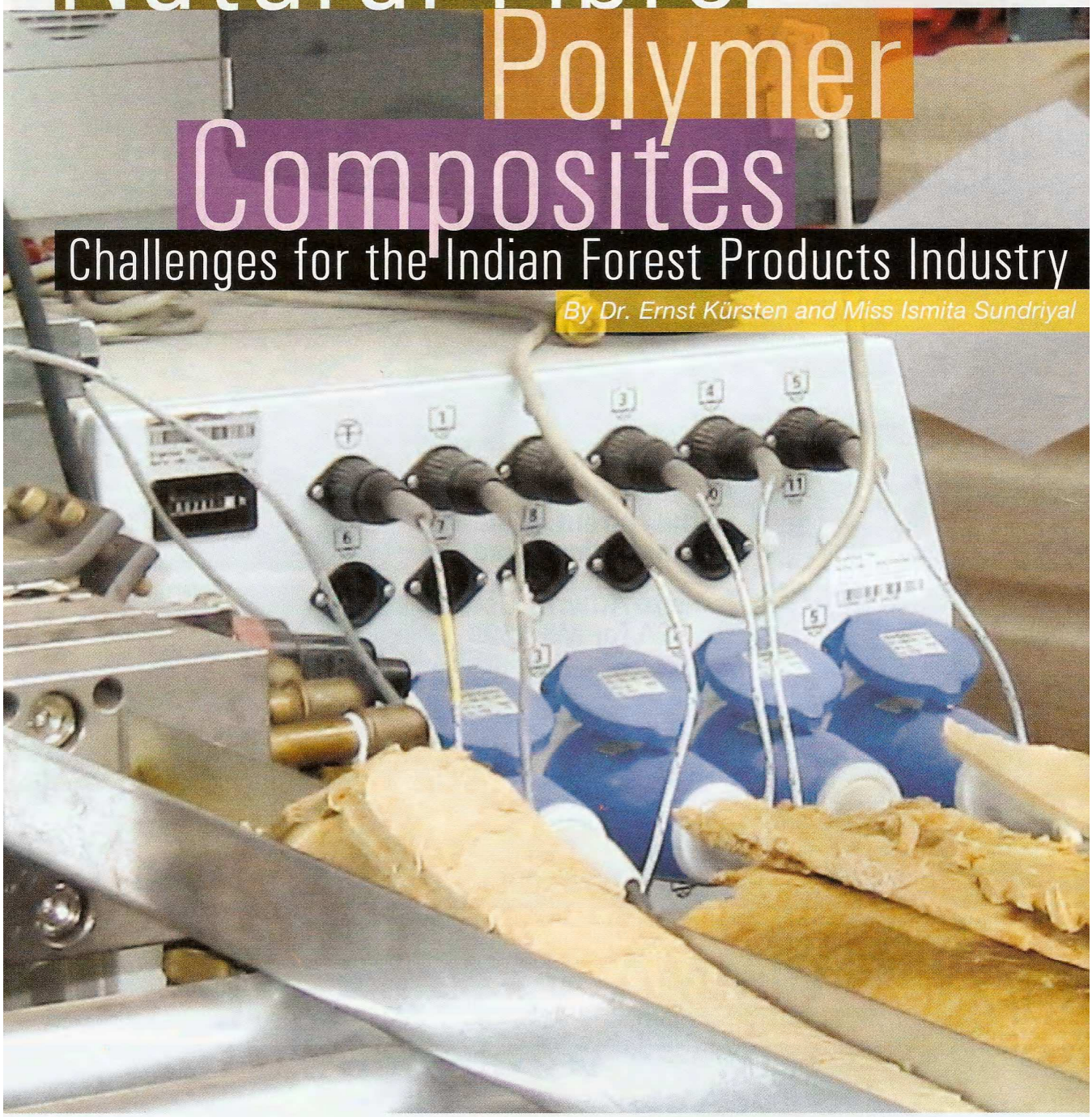
Natural Fibre Polymer Composites

Challenges for the Indian Forest Products Industry

By Dr. Ernst Kürsten and Miss Ismita Sundriyal



While oil prices are rising and the depletion of the crude oil sources is coming closer, in the plastics industry a switch to renewable resources is already ongoing. The partial (up to 70%) replacement of oil-based plastic material by wood particles or agricultural residues is gaining more and more economic importance. Secondly, there is a trend to replace mineral fibres by natural ones in composite materials.

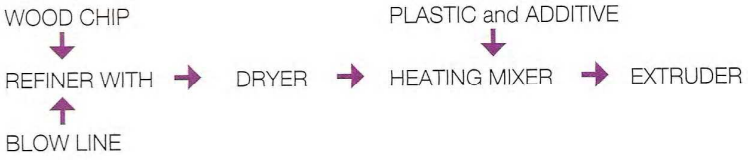
On the one hand, these developments may create new surrogates for wood products but on the other hand they may provide new raw materials and markets for the furniture and other wood-based industries. At least a new market for wood residues can be created. Therefore it makes sense to become aware of the new developments which have meanwhile gained considerable market shares in other parts of the world.

Since nearly 20 years ago, wood plastic composites (WPCs) are being developed and sold. Mainly the plastic industry is dealing with the new material as the production processes are theirs: extrusion and injection moulding. They have the machinery and the experience with it. Applications first captured by WPCs included landscape timbers, picnic tables, playground equipment, benches, fencing and trash receptacles. These uses have relatively low structural requirements and are not regulated by building codes. From the early 1990s on, WPC-decking began to conquer the U. S. market even though it was more expensive than the traditional wooden planks. But lower maintenance costs and growing concerns about the environmental impacts of the usual pressure-treated lumber products were convincing marketing arguments. (On January 1, 2004, there was a voluntary transition from the most widely used chromated copper arsenate (CCA) to arsenic-free preservatives for wood products used in residential areas.) The third market driver facilitating the entry of WPC products into the U.S. marketplace is the general builder's acceptance of new wood composite building material solutions such as oriented strandboard (OSB) panels and laminated veneer lumber (LVL) products. Residential decking and railings consumed nearly two-thirds of the $1 billion (estimated retail) extruded WPC market in the United States in 2005, followed by window and door frames (11%) (Clemons 2002).

Another path to more "nature" in composites is the replacement of inorganic fibres – such as glass or aramid fibres – with natural fibres. Over the past decade, important industries such as the automotive, construction and packaging industries have shown enormous interest in the development of new composite materials (Espert 2003). For these applications mainly boards or mouldings are being produced. The advantages of natural fibres as compared with inorganic fibres are:

- Lower price.
- Lower weight and density, therefore less abrasion of processing tools.
- They are renewable, biodegradable and do not cause health problems.

To prepare wood fibres for WPCs, refiners from the MDF industry can be used (see below). The further processing can be either by injection moulding, extrusion or even in the formation of boards. In the latter case a mixture of fine powdered polypropylene and wood fibers or particles is compacted in a hot press with temperatures about 180 - 200°C. To avoid decompressing, the material has to be cooled under pressure which requires a continuous press with a heating and cooling zone or a single-light press with a combination of heating and cooling technology. This technology is suitable for panel-like WPC products. (Marutzky, Buchholzer and Thole 2005).



All kinds of natural fibre composites consist of two major components:

- A matrix of mainly thermoplastics such as polyethylene, polypropylene, polystyrene and/or polyvinylchloride.
- Flour (typically 400 µm) or fibres mainly from wood; but also bast fibers (flex, hemp, jute, kenaf, ramie, etc), leaf fibers (sisal, pineapple) and fruit fibers (coconut husk or coir). Waste materials such as rice hulls and pulp and paper sludge is offering further possibilities, especially in WPC production.

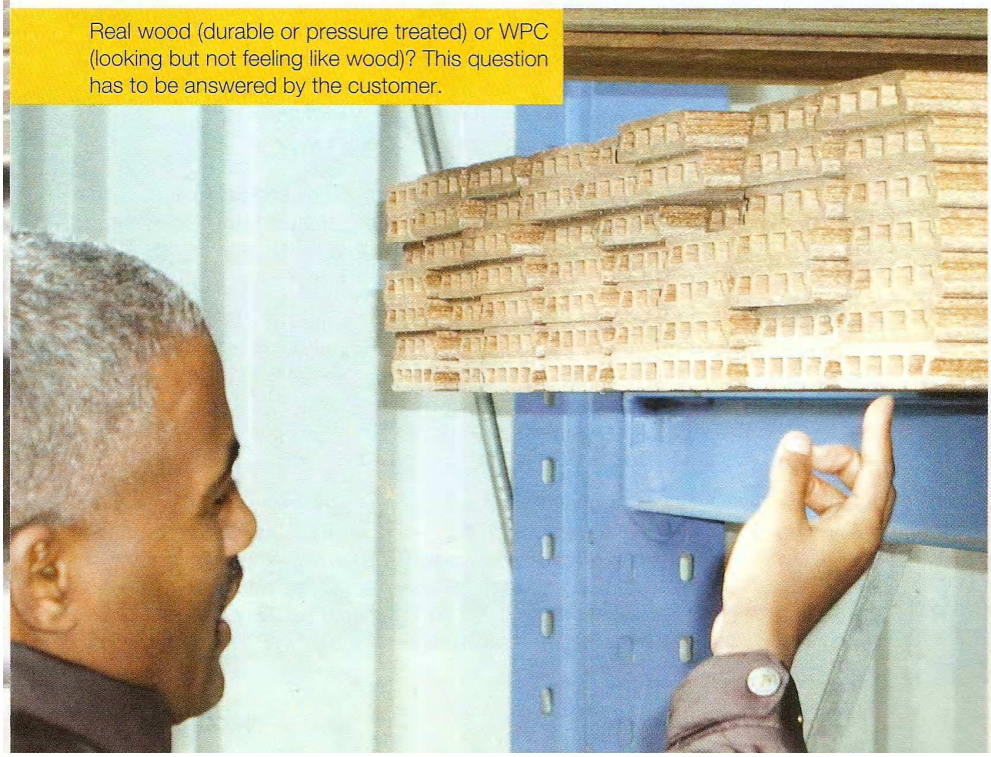
As the plastics are hydrophobic and the natural fibres are hydrophilic some treatment of the fibers is necessary to satisfy adhesion and strength requirements. Many chemicals are being tested for their suitability as coupling agents and to modify the surface of the natural fibres. Different types of coupling agents include maleated polyolefins, silicates, titanates, isocyanates, amides, chlorotriazines and silanes. Finally lubricants are a type of additive that decrease friction during WPC processing.

Saheb and Jog (1999) gave a very good overview on all these aspects of natural fibre composites. At the end they concluded: *Recently, there has been increasing interest in commercialization of natural fibre composites and their use, especially for interior paneling in the automobile industry. These composites with density around 0.9 g/cm³, stiffness around 3,000 MPa, impact strength of 25 kJ/m² and good sound absorption characteristics are being used by a number of leading companies.*

Composites based on polyolefins are now commercially available. It is reported that these composites offer advantages of 20% reduction in processing temperature and 25% reduction in cycle time in addition to a weight reduction of about 30%. The composites provide wood-like appearance without requiring the maintenance. The extruded profiles can be used as a wood substitute in various applications such as window systems and decking.

Weight reduction is a top issue in vehicle and aircraft construction nowadays as energy consumption becomes critical. There is a switch from steel to aluminium and to carbon fiber/polymer matrix composites, the latter being significantly superior in specific strength, modulus and fatigue resistance. As aluminium and carbon fibres are becoming more and more expensive, all potentials of the application of natural fibres in these industries should be explored. Sometimes even special plywood might serve the needs! In any case, there are non-technical challenges to be overcome, which include manufacturers' lack of comfort and familiarity with the manufacturing and safety of the vehicles made from these new materials, capital already invested in steel-forming technologies and recycling (Carpenter et al. 2008).

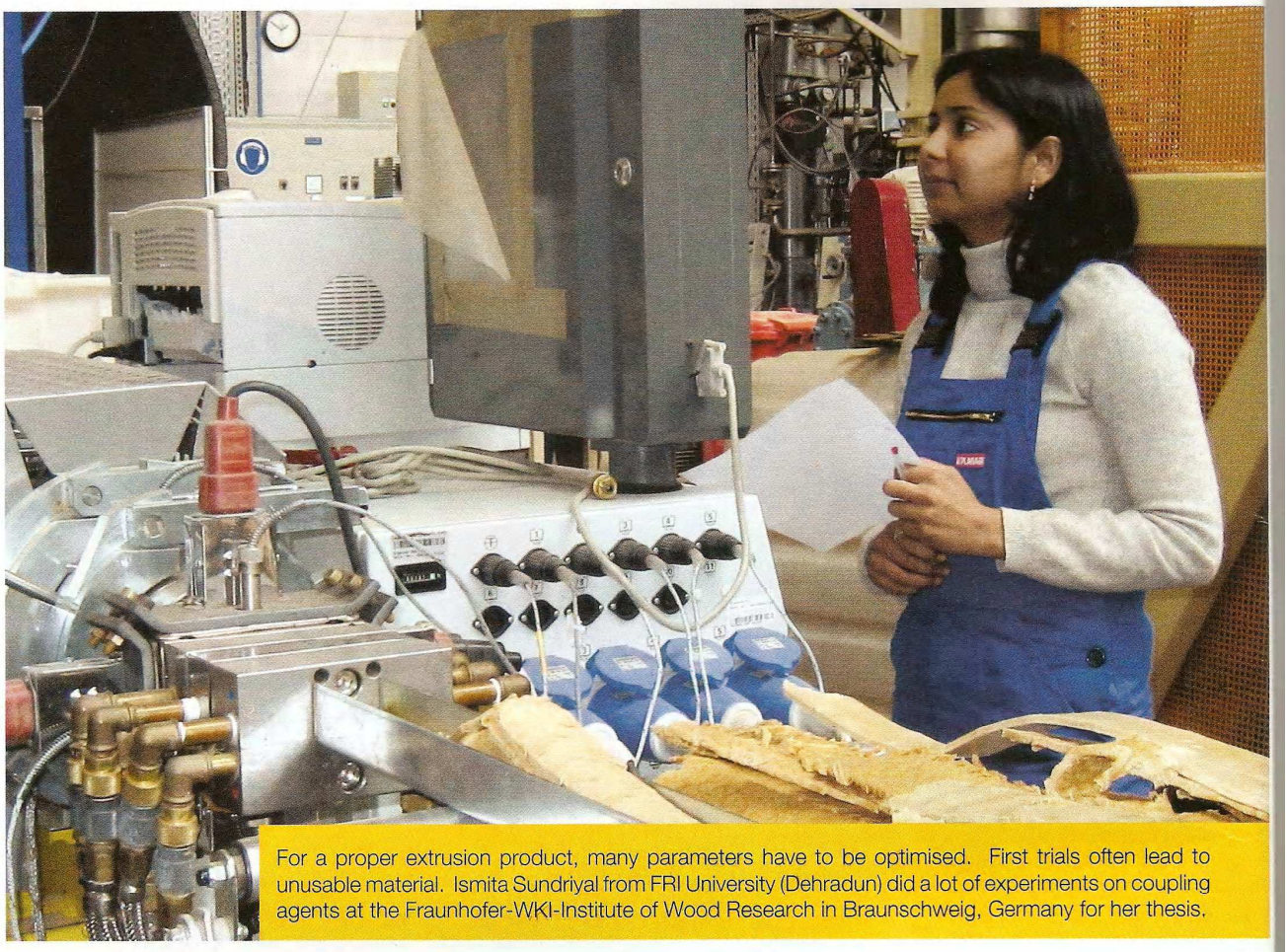
At the Ligna-Fair 2005 in Hannover (Germany) a variety of wood plastic composites (WPC) was shown including armchairs, tables, automotive parts and outdoor flooring. Wood flour is replacing plastics and/or timber.



Real wood (durable or pressure treated) or WPC (looking but not feeling like wood)? This question has to be answered by the customer.

In India, there seem to be promising preconditions and huge potentials for the production and application of natural fibre polymer composites:

- Even though timber is short in supply, residues like sawdust could be used more efficiently for the production of WPC. (In the case of rubber wood its rubber content might be a special advantage!).
- There are plenty of fibre sources in the country for the reinforcement of matrix material. Especially on jute a lot of research has been done already.
- Plastic waste, like plastic bags or bottles – if cleaned and pure – could be used as WPC matrix and by this give an impetus for better recycling in India.



For a proper extrusion product, many parameters have to be optimised. First trials often lead to unusable material. Ismita Sundriyal from FRI University (Dehradun) did a lot of experiments on coupling agents at the Fraunhofer-WKI-Institute of Wood Research in Braunschweig, Germany for her thesis.

- As an alternative to plastic and metal in India, WPC for furniture making might be a good idea. The Swedish furniture company IKEA recently exhibited and marketed a rocking chair from this material.
- Construction and automotive industries in India are flourishing and needing more and more material. WPCs and other natural fibre polymer composites could be used for all the purposes mentioned above.

Many research institutions in India are already involved in the development of products and processes. Now industries have to take the initiative to capture the market. **WN**

References:

Carpenter, J.A., Gibbs, L., Pesaran, A.A., Marlino, L.D. and K. Kelly. 2008. Road Transportation Vehicles. MRS BULLETIN 33:339-344, www.mrs.org/bulletin

Clemons, Craig (2002): Wood-Plastic Composites in the United States – The Interfacing of Two Industries. For. Prod. J. 52(6):10-18.

Espert, A. 2003. Natural Fibres/Polypropylene Composites from Residual and Recycled Materials : Surface Modification of Cellulose Fibres, Properties and Environmental Degradation.

Thesis, Technical University of Stockholm. Download: www.diva-portal.org/diva/getDocument?urn_nbn_se_kth_diva-1667-2__fulltext.pdf

Marutzky R., Buchholzer, T. and V. Thole. 2005. Fibre-based WPC with Enhanced Mechanical Properties - New Manufacturing Processes and First Research Results

Centre Technique du Bois et de l'Ameublement -CTBA-: Proceedings 2nd Wood Fibre Polymer Composites Symposium Applications and Perspectives. Bordeaux, France

Saheb, D.N. and J.P. Jog. 1999. Natural Fibres Polymer Composites. Adv. in Polymer Techn. 18:351–363

Sundriyal, I. 2008. Maleic Anhydride-Grafted Polypropylene as a Coupling Agent for Wood Polymer Composites - Its Effectiveness in Solid and Liquid form. Masters Thesis, FRI University, Dehradun.