Human Factors Assessment for Manufacturing Process Selection. A Rapid Evaluation Methodology Based on the BICEPS Taxonomy. Application to the Design of a Biocomposite Production Line in Cameroon including 5.0 concepts.

Dehombreux, P.[*,1], Fotsi, J. A.[2], Equeter, L.[1], and Kouteu Nanssou, P. A.[3]

*Corresponding author

1. Machine Design and Production Engineering Lab, Research Institute for the Science and Management of Risks, University of Mons, Belgium, Pierre.DEHOMBREUX@umons.ac.be
2. Ucac-Icam, Cameroon
3. University of Douala, Laboratry of Chemical Engineering and Industrial Bio-Processes, Douala, Cameroon

---

Cite this contribution as: Dehombreux, P., Fotsi, J. A., Equeter, L., & Kouteu Nanssou, P. A. (2026). Human Factors Assessment for Manufacturing Process Selection. A Rapid Evaluation Methodology Based on the BICEPS Taxonomy. Application to the Design of a Biocomposite Production Line in Cameroon including 5.0 concepts.. In L. Equeter (Ed.), *Proceedings of the Collaborative Research and Education for Asset Management 5.0 International Conference* (pp. 20–21). Éditions universitaires de l'UMONS.

In the framework of the ValoFiBan project, which focuses on the sustainable manufacturing of bio-sourced composite products from banana pseudo-stems in Cameroon, designing production lines requires a paradigm shift towards Industry 5.0 principles: human-centricity, sustainability, and resilience.

Traditional design methods often prioritize technical and economic performance, considering human factors only as secondary or late-stage corrections. This proposal outlines a rapid human factors evaluation methodology intended for the early design phase, providing designers with a structured aid to compare manufacturing processes—such as thermoforming, injection, or compounding—without the need for complex computer simulations.

As highlighted by Arkouli et al. [2], integrating HF early in the operations design phase is essential to mitigate discomfort and safety risks that lead to musculoskeletal disorders (MSDs) and production delays. While traditional methods often rely on digital human modeling (DHM) and virtual simulations, they can be resource-intensive and difficult to apply when equipment choices are still being defined. This methodology draws inspiration from the ISO/TR 12295:2014 "Quick Assessment" approach, which identifies activities that are "certainly acceptable" or "certainly critical" early in the concept phase to avoid costly late-stage redesigns.

The central pillar of this methodology is a robust taxonomy derived from the BICEPS framework (well- BeIng, Cognitive, Environmental, Physical ergonomics and Safety). The evaluation ensures a 360-degree view of the operator's interaction with the system across five critical dimensions:

1. Physical ergonomics (P): evaluates task factors such as working posture, gestures, physical forces and pressures, duration, repetition in relation with the workstation factors such as accessibility, adjustability, manoeuvrability. 2. Cognitive ergonomics (C): evaluates task complexity, interface clarity, and mental workload to prevent human errors and ensure intuitive action sequences. 3. Environmental ergonomics (E): addresses thermal comfort, noise and vibration, lighting, and air quality which can be very sensitive for composite manufacturing. 4. Well-being (B): measures job autonomy, workload realism, social interactions, and recognition to ensure psychological resilience. 5. Safety (S): identifies mechanical, electrical, electromagnetic;, thermal, and toxic hazards according to standards. A special attention is paid here for natural fiber-specific risks such as the inhalation of banana fiber dust, skin allergies, and exposure to biological agents like mold release agents. The evaluation process utilizes a standardized 1-to-5 scoring scale, ranging from "Inacceptable" (risk level too high) to "Excellent" (aligned with best practices). When concerning scores are detected, the procedure recommends a more detailed assessment using one of the appropriate standards (EN 12295, RULA, OWAS, . . .).

This scoring is integrated into a global formula to calculate the BICEPS Index (FGH). By applying this taxonomy early, designers can objectify the choice of a manufacturing process, including technological, socio-economical, and environmental factors which are evaluated in complementary studies. For example, it allows for determining if a specific thermoforming setup reduces musculoskeletal risks better than a compounding line in the local context. This proactive approach facilitates a "Design for Ergonomics" strategy, reducing the need for costly late-stage modifications and ensuring that the ValoFiBan production line is both technically efficient and socially sustainable.

References

[1] *Ergonomics — Application Document for International Standards on Manual Handling (ISO 11228-1, ISO 11228-2 and ISO 11228-3) and Evaluation of Static Working Postures (ISO 11226)*, ISO 12295:2014, 2014.

[2] Z. Arkouli, G. Michalos, G. Kokotinis, and S. Makris, “Worker-centered evaluation and redesign of manufacturing tasks for ergonomics improvement using axiomatic design principles,” *CIRP J. Manuf. Sci. Technol.*, vol. 55, pp. 188–209, 2024.