PROJECT

VEER: Rice Husk Bio-Composite Chair

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VEER investigates an innovative new biocomposite material examining its formal and manufacturing limitations. The material research informed the design and production of a prototype chair, VEER.

The biocomposite under investigation is comprised of two constituent materials, the first from the fourth material kingdom[1]: plastics. Most plastics in use today are synthetic, meaning they originate from a non-renewable substance. Celebrated for an incredible range of material properties, formal freedom, durability, and low cost, plastics have become ubiquitous over the last century. Omnipresent, the perception around plastic materials has also shifted, now synonymous with 'cheap' or 'disposable'. This condition has led to an overwhelming amount of plastic consumption and disposal—often as single-use plastics—which, if rethought, can emerge as a rich and more sustainable source-material. Thermoplastics, like the PVC used in the biocomposite, can be recycled and reused, diverting additional plastic from landfills while simultaneously offsetting the new production of synthetic plastics. The manufacturer of the biocomposite has in place a workflow for recycling the material.

The second component is the fiber reinforcement added to the recycled PVC. The incorporation of a rapidly renewable agricultural byproduct, rice husks, produces a fiber-reinforced plastic that offers improved mechanical properties over the plastic alone. In addition to the added strength, the integration of the

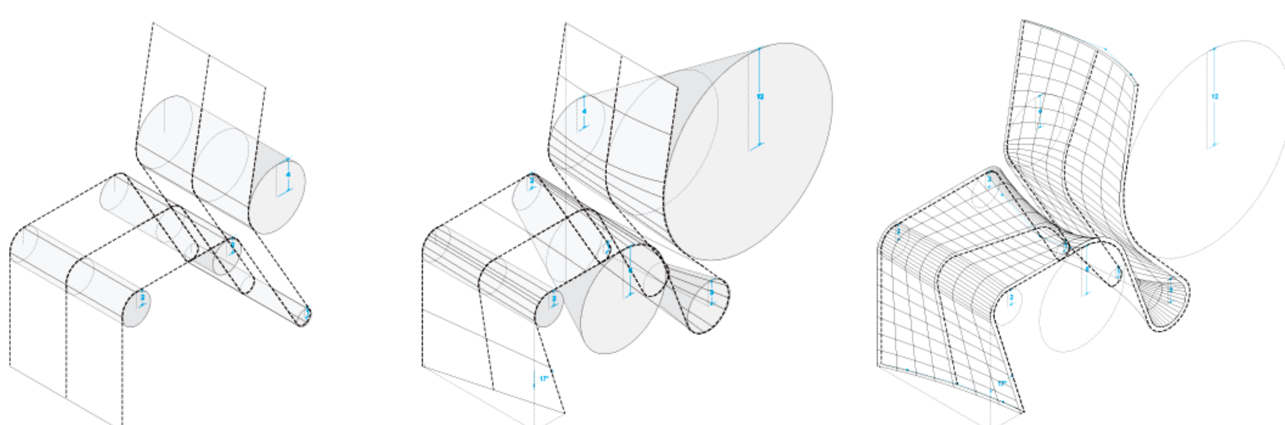

Figure 1. Geometric evolution—single curvature, ruled surface, double curvature . Image by author.

Figure 2. VEER—Side profile. Image by author.

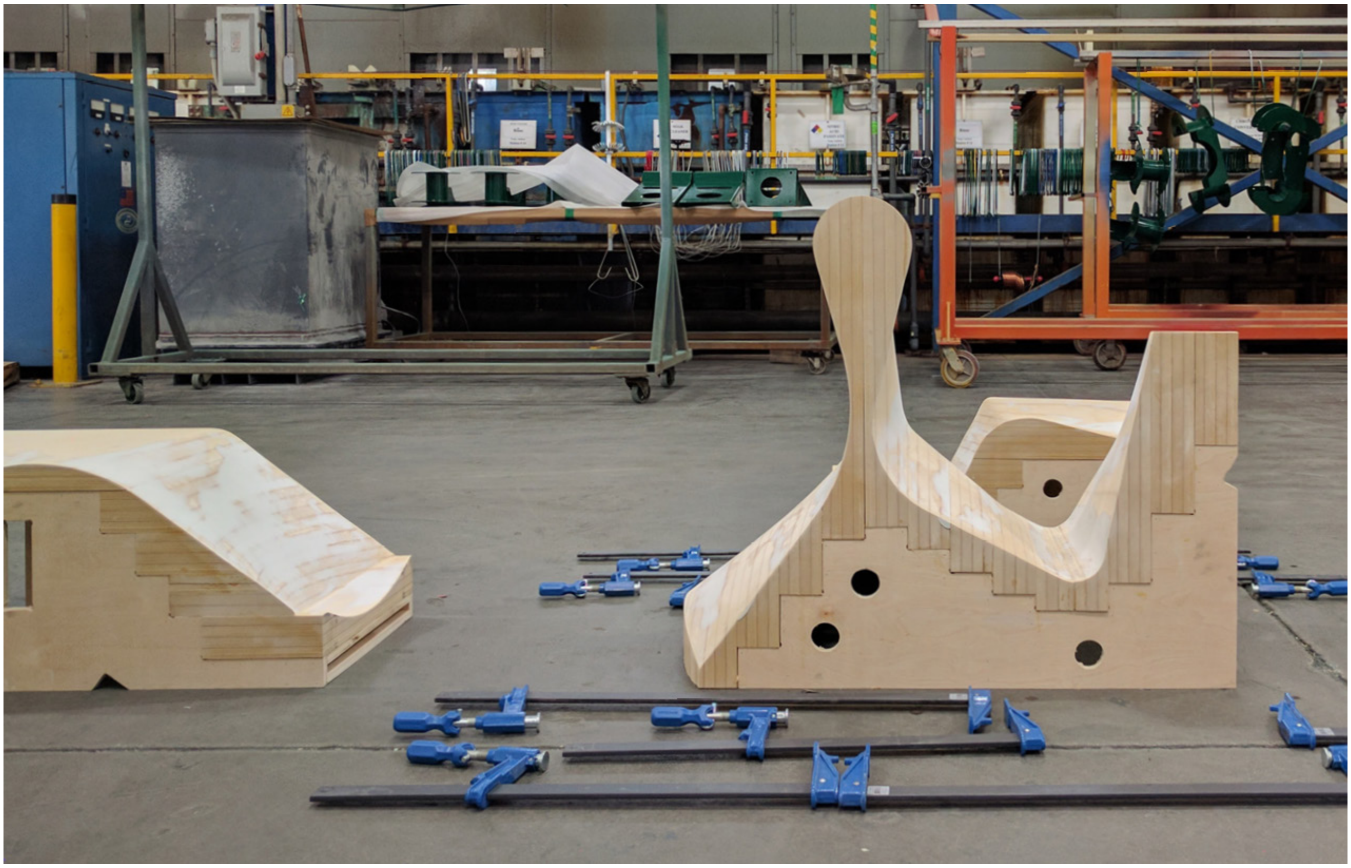

Figure 3. 5-Part MDF Mold. Image by author.

rice husk fibers diverts and repurposes a significant source of pollution in many developing countries. As a byproduct without a commercial value, the rice husks are often burned during the harvesting season, contributing to poor air quality and unsafe conditions, most extreme in New Delhi, India.

This new material, Resysta®, is comprised of approximately 60% agricultural waste and 40% PVC and provides the durability, formability, and strength of a fiber-reinforced plastic with a surface quality more akin to wood. The material, while relatively new, is already being marketed and used within the industry, mostly as a cladding. The fibers suspended in the PVC matrix produce an orientation or grain to an otherwise homogenous material that contributes to both its aesthetic and mechanical properties. The biocomposite exhibits two distinct qualities: those of a synthetic material— in that it can be heated and formed and operates plastically—while simultaneously behaving in many ways like a natural material such as wood in that it has a grain and various limitations in the extent to which it can be formed before breaking or splintering.

Full-scale material tests were undertaken to understand the potential of how this new material behaves and how it could be processed. Taking advantage of the thermoplastic PVC matrix, the primary mode of manufacturing explored was thermoforming. Through the iterative tests, we examined and documented the plastic thermoforming limits of the biocomposite and developed a catalog of geometric and manufacturing constraints that could inform the design process. The full-scale tests included the maximum and minimum radius of curvature, the degrees of double curvature across a single surface, and the relation of material thickness to stiffness.

VEER emerged from the material research and served as a prototype, demonstrating the possibilities of this new biocomposite. The production of a chair allowed us to expand on the material research through both an aesthetic and structural lens. Additionally, the chair allowed us to work with the material at full scale, testing and iterating continuously during the design process.

The material's properties recall both the bent plywood—primarily single curvature—and fiberglass chairs—often double curvature—of mid-century, Panton meets Eames, and so the design takes a cue from both. The concept begins with a single, filleted profile along one edge but replaces a logic of surface fillets with conic sections. The result is added strength, an ability to nest for shipping, a space for storage in the leg, and a subtle, iconic asymmetry. More complex curvature, achievable

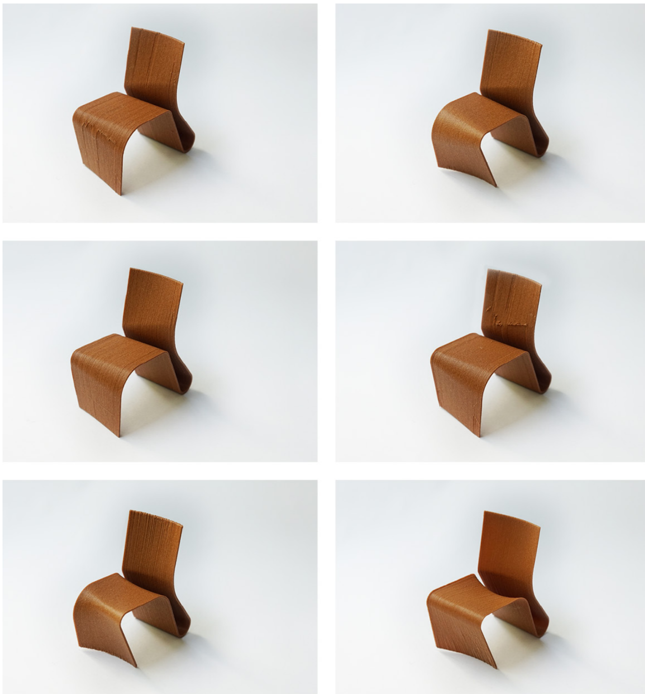

Figure 4. 3D Printed scaler prototypes

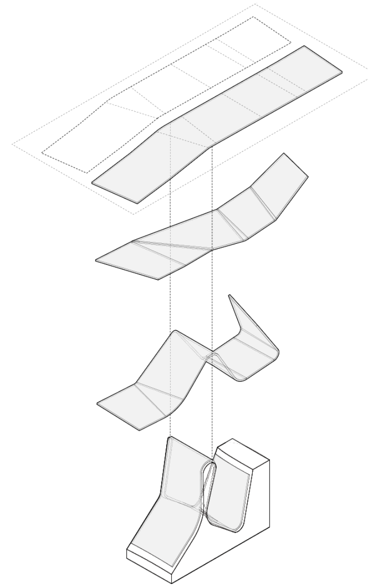

Figure 5. Thermoforming process—flat to formed. Image by author.

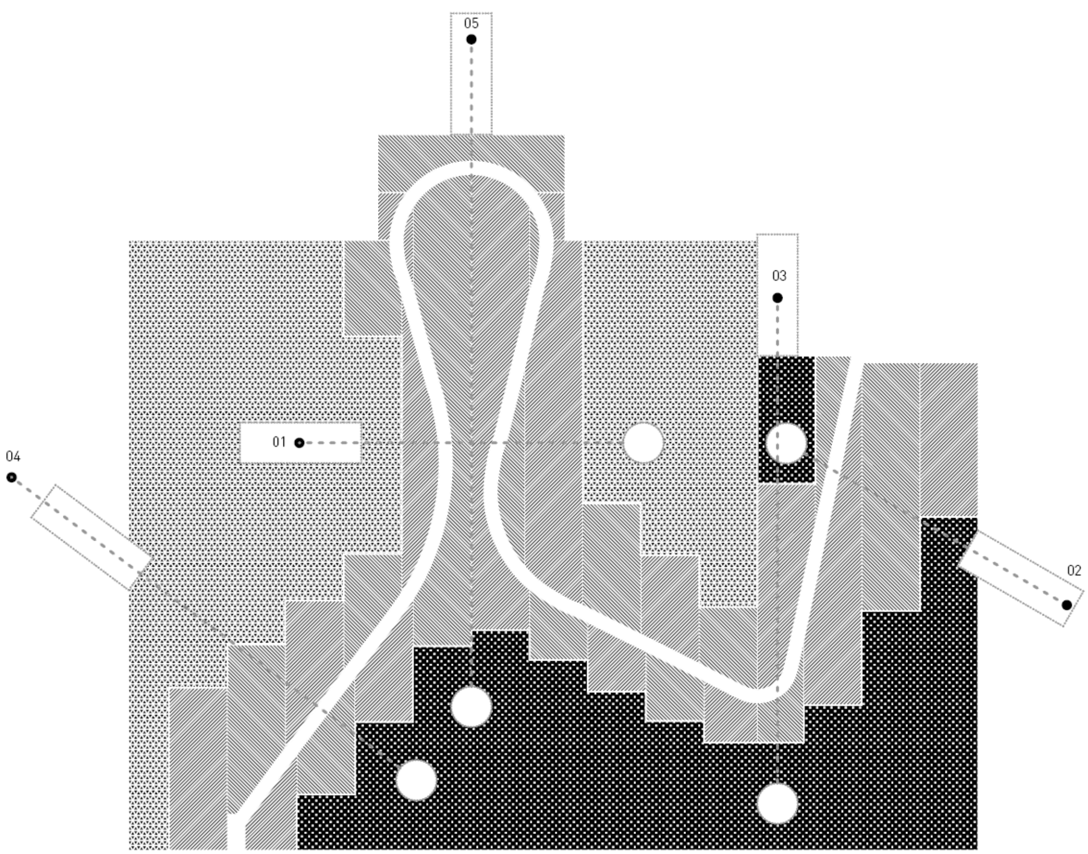

Figure 6. 5-Part MDF mold with clamping positions. Image by author.

Figure 7. VEER—Without scale figure. Image by author.

Figure 8. VEER—With scale figure. Image by author.

given the material's plasticity, is also introduced to provide both added strength and comfort at the feet and chair back.

In addition to the full-scale tests, the design process utilized rapid prototyping of scaled models to asses the basic performance and viability of different geometric variations. From these small heuristic models, general stability, ease of nesting and variation in deflection due to curvature were easily evaluated.

A series of half-scaled prototypes were then undertaken to develop and evaluate the molding and thermoforming process, ultimately resulting in a five-part, double-sided mold to accommodate the repeated inflection of the curved surface. The final mold was CNC milled from MDF and set within a plywood frame (to reduce weight). A series of five strategic clamping locations at either side provided the needed compression to form the material into the mold. Once cooled, the mold limits were traced upon the formed material which was then trimmed and sanded smooth. A second and final iteration of the chair doubled the layers of material—from 8mm to 16mm, chemically welded with PVC cement—for added strength and rigidity.

Future investigations will consider the viability of 3D printing the biocomposite material. Scaler iterations of the chair geometry and surface stiffness were developed and tested using fused filament additive manufacturing methods. As a thermoplastic, the PVC binder allows for the material to be heated and remolded or recycled. This material quality, coupled with a pellet heat extruder end effector, would allow for future research to be printed, reducing material waste and eliminating the high production cost of a more robust mold.

ENDNOTES

1. Jeffrey L. Meikle, "Into the Fourth Kingdom: Representations of Plastic Materials, 1920–1950," *Journal of Design History* 5, no. 3 (1992): 173–82, www.jstor.org/stable/1315836.

Figure 9. VEER—Detail. Image by author.

Figure 10. VEER—Detail. Image by author.