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Isn't It Great When We Iterate: Rapid Innovation for Additive Manufacturing

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Learning Objectives

- Learn how to use Fusion Lifecycle to facilitate innovative, divergent thinking toward achieving a product goal.
- Discover how to use the Rapid Innovation Cycles in Fusion Lifecycle for additive product development.
- Learn how to use design for additive manufacturing cards to help identify opportunity and the related manufacturing solution space.
- Learn how to consider design enablers and inhibitors for additive product development.

Description

Learn how to kickstart your design for additive manufacturing (DfAM) process by using Fusion Lifecycle software for rapid innovation and concurrent design. Conventional design methodologies tend to be linear with siloed functional groups relegated to their respective touchpoints in the design development lifecycle. The complexities and nuances of DfAM require a modern and flexible approach that facilitates additive manufacturing's unique design space and value proposition. With an emphasis on exploring divergent and creative thinking, we will examine how Fusion Lifecycle can manage innovative design development for DfAM and become the foundation of a digital product thread.

Introduction

Additive manufacturing presents a unique value proposition. Its multitude of applications and processes lend significant advantage in many cases when compared to conventional design and manufacturing techniques but also present challenges and limitations. To fully maximize our advantage with AM we must thoroughly explore the AM design space. Conventional manufacturing design typically has a heavy reliance on prior knowledge and expertise can become a hinderance to generating novel AM solutions. As stated by Professor John Hart from MIT in his course **Additive Manufacturing for Innovative Design and Production**, “While past knowledge and expertise has often been the value we add in our work, it may ... become one of the biggest inhibitors to generating new AM innovations.”

AM design can benefit from a new approach that prioritizes feedback from team members, stakeholders, and customers while promoting creative and divergent thinking during the design development. A new, structured approach to Design for Additive Manufacturing (DfAM) is needed, one that seeks to maximize creativity early in the design process and align it with the development of a concrete product solution.

Rapid Innovation for Additive Manufacturing

Inspired by the **MIT DfAM Innovation Process** the image below illustrates the process enacted by the Fusion Lifecycle DfAM Application. This approach is used to coordinate various team members and activities into a cohesive, collaborative unit of work that explores the AM design and solution space.

Product Definition

The first step in the process is to clearly define the intended purpose and/or utility of the product to be created. In this step to use case and value to the user is fully considered with little to no thought given to the AM processes to be used. This is purely a statement of need and identification of the value drivers to be attained. This may be a bit unusual and strange to do for many who employ this process for the first time but with practice will become more natural and fluid.

DfAM Cards

Next, we consider the Creative Dimensions (otherwise known as DfAM “Cards”). These are meant to provide guide to the AM process and not necessarily specifications. The team will carefully consider each dimension and select the “card” that best describes the desired outcome. In the FLC DfAM app you can reconfigure the cards (i.e. add/remove picklists and categories) to suit your needs. Next, we consider the Additive Manufacturing Dimensions which are manufacturing specifications that fulfill the end product’s use case. While these are not required, they are present as it will be very helpful in driving the selection of the specific AM process(s) to be used. Again, these fields can be reconfigured to suit your specific needs.

The Creative Dimension (DfAM Cards) can be used in the following way.

1. Characterize an existing product - fully defining or characterizing an existing product in the context of these categories helps solidify learner understanding of why and how AM was used in a current application.

2. Generate a design space around a goal - based on a produce definition, the DfAM cards can be utilized to brainstorm useful design spaces (an array of cards) and help unstick stalled thinking.
3. Generate new opportunities - a series of DfAM cards can be randomly chosen, to inspire generation of new opportunities to use AM.
4. Identify patterns - cards can be screened against the most critical value propositions for particular industries and applications.

Source, MIT, Additive Manufacturing for Innovative Design and Production

At this stage the item can be transitioned using “Innovate” transition. If an Innovation Manager is not named in the points of contact a validation error will be thrown.

Concept Whiteboard

The next step in the process generates as many creative, divergent concepts as possible that seemingly fulfil the customer/product needs. These concepts are guided by (but not constrained by) the Creative Dimensions with consideration given towards the AM Dimensions needs. The Concepts Whiteboard tab is intended to record the ideas and track their development. The ideas do not need to be complementary towards each other and in fact can be contradictory. As they are developed and considered they can be refined as “stand alone” ideas. These then can be evaluated in totality with the other concepts.

When ready the named Innovation Manager will have the ability to transition thru the “Explore Concepts” transition. When this happens any concepts that are marked in the “Explore” column will be used to spawn a new Rapid Innovation Cycle. The concepts will be concatenated and become the Design Concept for the RIC which will now be added the relationships tab which is named “RIC”.

This process is repeated for as many RICs as needed.

Rapid Innovation Cycles

The Rapid Innovation Cycle (RIC) tracks and manages the evolution of the chosen creative concepts and their development for specific AM processes. Within the chosen manufacturing process specific design enablers and inhibitors are considered for their relationship towards the producing the desired AM part.

When the RIC is spawned the named Innovation Manager from the parent Agile Product Development item will automatically be assigned as the RIC Manager. This can be changes as needed.

Concept Definition

First, the RIC starts with a review and refinement of the desired use case while in the Concept Definition state. The RIC manager is responsible for this activity which is generally done with the design team. When ready the item is transitioned thru the “Solve” transition and the named Solution Manager will be responsible. If a Solution Manager is not named a validation error will be thrown.

Solution Development

In this state one or more specific AM processes are selected for their ability to uniquely satisfy the product needs. When considering a particular manufacturing process, we should also consider its design enablers and inhibitors that are unique to the machine. It is at this state that a process specific CAD model can be developed. We should consider the chosen process and allow it to influence the choice of AM specific design features.

When adding a row to the DfAM Solutions the “Status” column defaults to Under Consideration. This column is used to track the status of the DfAM row. If a DfAM Solution row is no longer desired, it is recommended to set its status to Discarded and not to delete it. This way we have a record of its existence and can write a note for our reasoning when discarding it.

When choosing a status consider the following:

- Under Consideration – used to identify a potential solution undergoing active exploration.
- Reference – only used to denote a row that is not being considered as a solution. This allows row to retain useful information but is not considered as a solution i.e. a model used for a generative design study.
- Discarded – for rows that are no longer under consideration.
- Selected – indicates that the stakeholder has chosen this solution. Only one row should have the status of “Selected”. Validation script will ensure this before the item transitions to the “Selected” state.
- Stakeholder Rejected – only used in the “Stakeholder Review” state. This has the same meaning as Discarded but shows that the decision is from the stakeholder.
- Viable – only used in the “Analyzing” state once the DfAM Analysis item completes and the results indicate that the solution is potentially viable.

Additionally, we may generate an DfAM Analysis item for chosen solution(s). We do this by tagging the selected row in the “Additional Actions” column and running the on-demand script [Create DfAM Analysis RIC](#). We can populate the DfAM Analysis item with details about the CAD model that we want to communicate with the team. By capturing this in the DfAM Analysis we are retaining the thought process that can be reviewed throughout the lifetime of the product.

Analyzing

When ready the RIC is sent to the analysis state where it is digitally examined for design efficacy along multiple process parameters – perhaps even a prototype part is printed if needed. The named Lead Analyst is responsible for the item and the conduct of the analysis, but it is expected that a team will participate. If the rows of the DfAM Solutions tab do not have a DfAM Analysis item one will be automatically generated. While the sections and fields in the DfAM Analysis workspace are purposely general in nature you can refine and modify these to meet your company’s specific methodology. The goal here is to invest the minimum effort needed to sufficiently inform the stakeholder.

The DfAM Analysis workspace can be modified to match your particular process and needs.

NOTE: DfAM Analysis items associated to a particular DfAM Solution are “closed” in that they cannot be deleted, removed, or associated to a different item except by an administrator.

Stakeholder Review

Once the AM design passes digital analysis it is ready for stakeholder review and the named RIC Manager is responsible for the item once again. It is at this state that the stakeholder can review the results and choose the solution that meets the user/customer needs or start the process anew. The RIC Manager will tag the row with a Selected status and record any notes. If none of the solutions meet the stakeholders needs the RIC can be sent to the Concept Definition state for further refinement or it can be discarded in its entirety and the next RIC can be examined or generated.

At all states along the way feedback is essential when returning to the previous state. It is from this rapid, state changes that the concept and processes are refined to zero in on attaining the desired outcome(s).

Splitting DfAM Solutions

A scenario may arise where 1 or more DfAM Solutions are viable but 1 or more solutions need additional work. Since the purpose of this workflow is to arrive at the selected solution as quickly as possible, we may consider splitting the DfAM solution into its own RIC. This technique allows us to proceed to Stakeholder Review while continuing to develop other less promising solutions. We do this so the stakeholder can review the viable solutions (and maybe select one) knowing that perhaps the newly split RIC could ultimately become the selected solution but just needs a bit more refinement.

The RICs in the FLC AM App are designed to be a 1:m (one-to-many) relationship with the Agile Product Development item. Each APD item can have one or more RICs each exploring a different approach to achieving the desired product outcome. The RICs can be processes either sequential (one after another) or in parallel or both.

All these techniques combined allow the application to provide great flexibility for managing the DfAM process development.

Completing the Process

Once the stakeholder selects a particular AM solution all other active RICs are transitioned to the Discarded state as work on those items can stop. The selected RIC and its processes are presented in the APD item for easy access by downstream internal consumer processes. Additionally, the APD item is automatically transitioned to the Process Validation state so that an actual part can be made using the solution, specified machinery, and processes.

Process Validation

In the Process Validation step more detailed study is performed and a part is produced. The Process Validation state in the app is deliberately simple. The actual validation process at each company will vary depending on specific needs. Additionally, the actual process used to validate the production method is likely to be very complex and beyond the scope of a general-purpose app. This complexity, of course, can be modeled as an FLC process but it is left to the individual companies to decide to further develop FLC for validation. If you find that you need more detail the workflow and behaviors can be modified to suit the needs. The simplified state used here should suffice as a proxy for more complex methodologies.

In Production

Once the AM part is validated for the production process and all other tasks for inducting the part into the production schedule, ERP, BOM etc. the APD item is transitioned to the In Production state.

Process Validation Failure

Of course, sometimes process validation fails. In that case the APD item is transitioned back to the Innovation Cycles state and the RIC process continues. The previously selected RIC is moved back to Stakeholder Review and ready pick up where it left off. The other RICs which were automatically moved to the Discarded state are now eligible to transition thru the “Resurrect” workflow and into the Concept Definition state and can continue their development process.