final products through methods involving spinning and weaving. Compared to technologies adapted by other fibres and textile industries, jute processing techniques and productivity have remained very much unchanged and less competitive. The traditional jute products' markets, such as packaging materials for agricultural products (including sacks, bags, carpet backing cloth, packaging for fertilisers, cement and chemicals) are being eroded by synthetic substitutes. Diversification of the uses of jute has been the main thrust of global efforts in both the producing and consuming countries aiming at identifying major market outlets for the jute sector. One alternative to which a great deal of attention had been given in the recent past is the possible utilization of jute as a reinforcing agent in thermoplastics.

2.2 Specific objectives and expected outputs

The purpose of this project was: a) to develop pilot scale jute-PP granules, which have a better price/performance ratio than glass fibre-PP granules, b) to apply these granules in industrial injection moulding equipment to produce demonstration products, and c) to open up large market outlets for jute.

The specific objectives and expected outputs were:

Objective 1: To collect enough data from industrial moulders in jute producing countries to produce granules, which meet the industry's product and process requirements.

Output 1: Data-sheets with detailed product requirements and production parameters.

Objective 2: To design appropriate lab scale materials, meeting the industry's initial requirements.

Output 2: Lab scale test samples, meeting the industry's initial requirements.

Objective 3: To produce pilot scale amounts of granules and to mould these using industrial equipment.

Output 3: Industrially processed test products.

Objective 4: To design appropriate lab scale materials, meeting the industry's final requirements.

Output 4: Final test samples, meeting the industry's final requirements.

Objective 5: To produce pilot scale amounts of appropriate granules and to mould these using industrial equipment.

Output 5: Industrially processed demonstration products.

Objective 6: To carry out an evaluation/impact assessment and needs assessment for jute reinforced polyolefine market development.

Output 6 i: A concise strategy paper on jute reinforced polyolefine market development.

Output 6 ii: Comprehensive analytical document, which includes assessment of jute reinforced polyolefine market development.

Objective 7: To organize a large-scale demonstrative workshop at industrial site.

Output 7: Demonstrative workshop at industrial site; draft technical manual and draft project completion report.

2.3 Targeted beneficiaries and extent of benefits

The use of jute sliver as reinforcing material for the production of thermoplastic composites will be a significant break-through, which may have significant impact both on demand for jute fibre as well as on the international polymer processing sector. The large-scale use of jute sliver was expected to rapidly increase demand for jute in several end-use areas including in the automotive, packaging and household appliances industries. It was foreseen that the use of glass fibres as reinforcing material may be restricted, due to its suspicious carcinogenic behaviour; this process can be sped up once the use of jute sliver as an alternative to glass fibres would be established. At the same time, the substantial import bills of the producing countries will be substituted by domestic production of jute/plastic materials. This pioneering area of diversified agro-industrial development was also expected to have substantial socio-economic impact on the national economies of producing countries. It may contribute in rural poverty alleviation as mostly marginal and small farmers grow jute. Through the creation of additional demand and additional job opportunities in the agro-industrial sector, it was expected to generate new and stable incomes for farmers and workers. The primary beneficiaries of this project from developing countries would be Bangladesh and India, who would be directly involved in the activities of the project. From the consuming countries the Netherlands would participate in the project. It should be noted, however, that the project outcome may be of interest to a larger number of countries who would derive benefits from technology transfer emanating from the project. Interest had already been shown by a number of countries. Successful development of the technology and its application in various product areas was also expected to generate positive environmental impacts as the new products may be recyclable and biodegradable. Furthermore, the end products may be lighter than the currently produced alternatives, which leads to substantial fuel reduction during transportation. Most likely, replacing glass fibres by jute fibres, may result in reduced energy consumption during processing.

2.4 Project cost and financing plan

At the start of the project, financing of the project comprised the following numbers:

- Total Project Cost: USD 398,220

of which:

- CFC Financing (Grant): USD 306,853
- Co-financing: USD 91,367 (of which: USD 60,000 grant by European Commission/Government of Bangladesh-COMPEX, USD 6,705 in-kind by Government of Bangladesh and USD 6,705 in-kind by Government of India) PEA Counterpart contribution: USD 17,957

Since the publication of the Appraisal report, the project has seriously suffered from the changing Euro/Dollar ratio because almost all project costs were being charged in Euros. To compensate for the 'loss' in funding, CFC has made available to the project another USD 83,147 (Addendum No 1, June 2006).
This has resulted in the following financing numbers:

- Total Project Cost: USD 481,367

of which:

- CFC Financing (Grant): USD 390,000
- Co-financing: USD 91,367 (of which: USD 60,000 grant by European Commission/Government of Bangladesh-COMPEX, USD 6,705 in-kind by Government of Bangladesh and USD 6,705 in-kind by Government of India) PEA Counterpart contribution: USD 17,957

<u>Co-financing</u>
In January 2008 the Government of India – Ministry of Textiles has transferred the committed US$ 10,000 as co-financing contribution to the Market Research (Component 6 of Appraisal report). The Government of Bangladesh – Ministry of Textiles and Jute has transferred US$ 10,000 to the projects account late September 2008. The PEA, with full support from IJSG and CFC, has not been able to get arranged the transfer of the US$ 50,000 committed by Bangladesh Government. This has forced the project team to modify both the size as well as the time schedule of the Market Research. Actually the Market Research could only be started during the PEA's visit to India and Bangladesh in October 2008.

This has resulted in the following financing numbers:

- Total Project Cost: USD 441,367

of which:

- CFC Financing (Grant): USD 390,000
- Co-financing: USD 51,367 (of which: USD 9,925 grant by the Government of Bangladesh, USD 10,000 by the Government of India, USD 6,705 in-kind by Government of Bangladesh and USD 6,705 in-kind by Government of India) PEA Counterpart contribution: USD 17,957

In kind contribution Governments of India and Bangladesh

With respect to the in-kind contribution by the Governments of India and Bangladesh, it may be noted that the IJSG has supported the PEA in full by:

- contacting private companies in the region
- arranging industrial injection moulding trials
- organizing efficient trips of the PEA to Dhaka and Kolkata
- organizing the dissemination workshop.

PEA counterpart contribution

The PEA has covered expenses for maintenance of the extrusion compounding patent. These expenses exceeded the committed US$ 17,957 already in the period 2004-2005.

2.5 Management and implementation arrangements

Agrotechnology and Food Innovations b.v. (AFSG), member of Wageningen UR, based in Wageningen, the Netherlands, has been the PEA with the responsibility for implementation of the project. At the moment of signing of the Project Agreement, 3 industrial enterprises had been contacted to act as an industrial partner in the project, viz.: Aziz Pipes Ltd. in Bangladesh and Birla Corporation Ltd. and Agarwal in India.

During the project implementation period, Collaboration Agreements were signed with Aziz Pipes and Birla Corporation.

The International Jute Study Group (IJSG) based in Dhaka, Bangladesh, was the supervisory body of the project.

2.6 Borrower and summary loan terms

None

3 Project Implementation and Results Achieved

3.1 Project Implementation

General project implementation

The project design appeared logical; the foreseen order of components turned out practical. The time frame though appeared too short. The material development activities and pilot scale production of granules were all undertaken by the PEA and did not exhibit any problems as such. The time required 1) to arrange the Collaboration Agreements with industrial parties, 2) to ship granules from the PEA to the industrial processors in Bangladesh and India, and 3) to release counterpart funding from the Governments of India and Bangladesh appeared to be far more than anticipated in the Appraisal report. Once the pilot scale produced jute-PP granules had arrived at the industrial partners in Bangladesh and India, industrial injection moulding trials were arranged on short notice and feedback regarding the trials from the partners to the project was as may be expected from industrial enterprises. The cooperation between the PEA and the supervisory body, IJSG, was very well. IJSG has contributed significantly to the efficiency and effectiveness of communication between the PEA and the industrial parties in Bangladesh and India.

Project extensions

The implementation time was foreseen to be 18 months from the starting date of the project, being August 1st 2004. The project, however, has suffered from several delays at various stages during the project. Therefore, at several moments during the project the PEA has requested budget neutral project extensions which were supported by IJSG and kindly provided by CFC. The project implementation period was finally extended to 31 December 2008.

The delays were due to the following issues:

- It has taken up to March 2006 to come to a collaboration agreement with Aziz Pipes that was acceptable for all project parties.
- Once signed, the first consignment of jute-PP granules could be sent to Aziz Pipes in Bangladesh. However, although the granules were sent from Wageningen in June 2006 and arrived in Chittagong port end of July 2006, it took to March 2007 to get the granules to Aziz Pipes' facilities. Only at this stage, industrial trials could be scheduled. The long stay at Chittagong port was said to be due to customs related issues like the value of the granules and political disturbances in Bangladesh during part of this period.
- The collaboration agreement with Birla Corporation in India was only signed in February 2007.
- The actual transfer of counterpart contribution to the project's account by the Governments of India and Bangladesh has taken much effort from both IJSG, CFC and the PEA. Finally, the Government of India has transferred its committed USD 10,000 in

January 2008. The Government of Bangladesh has transferred only USD 9,925 from the committed USD 50,000 in late September 2008. This has forced the project team to modify both the time schedule as well as the size of the Market Research. The market survey by Market Forces, Calcutta, India, was finally delivered 6 March 2009.

Transportation of goods

The shipments of goods, both from Bangladesh to the Netherlands, as well as from the PEA to Bangladesh and India, has shown some difficulties. The first consignment of jute from Bangladesh to the PEA in the Netherlands, in which all the (customs) paper work had been left to the shipper, appeared to be very costly. Therefore, for the second consignment, the arrangement of the required documents was done by Aziz Pipes and the PEA, which took far more time.

Regarding the shipment of granules from the PEA in the Netherlands to Aziz Pipes, the fact that Bangladesh customs authority was not ready to treat the 400 kg batch of jute-PP granules as a free sample for research purposes caused dispute and delay. Learned from this experience, the consignment of jute-PP granules to Birla in India one year later, was sent from door to door using Copex Maritime, a seaway transporter based in the Netherlands. However, soon we learned that Copex was not willing to accept another request, due to problems with Indian customs.

Industrial moulding trials

Once the granules had arrived at the industrial partners, the industrial injection moulding trials in Bangladesh and India could be promptly and efficiently planned. For organizing the trials in Bangladesh, the assistance of IJSG appeared to be needed and this assistance has been effectively provided. Both in Bangladesh and in India, several series of successful injection moulding trials have been performed. Products made include: several automotive door trim items, step of a lorry, different cones (for yarn production and electric wire winding), electronic ballast, electric extension cable cover, household items, and pencil tops.

Withdrawal Aziz Pipes as industrial partner

Aziz Pipes has withdrawn from active participation in the project in Autumn 2007. Although no official reason has been given, the withdrawal was probably due to change in management.

Resource utilization

All planned activities have been performed within the foreseen budget for PEA-managed activities. However, due to high transportation costs already made, materials budget has exceeded the foreseen amount by over US$ 11.000 by October 2007 (see Project progress report #3). As a result of unforeseen large amount of effort required to arrange MoUs with Aziz Pipes and Birla, effort required to get the 400 kg batch of granules to Aziz Pipes, and to discuss the follow-up of the industrial trials in Bangladesh, personnel costs to implement the activities as described in the Appraisal report exceeded the foreseen budget. Due to combined travelling and

shared equipment facilities at the PEA, savings compared to the original budget could be made in these categories. Therefore, in November 2007 the PEA has requested the following re-allocation of budget between categories, which was kindly provided by CFC:
USD 10,000 from Equipment to Materials
USD 4,000 from Duty travel to Materials
USD 10,000 from Duty travel to Personnel

Further, since the extension of the grant by CFC with Addendum No. 1 in June 2006 to compensate for 'losses' due to a dramatic change in USD/€ ratio since the publication of the Appraisal report, the USD/€ ratio has changed worse, accounting for an additional 'loss' of USD 19,000 over the period July 2006 – December 2008. Due to very efficient organization of the dissemination workshop in good cooperation with IJSG and Birla Corp. Ltd., savings could be made compared to the anticipated costs of USD as stated in the Appraisal report. From the foreseen USD 35,000 only about USD 7,000 has been consumed, leaving USD 28,000.
In a letter d.d. 7 January 2009 to CFC, the PEA has requested for reallocation of USD 19,000 from 'Materials budget of the Final Workshop' to the PEA's material, personnel and duty travel budget. The PEA offers to allocate USD 19,000 of expenses made for the extrusion compounding patent application and maintenance over the period 1 January 2006 to 31 December 2008 as additional counterpart contribution to the project. In an E-mail d.d. 14 January 2009, the CFC has advised to have no objection to the requested within-budget re-allocation.

Supervision
IJSG has shown to be a very active supervisor, which has contributed to a large extent in: contacting industrial parties, organizing efficient trips by the PEA to Bangladesh and India for attending the injection moulding trials and further discussions, and organizing the disseminating workshop.

3.2 Project Results Achieved

Within this project, many demonstrative products have been made, including: diverse automotive door trim panels, cones, diverse household items, a step for a lorry, a stool, and pencil covers. The project has shown the good properties of jute-PP granules (strong, cheap, processable on standard injection moulding equipment) and the characteristics that require further attention (impact strength, importance of drying prior to moulding, less good flow properties compared to pure PP which means that for several types of products moulds may need modification, sensitivity to biodegradation). Although no quantitative instrumental analysis has been performed, because the business practice in Bangladesh and India seems to be that the customers provide the polymers/compounds and the machine settings, and that moulders only perform actual moulding, the general experience of the moulders was that jute-PP is a strong material which processing requires a slight different approach from pure PP: mainly when it comes to pre-

drying and flow. A more detailed presentation of the results per Component has been given in the Tables below. Technical details have been addressed extensively in the Technical Manual. A succinct overview of the results will be presented in the Appendix 1.

The results of the project were such that Birla has stated in a fax that (quote) "with these trials, the technical and process feasibility has been established". Yet, no investment decision has been taken yet.

Benefits

The development of jute reinforced polyolefines is meant to invert the decreasing demand for jute for traditional outlets like bags and carpet backing. The main beneficiaries are the jute farmers; it is expected that an increase in jute demand will make a more solid financial base for jute producers. At the same time, the development of jute reinforced polyolefines will broaden the product portfolio of plastic processors.

Extent of benefits initially will be relatively small. One industrial jute-PP granules manufacturing facility will consume about 360-720 tons of jute per annum, which is a small amount compared to the annual production worldwide, being about 3000 kton/a. Once the jute-PP granule production becomes common technology, jute consumption may increase to a fraction of the polymer consumption, which is currently 12,500 kton/a in India and 300 kton/a in Bangladesh. The project has shown that jute-PP granules are competitive with both PP and glass-PP for many applications (for details see Technical Manual).

Impact on physical and social environment

The social and environmental effect of the project is relatively low. The foreseen scale of a first industrial production unit of jute-PP granules is very small compared to annual jute production, less than 0.1%. At the moment of writing, no concrete plans to establish such a production facility have been heard of. The currently produced amount of all natural fibre polymer composite granules in Europe is about 0.1% of the annual jute fibre production. This may change once natural fibre reinforced polymers and in particular jute-PP materials really lift off, because automotive industry is really interested in the material, though there are problems currently with car production due to financial crisis.

On the other hand the project has received substantial positive feedback on publications and presentations, as such increasing the chances for technology implementation all over the world. Because of the relatively cheap jute compared to other natural fibres, this could positively impact the jute export in the near future.

3.3 Dissemination of Project Results

A dissemination workshop has been organized by IJSG, A&F, CFC and Birla on December 3-4 2008 at Indian Jute Mills Association (IJMA) in Calcutta, India. The oral presentations included

an technical introduction to the project (by IJSG), the processing and technical properties of jute-PP granules (A&F), experiences by industry regarding injection moulding of jute-PP granules (Birla and Total Plastics Solutions), cost aspects and marketing of jute-PP granules (A&F), and market research on jute-PP materials (Market Forces). The key presentations have been distributed to the 26 attendees as hand-outs. Apart from the project partners directly involved in the project, 15 participants attended the workshop; 1 participant was from a panel manufacturing plant, all others were from jute industry/consultancy/research/teaching. The Indian automotive and electronic products industry had been invited but did not attend. A more detailed report of the dissemination workshop has been added in Appendix 2.

A Technical Manual has been prepared and will be disseminated as CFC technical paper.

Targets Set	Results achieved
Component 1: Collection of product requirements and production parameters	
Two suitable production sites selected	Aziz Pipes Ltd. (Bangladesh) and Birla Corporation Ltd. (India) have been selected and collaboration agreements were signed in March 2006 and February 2007, respectively
Commitments to participate in the project established	Both parties have the know how and relations to perform industrial moulding trials so as to evaluate the potential of jute-PP granules, and they have committed themselves to performing such trials as defined in the Appraisal Report. Aziz Pipes has withdrawn from active participation in Autumn 2007 as a result of new management.
Demonstration product to compete with selected	In first instance, in cooperation with Aziz Pipes, cloth hangers, buckets and crates have been identified. During actual trials, different products were selected due to availability of moulds and due to new insights at moulders upon closer acquaintance with the jute-PP material: door trim panel items, household items, cones, step of a lorry.
Suitable materials selected	At project definition, glass-PP was the material to be replaced by Jute-PP. At the project kick-off, it appeared that in Bangladesh no glass-PP is being processed. Therefore, semi-structural PP based products have been selected as target. With the incorporation of Birla in the project team, glass-PP materials have come into scope again.
Data-sheets of currently used materials available	Data-sheets for PP and PE materials have been collected. It appeared extremely difficult to obtain data-sheets of glass-PP. Finally, glass-PP data have been obtained by analysis of the material itself at the PEA. Apparently, moulders are not eager to share their choices, neither of material used, nor of processing parameters used.
Overview of process parameters available	Detailed *processing* specs for cloth hangers, buckets and crates have been collected from Bangladeshi moulders. For glass-PP only processing parameters could be collected at the very end of the project.

Targets Set	Results achieved
Component 2 : Materials research	
Lab scale granules available varying in stiffness, strength and impact properties	Series of compositions produced with varying coupling agents (two best known), impact modifiers (six, both rubber-based and fibre-based) and jute content (four). Details have been provided in the Technical reports.
Lab scale test samples available varying in stiffness, strength and impact properties	All compositions have been injection moulded to test samples successfully under standard conditions.
Overview of properties of test samples with varying stiffness, strength and impact available	Test samples from all compositions have been tested successfully for flexural mechanical behaviour and impact properties. Details have been provided in the Technical reports.
Melt flow properties available	Both capillary rheology behaviour and MFI analysis show that jute fibres decrease the flow properties of PP. (Also see last Target of this Component)
Degradation behaviour during moulding determined	Results show that jute-PP does not block injection moulding equipment during extremely prolonged cycle times. Mechanical properties decrease upon prolonged cycle times.
Insight in effectiveness of processing aids	Best performing granules have been compounded with lubricant as proposed by leading manufacturer (Clariant). Although flow improved to some extent, the mechanical properties decreased tremendously.
Lab scale test samples available, meeting the industry's requirements	Although flow is not as good as of pure PP, industrial injection moulding trials in Germany have shown that products of up to 70 cm length can be moulded without problems. Mechanical performance is competitive with pure PP, except for impact strength, which is not required in all applications though.

Targets Set	Results achieved
Component 3: Process up-scaling; first trials at industrial sites	
Pilot scale amount of granules with pre-optimised properties produced	400 kg of best performing jute reinforced PP granules have been produced.
Pilot scale granules available at industrial site for further processing	400 kg of jute-PP granules have been shipped to Chittagong Port in June 2006 and were cleared by Aziz Pipes in March 2007. An extreme retardation of clearance by the customs was said to be due to dispute on the value of the goods (400 kg is not being regarded as a free sample for research by Bangladesh customs) and due to political disturbances in Bangladesh during part of the period. In May 2007 Aziz Pipes has shipped 40 kg of these granules to Birla in India. The quality of the jute-PP granules at arrival was still very good.
Injection moulding trials performed	Successful moulding trials have been performed at BITAC (Dhaka, Bangladesh) in April 2007, industrial moulding trials at private sector were not successful due to insufficient pre-drying of the granules, due to lack of experience with dryers. At Birla, test samples and a door trim panel have been injection moulded successfully.
Insight in industries capacity and limitations regarding injection moulding	Pre-drying of jute-PP granules appeared to be very critical. Despite having communicated this several times, moulders appeared to keep approaching jute-PP as if it were PP. BITAC in Dhaka is directly aware of the importance and may be involved in future projects. Trials showed that machine (temperature) calibration was not always adequate and this needs to be addressed during further communications.
Insight in required material adjustments in order to meet industry requirements	The processing chain in Bangladesh and India seems to be organized such that the moulders do not perform testing of products. Actually, polymer material is supplied by the customers and ready goods are accepted or rejected by customers; the moulders only provide processing data in case of *high precision* applications. Yet it could be concluded that mechanical strength is good and that effort may be put in further improving impact and flow properties.

Targets Set	Results achieved
Component 4: Compound optimisation	
Lab scale granules available with optimised properties, meeting the industry's final requirements	Series of compositions produced based on jute without batching oils and based on polyolefines with better flow properties. The jute grade free of batching oils has been selected also because of comments from European automotive industry regarding fogging and odour.
Lab scale test samples available with optimised properties, meeting the industry's final requirements	All compositions have been injection moulded to test samples successfully under standard conditions.
Optimised performance quantified	Test samples from all compositions have been tested successfully. Both jute fibre free of batching oils and the use of PP grades with a better flow resulted in both a better strength, impact as well as flow behaviour. The absence of batching oils also improved (= reduced) the fogging behaviour. Details have been provided in the Technical reports.

Targets Set	Results achieved
Component 5: Process up-scaling; final trials at industrial sites	
Pilot scale amount of granules with optimised properties produced	500 kg of jute without batching oil shipped from Aziz Pipes to the PEA. About 400 kg of jute-PP granules have been produced with optimised properties, based on results from Components 2, 3 and 4. Because jute shipment only arrived in September 2007, and because at the time of production, time schedule was very tight, half of the 400 kg is based on remains of jute sliver from earlier batches and half is based on the new batch.
Pilot scale granules available at industrial site for further processing	200 kg of jute-PP granules (based on the new jute fibre batch) has been sent to Birla, from door to door, using Copex Maritime as a shipping agent. Soon during the shipment, we were told by Copex that they was not willing to accept another request for shipment to India, due to problems with Indian customs.
Injection moulding trials performed	Successful moulding trials have been performed by Birla, including several automotive door trim panel items, diverse household goods, a step of a lorry, a cone, pencil covers. Also in Bangladesh a series of trials has been performed, based on the granules from Component 3. The items produced were a cone and a stool, both with good result.
Demonstration products produced that meet industry requirements	Although moulders seem not to have a standardized method for product evaluation, the general conclusion was that jute-PP is a strong material that can be injection moulded well into products. In a fax, Birla has stated that (quote) "with these trials, the technical and process feasibility has been established".

Targets Set	Results achieved
Component 6: Market research	
Interviews with all players within the (foreseen) jute reinforced composite-product's supply chain	Committed counterpart funding from Governments of India was USD 10,000 and from Bangladesh USD 50,000. Funding was only released in January 2008 (India) and late September 2008 (Bangladesh, only USD 9,925), despite serious effort from the PEA, IJSG and CFC. This has forced the project team to modify the time schedule of the market research as well as to downscale the size of the research. After negotiations in October 2008, Market Forces from Calcutta, India, has actually started the market research in Nov 2008 and has delivered a draft report in Febr 2009, and a final report on March 6th 2009. Also A&F has contributed by using part of the visiting time to Bangladesh and India in April 2007 and October 2008 to collect market information, so as to anticipate that no partner for market research may be found at all on so short notice.
Market research concluded in an analytical document	Document prepared. Draft document sent on January 15th 2009. Final document sent together with this report.
Concise paper available on jute-based composite market development strategy	Document prepared and sent together with this report.
Patent published and financially maintained (during the course of the project)	The patent has been granted in Bangladesh with number 1003236. The patent has been granted in India on 12 June 2007 with number 207311.
Acquisition for potential patent licensees (project partners have first right of refusal)	As a result of terminating its activities related to the project, Aziz Pipes is also supposed to terminate its application for a license on the patent. A letter to request for confirmation has been sent to Aziz Pipes. Birla has orally expressed not to be interested in a patent; this will be checked. In case Birla decides not to enter negotiation for a license on the patent, CFC has expressed to prefer dissemination of the technology over keeping it confidential.

Targets Set	Results achieved
Component 7: Dissemination of project results	
Demonstrative workshop and draft technical manual and draft project completion report prepared	A disseminating workshop has been organized by IJSG, A&F, CFC and Birla at Indian Jute Mills Association in Calcutta. A demonstrative injection moulding trial has been organized by Birla at one of their relations. Hand outs of the presentations and an example of an injection moulded item based on jute-PP granules have been prepared for each attendee. A first draft of the Technical Manual has been sent to CFC and IJSG on November 28th 2008, a second draft has been sent on 15 January 2009. A first draft of the Project Completion Report has been sent on 15 January 2009.
Demonstrative workshop held	Workshop + demonstrative injection moulding trial has been held on December 3-4 2008 in Calcutta, India. The workshop included technical presentations from IJSG (introduction to the project), A&F (processing and technical properties of jute-PP granules), Birla (experience with jute-PP during injection moulding trials), A&F (cost aspects and marketing of jute-PP granules), Market Forces (market research on jute-PP materials). Apart from the project partners directly involved, 15 new participants attended the workshop; 1 participant was from an panel manufacturing plant, all others were from jute industry/consultancy/teaching. Indian automotive industry had been invited but did not attend.
Technical manual and project completion report finalized	Technical manual and Project Completion Report have been submitted d.d. 12 May 2009. Comments from participants during the disseminating workshop have been included in the draft Technical Manual.

4 Lessons learned

4.1 Development lessons

Early practical experience by end users

Communication within the project has been performed on the level of E-mails, telephone conferences and visits. It appeared that the critical aspects of jute-PP granule processing, despite repeated oral and written information, became only clear after the several partners had the opportunity to perform actual trials with the jute-PP granules themselves. These first trials were foreseen to take place only after 10 months from project kick off, while the project was foreseen to be completed in 18 months. The importance of 'learning by doing' may need to be considered during project design and initial practical experience by end users, if only lab scale trials, may be planned early in the project.

Long transportation times required for pilot scale amount of material

The transportation of large amounts of jute-PP granules from the Netherlands to India and to Bangladesh appeared to take several months up to nearly one year instead of the foreseen one month, in order to keep transportation costs acceptable. This appeared to be due to issues related to customs handling in India and in Bangladesh; an amount of 400 kg makes the customs officers hesitate about the R&D character of the consignment, while the novel and therefore unfamiliar character of the material causes problems with an accepted value of the goods. Discussions with an experienced sea shipping company, Copex Maritime of Rotterdam, the Netherlands, have learned that it may be impossible to arrange a more quick transportation of such consignments at acceptable cost level. These long transportation times need to be taken into account during project time scheduling.

Availability of counterpart funding

Prior to the kick off of the project, the Governments of India and Bangladesh have committed themselves to contribute financially to the project. During project implementation, both the PEA, the Supervisory body as well as the Funding body have spent huge effort to arrange actual transfer of this counterpart funding. Actually, only part of the committed counterpart funding has been transferred to the project. This issue needs to be addressed and anticipated in future project designs.

4.2 Operational lessons

Focus on several partners

Industrial enterprises often are only interested in co-development of a new material (or process) if they receive rights to the knowledge and/or technology for a specified period, region and/or

application area. This has also been the case for this development project, which has made the project dependent on changing management focus of such a company. The way to minimise this risk is to focus on different application areas or on different countries. Focus within this project on both India and Bangladesh has enabled a successful completion of the project, the partner in Bangladesh exhibited more activities during the start up phase, the partner in India appeared to become more active during the course of the project.

Example of good cooperation

The project implementation has greatly benefited from the active contribution of the Supervisory body to the communication with project partners, the organization of visits by the PEA to the partners and the organization of industrial trials. From the PEA's point of view, this project may be an example of cooperation between PEA and Supervisory body.

5 Conclusions and Recommendations

The key technical conclusion of the project may be taken from a fax by Birla in which they have stated that (quote) "with these trials, the technical and process feasibility has been established". At the dissemination workshop, the project partner from India and its co-operating enterprises have shown many results of successful industrial injection moulding trials, while at the same time addressing the advantages and concerns of jute-PP granules. Estimating cost calculations show that jute-PP granule production may be economically very attractive if relatively cheap (Indian) equipment can be used and if large enough volumes can be marketed, in particular if the granules can be exported to for instance Europe. The production rate needs further attention though.
The attendees to the workshop were mainly from jute industry/consultancy/research/teaching; all technical details will be reported in a Technical Report, to be issued as CFC Technical Paper Nr. 54.
The industrial partner from Bangladesh has withdrawn from the project in the course of 2007, probably as a result of change in management. The partner in India has yet not made an investment decision for setting up a jute-PP granules production facility, but is continuing their evaluation of potential successful products from jute-PP granules.

Recommendations based on the lessons learned are:

- Initial practical experience by end users, if only lab scale trials, may be planned as early in the project as possible.
- The time required for transportation of pilot scale amount of newly developed materials like jute-PP granules at acceptable costs is several months at least and need to be taken into account during project time scheduling.
- Committed counterpart funding has to be transferred to the project's account or the supervisors account, prior to the kick off of the project.
- Focus of a development project on different countries or application areas, represented by 2 or more industrial parties, minimises the risk of project failure in the case that the management of a company changes its policy; as has been shown in this project.

Appendix 1

This appendix presents a summary of the key results obtained in the project 'Jute Reinforced Polyolefines for Industrial Applications: Phase II: Material Optimization and Process Up-Scaling for Commercialization' (CFC/IJSG/19)

Jute-PP granule production and industrial moulding trials

In this project, jute-PP composite granules have been optimized for injection moulding purposes in India and Bangladesh. Jute-PP granules have been produced on pilot scale at Wageningen UR – AFSG and evaluated at several industrial moulders in Calcutta and Dhaka. The industrial injection moulding trials have shown that jute-PP granules can be processed on any conventional injection moulding machine. A range of products has been moulded successfully, both in India and in Bangladesh. There are a few differences with pure PP processing, however. Whereas for small products the same moulds as for PP may be used, larger products may require adjustment of the sprue to account for the somewhat lower flow properties of jute-PP granules. Drying of the jute-PP granules prior to injection moulding is very important for obtaining products with good quality. Also, processing temperature should be kept below 200°C.

Jute-PP composite properties

An advantage of 50 wt.% jute-PP is that the strength is twice and the stiffness is 3 - 4 times that of pure PP. Actually, the stiffness performance of jute-PP is similar to that of glass fibre-PP composite materials, which makes them highly competitive in engineered products; compared to pure PP, less jute-PP material will be required to meet strength and stiffness requirements in products. Further, the jute fibres increase the maximum temperature at which the polymer can be used. Jute-PP composite also exhibits a performance that is competitive with other natural fibre composite granules. Moulded test specimens based on 50 wt.% jute-PP outperform natural fibre polymer sheet materials commercially available in India currently. The basic brown colour of jute-PP granules can be masked by addition of pigments to obtain any colour except bright colours, without loss of strength performance. Jute fibres may also be bleached prior to compounding.

Up-scaling of jute-PP granule production

A bottle-neck in the jute-PP granule production development is the granule production rate that has been confirmed experimentally on pilot scale thus far. The production rate is limited by the feeding rate of jute fibre to the compounding unit and should be increased by a factor 4 - 6 in order to reach the price level of pure PP according to the cost calculations made. Suggestion to solve this problem is to use a more twisted form of sliver and to modify the opening in the extruder where the jute enters. Also, the material exhibits a kind of pulsed flow which should be turned into a constant flow in order to allow adequate granule formation. Suggestion to tackle this problem is to include a single screw extruder melt pump system in between the

compounding and pelletizing sections. An other way for increasing jute-PP granule production rate is establishing collaboration with a company that already produces natural fibre reinforced thermoplastic granules.

Economic evaluation

An economic evaluation of industrial jute-PP granule production, shows that jute-PP granules can be produced at costs very similar to pure PP granule costs, while providing a far better performance. This evaluation is based on recent European equipment prices, and current Indian operation cost data. Next to direct competitiveness in stiffness applications, jute-PP granules are also competitive with glass fibre-PP granules on a strength performance/price ratio basis. With this performance/price ratio level, jute-PP granules offer a competing material for export markets. Following the most recent cost calculations made by an Indian market study consultant, jute-PP granules may even be cheaper than pure PP.

The minimum economically feasible production scale is about 360 MT of jute-PP granules per year based on Indian investment data while starting at a location with existing basic facilities like building, electricity, water, etc. The 360 MT/a is of similar size as the amount required for the production of 100,000 automotive dashboard panels per year of 3.6 kg each. Based on European investment data and starting from Greenfield requires a minimum scale of about 1.44 kton/a.

The initial jute consumption by compounders will be small compared to jute production in India and Bangladesh, thus hardly being dependent on jute supply.

Market development

Potential applications mentioned by industry in India and Bangladesh include: automotive industry, consumer items, storage, construction and housing and interiors. Currently these applications are made from glass fibre reinforced or pure polymers. Natural fibre reinforced polymer granules for injection moulding purposes are a new development and only a few kton per year are being marketed currently. This is only a fraction of the annually produced natural fibre polymer composites (< 1%), the glass fibre reinforced composites (< 0.1%) and the PP produced worldwide (< 0.01%), leaving many opportunities for replacement. Whereas the production and use of natural fibre-PP composite granules is still in its infancy, it may grow very fast. A driver for growth will be the CO_2 emission policy and the cradle-to-cradle philosophy that are gaining interest. For instance, jute-PP may be an alternative to formaldehyde bonded products, being under suspicion of causing health risks, and for solid wood products, being scarce in several countries.

In general, moulders of plastic products in India were unaware of natural fibre-PP composite granules. Considering that jute-PP composite granules have a number of processing and performance characteristics that are different from pure PP, marketing of jute-PP composite granules should address these differences between jute-PP and pure PP, both at moulder level as well as at end consumer level. The market survey revealed that 'natural fibre' was a much more appreciated terminology than 'jute fibres', which was associated with cheap and inferior.

The introductory price of jute-PP could even be lower than of PP, while providing higher strength and stiffness. This price advantage can be used for necessary marketing inputs. In order to obtain this price advantage, however, the throughput per extrusion compounding unit achieved so far needs to be increased.

Appendix 2

This appendix reflects the items discussed during the Dissemination Workshop on the project 'Jute Reinforced Polyolefines for Industrial Applications: Phase II: Material Optimization and Process Up-Scaling for Commercialization' (CFC/IJSG/19), held on 03-04 December 2008 in Kolkata, India

Attendees

The workshop was attended by 26 persons, including the project team. Besides the project partners directly involved in the project, 15 participants attended the workshop; 1 participant was from a panel manufacturing plant, all others were from jute industry, consultancy, research, and teaching. The Indian automotive and electrical products manufacturing industry and the Bangladesh Plastic industry were invited but did not attend.

Presentations

Opening addresses and remarks were made by Mr. Sudripta Roy (Secretary General of IJSG) and Mr. Sietse van der Werff (Senior Project Manager and Representative of CFC).

Presentations on the results of the project were made by Mr. Md. Siddiqur Rahman, Consultant (Operations) of IJSG with an Introduction to the project; Mr. Martien van den Oever (AFSG) on the Production Technology and material properties of jute-PP granules; Dr. Shyamal Goswami (Birla) on Birla's experiences and his views on the use of the jute-PP material; Mr. S. Shome (Market Forces) on market exploration (very first data); Mr. Martien van den Oever on cost aspects and market research and Prof. Alcides Lopes Leão on natural fibre composites in Brazil.

The key presentations were distributed to the attendees as hand-outs.

Demonstration

During the workshop an industrial injection moulder was also visited. A door trim panel item was produced in front of the attendees. There were several technical persons from the moulding company present to address questions.

Discussions

In this section, questions put forward and the answers given are as below:

1. Question: What products can be made?
   Answer: Basically any item.

2. Question: Are lower fibre contents possible?
   Answer: Yes. But products with less content of jute will be economically less attractive. As jute is a cheap fibre, its higher content in the product will reduce the cost of the product.

3. Question: Are there moisture problems?
   Answer: During moulding, yes. Therefore, adequate pre-drying of jute-PP granules is required. Good (small) products have been produced however without pre-drying.

4. Question: Are there moisture problems in the product on the longer term?
   Answer: Not in indoor situation. When constantly in water, jute will degrade and performance is likely to deteriorate. The jute-PP product may become wet without any problems if it is dried soon afterwards, e.g. within 1 day. Dr. Goswami of Birla remarked that a jute-PP door trim produced by Birla has the same performance after 10 years.

5. Question: Do the surfaces of moulds exhibit any problems?
   Answer: Total Plastics Solutions told that for PVC a special mould surface is required, and that this may also be the case for jute-PP. They have no particular experience yet, but do not see this as a serious problem.

6. Question: Mr P. Chatterji of Birla mentioned that there is some 7-8% of rejection during jute processing. He wanted to know whether these short fibres could be used by feeding them with the help of carrier fibres and also the minimal fibre length required for compounding?
   Answer: Short fibres could be used if these fibres could be properly fed into the extruder. Basically fibre length should be over 2 mm only because fibres will be refined during compounding, and reduced to about 1 mm length. It may, however, be difficult to feed such short fibres into the extruder. The feeding into the extruder sets the requirements to the minimum fibre length.

7. Question: Can non-woven be made from jute-PP granules?
   Answer: It may not be possible at this stage. More R&D work would be necessary for this purpose.

Dr. Goswami opined that the flow was not so good as compared to PP. He also said that this issue needs to be addressed as technology is already available and used for other systems.

Dr. Goswami added that the smell may be a problem, specially for the Japanese who are sensitive to odour.

Upon request, the industrial injection moulding company Total Plastics Solutions mentioned that only pre-heating is required and this can be handled. They have encountered no other problems.

Mr. Sudripta Roy asked Birla whether they would like to commercialize their findings. Mr. P. Chatterji mentioned that with the current level of information no investment decision can be made. It depended on economy of scale to adopt this technology.

In his presentation, Prof. Leão stated that the assumptions for the cost calculation by Mr. Martien van den Oever are correct and are comparable to the situation in Brazil and that they have been making an actual profit of 23%.

Further, Prof. Leão told that in Brazil his focus is on replacement of talcum filled PP by natural fibre PP composites.

At end of the workshop, the CFC representative mentioned that:

- This is the end of the project and the start of industrial implementation. It is up to the entrepreneurs to adopt the technology.
- If anyone had any comments to factual issues of the presentations like assumptions, they should communicate within 2 weeks to A&F and IJSG.
- The granule production is the key of the project and that AFSG has to make sure that all information is available in the Technical Manual; for instance topics like jute fibre length and jute quality should be included.
- He hopes that the market study will be available by the end of 2008 because it is a crucial element of the project.

Mr. Sudripta Roy concluded by saying:

- The technology will be adopted and will be economically feasible if investment costs are not very high.
- If cheap/waste fibres could be used the cost would be less.
- Though the costs appeared to be on the higher side at the R&D stage the same is likely to come down if large scale production takes place with the help of cheaper raw material such as waste fibre.
- He requested the entrepreneurs of India and Bangladesh to come forward and adopt the technology and set up units at a pilot scale to make it successful.