Availability Based Design (ABD) : A Resilient and Time Efficient Approach to Product Design – Improving Designer's Response to Modern Constraints

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Designing new products remains, at large, a complex, highly multifactorial and iterative problem. It often makes a designer's life a real puzzle: achieving at least one design option that is "technically viable", "technically reliable", and cost-effective is a tricky task. In our modern, versatile, and uncertain economies, ensuring that this single design option will be available at the specified "time to market" is a real challenge. Conventional Design Process (CDP), based on the German Standards VDI2221 to 2223, VDI2225-1998 and the works of PAHL & BEITZ, lacks to consider the delivery question: these last tasks are let to other specialty teams ("over the wall approach") with the risk that the designer should start back a part or the whole design process due to unavailability of the design itself or parts of it at the requested "time to market". Such a design issue becomes even more complex when a designer has to deal with multiple designs to compare or an optimization to perform.

To adequately address these novel design issues, a detailed review of the Conventional Design Process (CDP) was conducted: the main iterative loops, bottlenecks, and time-consuming steps were identified. Building on this deep-dive analysis, a new product design approach, named Availability-Based Design (ABD), articulated around 8 main design steps, was proposed: ABD reorganizes CDP in a way that the delivery constraints of design components are integrated at the earliest steps of the design process itself. Furthermore, instead of CDP, ABD enables the designer to easily generate multiple available designs that may be ordered on given Key Design Indicators (KDI). ABD not only avoids unplanned delivery risks along the value chain but also provides additional space for the designer.

For a second time, timeline models were built for CDP and for ABD based on identified time-consuming steps. A theoretical comparison was conducted to demonstrate the benefit of ABD. A simple case study of a ball screw drive actuator (BSD) was used to compare the two processes in practice. Time durations for each time-consuming step, carefully measured from similar industrial case studies, were allocated to both timeline models, and a comparison of their performance was conducted, confirming ABD benefits. Additionally, a probabilistic layer of the availability of the design's components was added to both models. The goal here was to understand the impact of the availability ratio of the design's components on the design times of both design processes, CDP and ABD. 3 design modes, identified in industrial practice (Manual design, Semi-automated design using low-tech tools, and automated design linked to ERP systems), were considered across a full range of availability ratios, varying from $0\,\%$ (Shortage) to $100\,\%$ (Full availability). Again, the results revealed that ABD improved CDP's design times by more than a factor of 3!

To further show the robustness of ABD, different sensitivity analysis were performed on different drivers: in practice, design times are especially influenced by the number of components a design is composed of but also the number of technical checks (TC, local level of the component) and the number of Key design Indicators (KDI, global level of the whole design) needed to rationally confirm any successful design. Models were tested within a range of full availability of components (Availability ratio Delta = 100 %) to full shortages of components (Availability ratio Delta = 10 %) for simple designs (7 components) to complex ones (100 components) but also for designs requiring only a few technical verifications (7 TC and 3 KDI) to ones needing large number of technical verifications (50 TC and 15 KDI). Variations in the availability ratio per component were also simulated (e.g., a shortage on all components, a shortage on 1 component with all other components available, and a normal distribution of the shortage across the design components). Results of these robustness analyses showed that running the ABD process is always quicker than CDP, except in manual design mode in cases close to full availability (the ideal situation of the VDI2221 to 2223, which is nowadays never the case). In semi-automated design and automated design, ABD systematically exhibits far stronger performances than CDP. These results are also confirmed under full availability in automated design mode, where ABD provides multiple design options more quickly than CDP. These multiple design options allow for discussion between the designer and the project manager, e.g., to optimize the design selection. If not, as ABD brings back useful time, the designer can use it to improve the overall efficiency of the design process, to focus on specific improvements, to deeper understand the present and/or future needs of the customer, to perform a double check of critical pain points, to follow some technological watch that could further be useful to the user, to make a fine tuning of the proposed solution, to increase the quality of the technical documentation, . . . , or even, to improve the communication quality with the customer. Instead of the bottleneck situation generated by the conventional design process CDP, ABD brings back more air to decide what is efficient to make.

The present article aims to demonstrate the benefits of ABD for modern designers in today’s highly versatile, competitive, and time-stressed environments.