2022-36-0068

SCRUM applied to foundry simulation projects

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Abstract

Process simulation has a growing role in the casting industry, considered as an essential tool by most foundries that aim to develop systems that deliver quality parts, with the highest possible yield and lowest scrap rate. The challenges of performing casting simulation as part of tool construction projects for permanent molds are presented here. Real schedules from tooling companies are analyzed and their bottlenecks are explored. Using the concepts of agile project management and the Scrum framework applied to a cast part, it was possible to verify that integration between tool construction and simulation can increase quality and robustness with no impact to product development time.

Introduction

Casting process simulation is now a widely-accepted tool in the foundry industry, especially when it comes to automotive parts which have higher quality, mechanical and microstructural requirements.

Since the first software capable of predicting the behavior of this complex process (with the first MAGMASOFT® release in 1988) a number of companies have integrated it in their production cycle.

Historically speaking, the casting process has relied on highly trained experts for the determination of how best to fill their molds (either sand or permanent) in terms of gating, riser, cooling lines or chill definitions. A simplified diagram showing the steps for cast parts production can be seen in Figure 1, below.

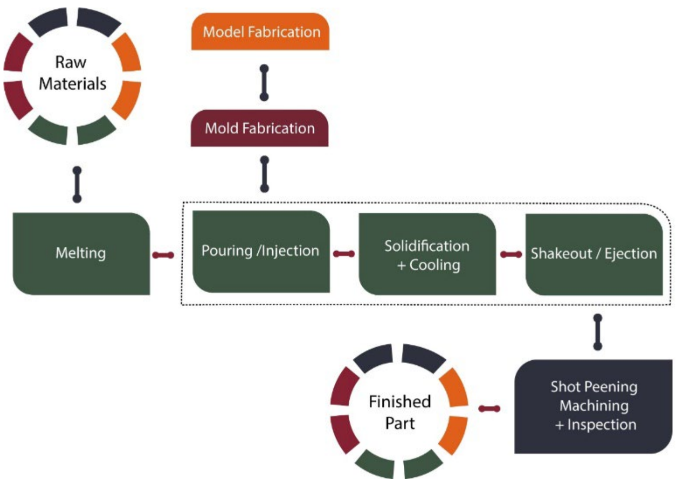

Figure 1. Workflow depicting the steps necessary to produce a cast part. Adapted from [1].

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After the incorporation of simulation, however, there was a significant change in how the overall process should be treated. The possibility of conducting several experiments at low cost, enabled the casting companies to try out multiple changes to their models and processes before production of the actual part. This new way of developing casting systems (illustrated in Figure 2) has allowed for various paradigm shifts in how casting defects are studied, analyzed and prevented.

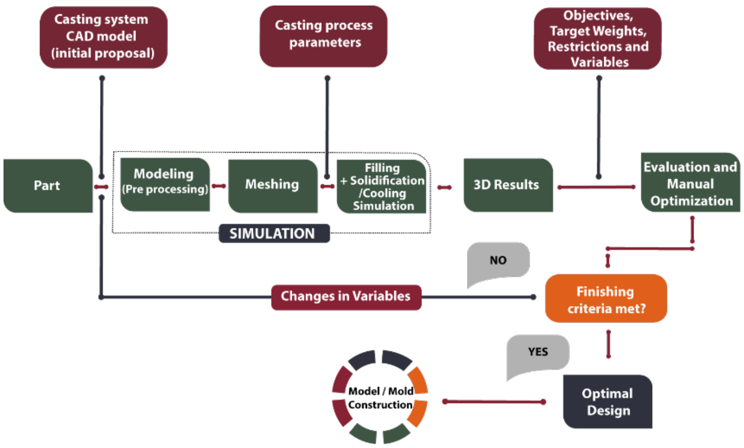

Figure 2. Workflow depicting the steps necessary to produce a cast part after the introduction of simulation – virtual try-outs. Adapted from [1].

In this workflow, the simulations are performed by experienced technicians and their results, therefore, reflect the technicians' metal-casting experience, considerations and know-how. Each individual simulation is comparable to a virtual experiment and, based on its results, these engineers evaluate, for instance, whether a chosen rigging system or process parameter configuration leads to acceptable casting quality at acceptable costs, ultimately proposing changes to find improved solutions [2].

As the casting consumers evolve, in particular the automotive industry, so do their requirements for cast parts [3]. In order to achieve higher mechanical properties in lighter parts with smaller lead times, the task of manually optimizing the cast parts using virtual trial and error also needs to evolve.

Simulation users and their task

To incorporate simulation in their production process, every company will need three main components: hardware, software, and 'human-ware' [4]. In this section we will focus on the third one.

To operate a casting simulation software the user will need:

1. Basic knowledge in CAD modeling, or to work in a company that has other options for modeling geometries;
2. To be fully trained in the software they will operate;
3. To have some level of expertise in the casting process that will be studied so that they can evaluate simulation results, compare them with the trials, and then propose changes that may solve the defects observed in simulation;
4. Time.

The first 3 are not particularly difficult to manage, especially for modern foundries. The fourth one, however, will usually present a challenge.

Even though there are various ways that casting simulation may be used towards different goals [1] to [6], there are certain concerns that every casting simulation user has (to a higher or lower degree) whenever they receive a new part to develop a casting system for.

Development time

Every new project comes with a deadline, sometimes even before the specifications and criteria have been laid out. This timeframe usually relates to a larger project schedule (other parts, assembly, final product release, etc.) rather than the complexity of the part and the number of virtual trials necessary to get a defect-free part under the desired costs.

Few colleagues to discuss results with

Most casting simulation projects are a one-person job, namely the user, who usually does not have many people to discuss the observed results with. Even when this person works in a project or engineering department, it is normally only the user that has simulation result analysis know-how.

Pressure

No matter how big the challenge presented by the project is, the user, as keeper of the simulation tool, is understood to have all that is necessary to solve the problem, even though some problems can only be solved by a radical change on the project's boundary conditions.

Where to start

Even though the user usually has (or develops over time) experience in how to work with cast part simulation projects, the constant changes required to develop parts which are up to date with evolving requirements, create a new challenge every day, to the point that it is no small task do determine where best to begin the analysis or even what potential problems to first optimize for.

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What to do when the tests do not yield the expected results

In the metal-casting process, everything happens at the same time and is closely coupled. Changing one process parameter, due to its interaction with other parameters, can have a multitude of impacts on the rest of the process and can influence the final casting quality in many different ways [2].

There is no recipe for solving all cast defects in every part. The know-how (both technical and scientific) allows the experts to devise action plans that can be applied to a given situation, but there is no guarantee that these actions will achieve the desired goals. Everyone who has worked with process simulation to perform virtual try-outs knows that sometimes the tests do not fix the problems as intended, or even create new ones, especially when there are multiple problems in one project and the tests to correct them are performed without organization or structure.

Figure 3 (below) exemplifies the aforementioned behavior. The part is produced by Gravity Die Casting (GDC) and presents several tendencies for shrinkage porosities (blue, yellow, red and white spots in the simulation result). With the objective of reducing/eliminating such tendencies, the simulation user ran 16 tests, after the base simulation. The overall shrinkage value for each test is represented by one of the dots in the graph.

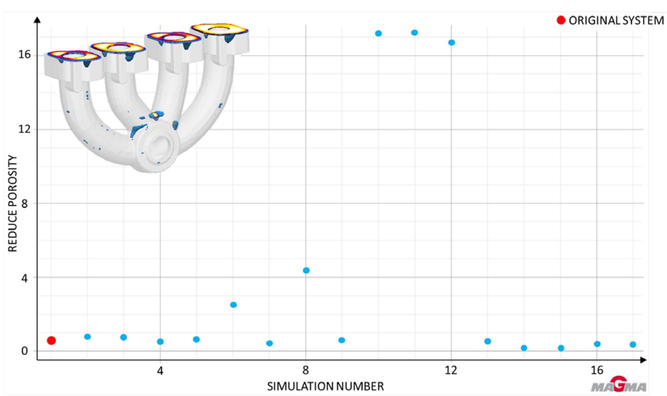

Figure 3. Graph extracted from the evaluation perspective of MAGMASOFT® for a given GDC project (the part's image is only illustrative). Each dot represents a simulation in terms of the porosity result (Y-Axis) and the number of the simulation test (X-Axis).

It is possible to visualize that the level of porosities did not diminish since the base simulation until the 14th test. Considering that each simulation took approximately 4 hours, the user invested almost 70 hours of computational time alone without getting closer to their objective. Even though it was possible to fix the problem in the end, the evaluation of this graph (and many others such as this) raises the question of whether or not there is a better way to conduct casting projects aided by simulation.

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Project Management in casting projects

Today's requirements on the development of a cast part and the corresponding metal casting process demand methodologies and tools which allow for a maximization of process robustness and profitability at the earliest possible timeframe [2]. However, there is little written about project management in casting projects, with or without simulation.

Project management techniques have been proposed by simulation software providers [7] to assist users on how best to use their simulation power. However, as previously stated, the simulation project of the casting process is always a small part of a much larger development, which means that better managing the simulation project of the cast part is not enough to ensure the target timeframe for part production.

Little has been written on project management methods and technics applied from the start of development that integrates casting simulation studies with mold construction.

A possible first attempt would be to use the conventional (or linear) project management as proposed by the Project Management Institute (PMI) to organize the simulation studies required to attain a sane part within the desired timeframe. In other words, to create a Work Breakdown Structure (WBS) that will allow the user to decompose the project into smaller and more manageable pieces [5]. A proposed WBS for HPDC (High Pressure Die Casting) and GDC simulation projects can be observed in Figure 4.

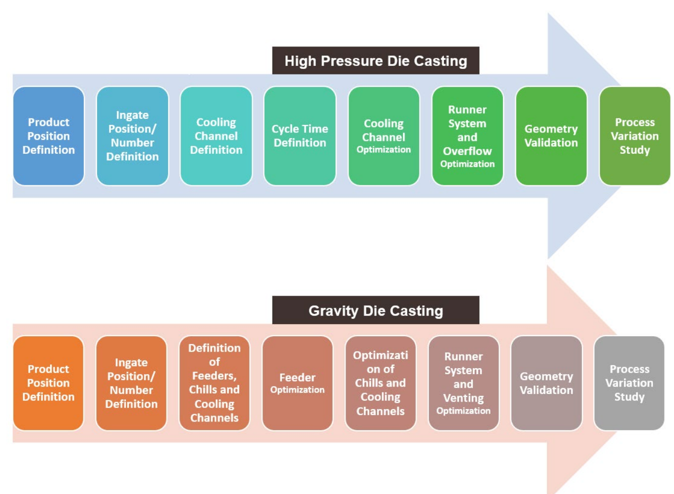

Figure 4. WBS to optimize HPDC and GDC systems in the simulation stage. Own authorship.

The purpose behind such breakdown structures is to run faster simulation studies that provide, each time, the most adequate answer in terms of the desired quality, productivity and costs, at smaller time

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intervals. A short description of each stage, and their goals can be reviewed in Table 1:

Table 1 Short description of simulation study stages, the necessary geometries and their respective goals.

	Necessary geometries	Decisions based on quality criteria?	Goal
1- Cast Part position definition (HPDC and GDC)	Part	YES	To cast the part by its different sides and evaluate according to the criteria.
2- Ingate definition (HPDC and GDC)	Part	YES	To define and test ingate (number and positioning) according to the criteria.
3- Cooling channel definition (HPDC and GDC)	Part	YES	To evaluate the thermal state of the system and determine if the cooling system is adequate.
3- Chill and Feeder definitions (GDC)	Part	YES	To define and test a 1st layout for chills and/or feeders and understand their potential to help meet the part's quality criteria.
4- Cycle time definition (HPDC)	Partial mold 3D project (cavity and insert) and initial cooling channel definition	YES	To define the real cycle time based on production condition simulations, criteria and the thermal profiles.
4- Feeder Optimization (GDC)	Partial mold 3D project (cavity and insert) and initial feeder, chill and cooling channel definitions	YES	To maximize part's quality with the highest possible yield.
5- Cooling channel optimization (HPDC and GDC)	Partial mold 3D project (cavity and insert) and initial cooling channel (also feeder and chill for GDC) definition	YES	To minimize cycle time and maximize part's quality
5- Chill optimization (GDC)	Partial mold 3D project (cavity and insert) and initial feeder, chill and cooling channel definitions	YES	To maximize part's quality
6- Runner system and overflow/ venting optimization (HPDC and GDC)	Partial mold 3D project (cavity and insert) and optimized definitions	YES	To maximize part's quality
7- Geometry Validation (HPDC and GDC)	Full Mold Project	YES	To guarantee that construction changes will not negatively influence the results.
8- Process Variation Study (HPDC and GDC)	Full Mold Project	YES	To understand how the process window will impact on the part's quality.

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The issue remains that, for castings, there are several stages of tool construction that also have to be observed. For permanent mold castings even more so, since the development and construction of the tool takes several months and, in most cases, simulation is regarded as only one of the packages of the WBS, as it can be seen in the example schedule of a Brazilian tooling company for GDC, depicted in Figure 5.

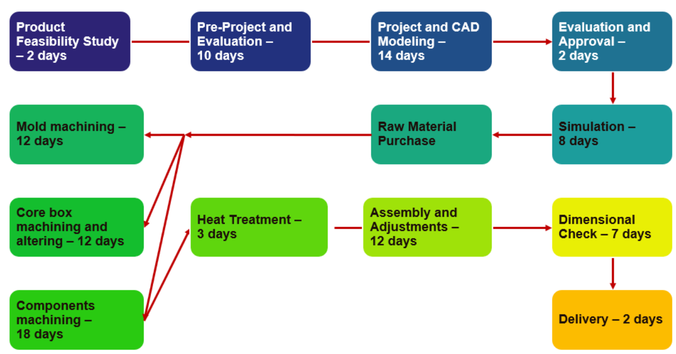

Figure 5. GDC Tooling company schedule for tool construction.

Of 92 days estimated for tool construction, only 8 are reserved for simulation studies, corresponding to 9% of the overall time.

To include all the steps described in Figure 4 inside an 8-day framework is not a feasible task, leaving the simulation users with only one option, which is to perform a limited number of tests on an already predefined tool concept and choose the best result among them. This approach, however, will not allow for the most robust system to be achieved.

The same single "simulation package" is seen in a HPDC tooling company's schedule (Figure A - 1 in the Appendix). In this example, a much larger portion of the overall project time is allocated for simulation studies (between 6 to 8 weeks, corresponding to 25 to 30%). Within this timeframe it would be possible to complete all the steps in the proposed simulation project WBS, but a 30% increase in the time necessary to start the production of any part is not ideal, desired or even possible sometimes. It is in this scenario that the Scrum method will be used to optimize the deliverables in order to get faster results.

SCRUM Framework

As opposed to the traditional methodologies, the agile approach has been introduced as an attempt to make software engineering flexible and efficient [9]. Instead of small packages, as shown in the previous

WBSs, agile frameworks are used to breakdown complex projects in a number of smaller cycles. Each of them comparable to a miniature project. Among the existing frameworks under the agile umbrella, Scrum is the dominant one.

The term Scrum has its origins in the game of Rugby, where, in this play, eight players dispute the replacement of the ball acting together with the same goal, and if one of them fails, everyone fails and if one succeeds, everyone succeeds [10].

Scrum is a framework [11] for developing, delivering, and maintaining complex projects. It is not a definitive process, technique or method (like a recipe) and can employ various processes or techniques. The rules contained within the framework integrate certain roles, events, and artifacts, managing their relationships and interactions aiming at iterative and incremental development of products.

There are also values that help teams adopt Scrum, deliver the solution in accordance to the customer's requirements, and still ensure a pleasant environment to work with.

Scrum, as the guide [11] itself states, is simple and purposefully incomplete. In each project or institution, the framework is built upon by the collective intelligence of the people using it. Their willingness to embrace the guidelines and model their behavior after them is of paramount importance for its successful implementation.

The following image (Figure 6) outlines the events and artifacts that compose Scrum.

Figure 6 Representation of Scrum artifacts and events. Adapted from [12].

Detailed information concerning Scrum, its values, artifacts, events, roles and application examples can be found in literature [9] to [13]. Here we provide only a brief overview that will allow the reader to grasp its concept and proposed use on the case study.

1. **Product Backlog:** Everything starts in the product backlog. To understand this concept, imagine a spreadsheet where each row contains items needed to make the product or service happen. As these items are regarded as done, they can be "checked out". We can consider that this list is a product backlog if, once everything in it is "checked out" the product or service is complete.
2. **Prioritized Product Backlog:** After defining what is required, the items are prioritized according to their value (usually defined by target audience/customer) and also to maximize the value of the developers' work; with this, a higher-level plan, called the release plan, is generated. Each release is a version that will be made available to customers for feedback and, consequently, product improvement.
   After the prioritization (keeping in mind that there is no need to have the full product backlog prioritized) the team will move on to the Sprint Planning.
3. **Sprint backlog**: Sprints are events in which ideas are turned into value. They start after the definition of the Sprint Goal (the 'why'). With that goal in mind, the team will filter the product backlog for the necessary items to achieve it (the 'what'), and refine them (the 'how'). The "why", "what" and "how" compose the Sprint Backlog.
4. **Running the Sprint:** During the Sprint the team will work towards the Sprint Goal by doing all the items of the Sprint Backlog. Each Sprint has a fixed duration of, at most, 30 days. Within the sprint 3 other events are held.
5. **Daily Scrum:** Meeting of up to 15 minutes to inspect progress toward the Sprint Goal and adapt the Sprint Backlog as necessary.
6. **Sprint Review:** When the Sprint deadline is over, the Scrum team presents the result of their work and progress towards the Product Goal to key stakeholders, receives feedback and updates the product backlog.
7. **Retrospective:** The last event of the Sprint is the retrospective, a meeting that aims to increase quality and effectiveness for the next Sprints by evaluating what went well or not with regards to individuals, interactions, processes, tools, and their definition of done. This evaluation allows the team correct and improve as they move forward. If necessary, some items can be added for the next Sprint Backlog.

To execute this framework there are 3 distinct roles: The Product Owner, the Scrum Master and the Developers.

PRODUCT OWNER: Person responsible for maximizing the value of the product resulting from the work of the developers (establishing of the product goal). The creation, ordering and maintaining of the product backlog are some of the Product Owner's charges.

SCRUM MASTER: Person responsible for stablishing Scrum as defined in the Scrum Guide. The effectiveness of the team, their continued improvement and ability to work within the guidelines of the framework are some of the Scrum Master's charges.

DEVELOPERS: Group of people that will develop the product or service. They are self-managed and are responsible for transforming the product backlog into potentially releasable feature increments.

Case study

Through a deep analysis of the HPDC tooling and simulation schedules the presented case study, although theoretical, clearly demonstrates the possibility to merge them, creating a product backlog, which in turn

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could be logically prioritized and divided in smaller projects according to certain goals.

Tooling company's schedule

Figure 5 and Figure A - 1 show complete schedules of tooling companies. It is important to note that the construction of tools can have varied processes depending on the part, company and available equipment, however, there are 12 steps that can be defined as commonplace for most tools [9]:

1. Quotation
2. Product feasibility study
   - Stage in which the product must be adapted for the production conditions inherent to the casting process.
   - Sharp corners, rake angles and excessively thin walls, for example are removed during this stage.
3. Project and approval
   - Stage in which the 3D model is created, evaluated and approved – usually simulation is used, on higher on lower degree, on this stage.
   - The model is build starting with the part's geometry, which is used to create the cavity and insert and after that the base mold.
   - The detailing of the mold (screws, pins, inserts, etc.) is necessary for later stages of its construction, but not for the simulation studies. This is an important distinction for it will allow us to create our first miniature project (Sprint).
4. Construction planning
   - Make or buy definition for the necessary components.
   - The bulk of the mold will be machined from steel blocks acquired by the tooling company, however, the components and sometimes the base mold can be purchased in their finished state.
5. Raw Material Purchase.
   - Even though this is not a technical step, it usually takes a long time (2-3 weeks) to receive the materials from the suppliers and start machining.
   - This is a critical step for the tool's project. That is because the delivery of the materials is completely dependent on a third party (supplier), it stops the continuation of the project (the machining of the received materials will follow) and for a long time.
6. Machining
7. Inspection
8. Assembly and Adjustments
9. Polishing
10. Try-out
11. Adjustments
12. Delivery

Simulation schedule

Depending on the part, it's geometry, history (when available), criteria and degrees of freedom (for changes) the steps to perform a complete simulation study and their order may also vary. The steps shown in Figure 4, however, are a good starting point on how to conduct a HPDC simulation project.

1. Product position definition
2. Ingate definition
3. Cooling channel definition
4. Cycle time definition
5. Cooling channel optimization
6. Runner system and overflow optimization
7. Geometry Validation
8. Process Variation Study.

Knowing the steps (or items) to both a complete HPDC simulation project and HPDC tool construction project, we stablish that their sum is our product backlog to be used in the Scrum framework, as shown in Figure A - 2 in the Appendix.

Following the guidelines of Scrum, the first stage is to stablish a product goal. When building a tool, the project objective is to deliver a working tool, within the agreed-upon timeframe, that meets the customer's requirements. When performing a simulation project, the objective is to deliver a robust casting system, capable of producing high quality parts, within the available time.

The new product's goal can therefore be; to deliver a working mold, within the agreed-upon timeframe, that meets the customers' requirements and that produces high quality parts (according to their criteria), with minimal scrap rate.

The idea of each Sprint is always to deliver something done that provides value. It is not possible, however, to release the mold in smaller increments that complement each other until we have the finished mold. Construction projects do not offer that kind of flexibility as software projects do. However, it is our understanding and intent that the definition of done can be successfully applied to certain aspects of mold construction. In this case, we will integrate items from the simulation schedule, that can be accomplished with only the part's CAD geometry, with construction items necessary to unblock material purchase – this will be our Sprint goal (why).

Unblocking material purchase is an important goal because, after it is done, there are 2 to 3 weeks of waiting to start machining. The evaluation of the schedules show that this time is, so far, unproductive.

In order to do that, we have to revisit and detail the purchase stage as well as the previous ones. Considering the evaluated tooling schedules, the purchase will occur after the completion of the mold's project.

Naturally, some components will be purchased in their finished state. However, the steel blocks that will be used for insert and cavity (which also have the longest delivery time) are defined based on the cavity and insert's seizes. This definition, in turn, is based on the product's size and its position. Therefore, it is no accident that the first step of a simulation study is to define the product's position which will allow

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the toolmaker to have all necessary information to make the first purchase.

SPRINT 1

In order to determine which items will compose the first Sprint, keeping in mind that the goal is to have the materials list ready and purchase orders placed, we firstly need to list the actions necessary to determine the size of the mold (what).

From a tool construction standpoint, they are as follows:

1. Product feasibility study
2. Project and approval*
3. Listing and purchase**

(*) The complete mold project will take several days to be completed, checked and approved. For that reason, the action will be broken down and simplified.

(**) As mentioned above, not all materials need to be purchased in this step, only the steel blocks that will be machined into the cavity/insert and the base mold, if standardized.

A. Cavity and insert simplified project
B. Base mold simplified project

From a simulation standpoint the actions are:

1- Product position definition
2- Ingate definition (***)

(***) Strictly speaking, it is not necessary to define the ingates' number and positioning prior to material purchase, but since it is a simple step, it can be accomplished in parallel with the remaining tool construction steps.

The time required to complete each item (without the usual safety margin) can be observed in Figure 7, below. Since these items can easily be parallelized and none of them have an estimated time longer than 6 days, we will define the time box for the first Sprint as 7 days.

It is important to note that, should this Sprint be successful, the time used for simulation studies will not add to the mold's construction time. The intention here is to exploit the particularities and details of each project (as well as the fact that they are treated as completely unrelated), verifying steps that can be done in parallel without injury to the timeframe and the cast part's quality.

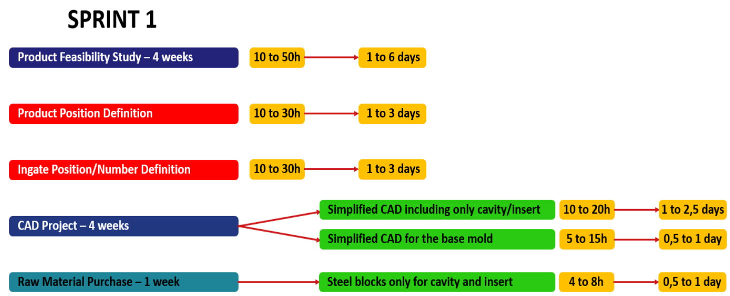

Figure 7 Time box for Sprint 1 items.

To complete our sprint backlog (already having the why and the what) we need to detail and plan for executing these items (how). The necessary detailing is exhibited in Figure A - 3 in the Appendix.

The items related to the mold's construction are well known by toolmakers and will not be discussed in detail in this article. The simulations steps, however, will be further explained.

To do so we shall consider the part shown in Figure 8. The first simulation step is to determine how the part can be positioned on the mold, to run the corresponding simulations for each one and compare the results based on the quality criteria. The analysis of the geometry allows us to conclude that there are 4 possible ways in which this part could be injected (numbered 1 to 4 in Figure 9). It is important to note that for this study there is no need for the mold's detailing or even cooling lines – only the part's geometry.

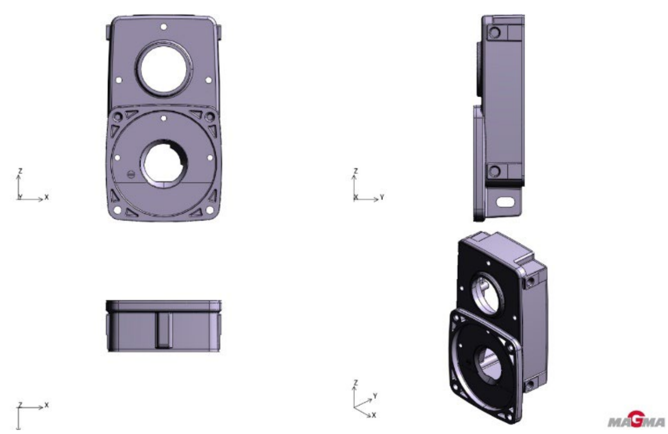

Figure 8 Evaluated part.

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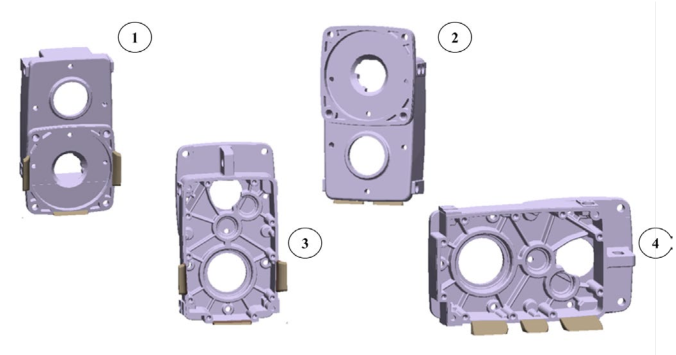

Figure 9. Possible positions for the cavity in the mold.

The position and number of ingates are determined by the available space and the experience of the user. If necessary, it is possible to run several tests in the same timeframe if necessary (also noting that runner system will be further optimized throughout the project).

After the initial simulation setup, the results have to be ranked in terms of quality criteria. In this case we will consider criteria often required in HPDC parts:

1. To Minimize cold shuts
2. To Minimize air entrapment
3. To Minimize oxide formation

Each simulation will provide a different filling profile (Figure 10) so the tendency for cold shuts, air entrapment and oxides will happen on different areas of the part. Also, depending on filling, their intensities will vary. Comparing these profiles permits us to make decisions that are better for overall part quality since the first simulation study.

Figure 10 Simulation flow front comparison for 4 possible positionings of the same part, run with MAGMASOFT® version 5.5.

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To determine which position is best according to the quality requirements (in this case cold shuts and air entrapment) we will use the Evaluation Perspective of MAGMASOFT® 5.5, that provides quantitative values for each simulation and the respective chosen criteria, allowing us to compare them in graph format (Figures 11, 12 and 13). In each graph, the X-axis indicates the simulation number and the Y-axis indicates the calculated value for each criteria.

In the first graph we analyze the filling results in terms of temperature. The Y-axis contains the predefined MAGMASOFT® objective called "Avoid Misrun", which is equal to the lowest melt temperature (in ºC) found in the cavity during filling. Therefore, the higher the value, the lower the tendency for cold shuts.

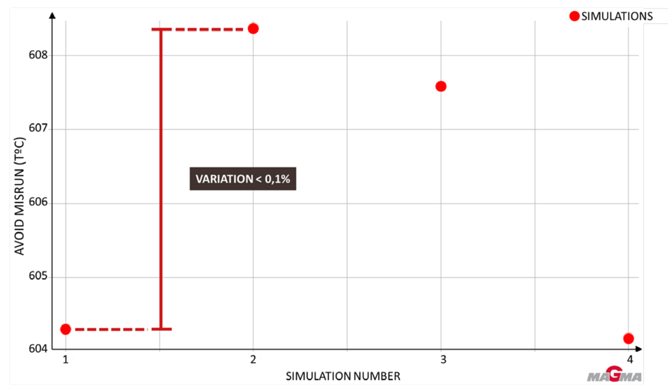

Figure 11. Comparison of the Avoid Misrun objective in the Evaluation Perspective of MAGMASOFT® among the 4 simulated systems.

The comparison makes it clear that simulation 2 has the lowest tendency for cold shuts and simulations 1 and 4 have the highest. The difference among them is, however, small (lower than 0,1%) to the point that every system could be expected to present similar temperature results when in production.

In the second graph the Y-axis shows the highest value for air pressure within the cavity during injection for each experiment. Higher air pressure values mean that more air was compressed by metal during injection which, in turn, means a higher tendency for air porosities (bubbles) in the finished part.

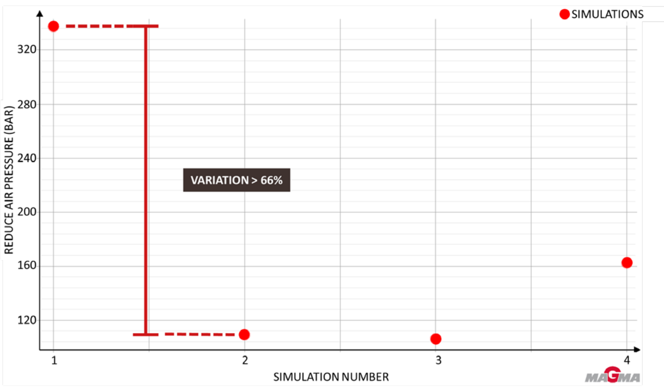

Figure 12. Comparison of the Max Air Pressure result in the Evaluation Perspective of MAGMASOFT® among the 4 simulated systems.

The difference in tendency among the versions is much more significant for this result. Simulations 2 and 3 (lowest air pressure values) are more than 66% better when comparted to simulation 1 (highest air pressure result).

In the last graph the Y-axis exhibits the, also predefined, MAGMASOFT® 5.5 "Smooth Filling" objective. Simply put, this objective is a measure of the amount of metal surface that was in thouch with air during filling. Higher values of smooth filling indicate a higher tendency for oxide formation.

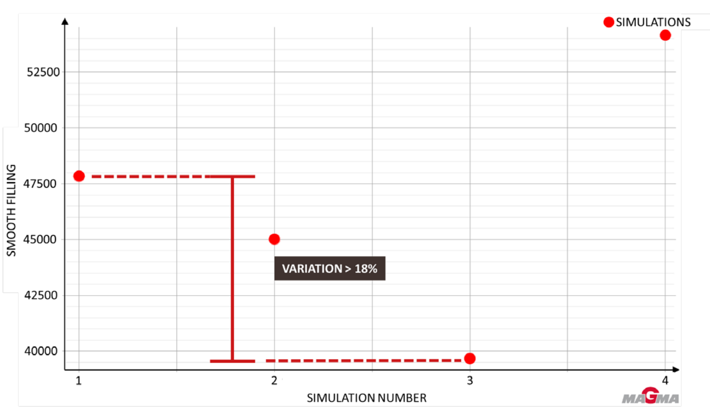

Figure 13. Comparison of the Smooth Filling objective in the Evaluation Perspective of MAGMASOFT® among the 4 simulated systems.

The third graph shows that simulation 3 has the lowest tendency for oxide formation. Overall, it is the most robust option for part position according to defined quality criteria.

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This conclusion means that the item "Product Position Definition" of the Sprint's backlog can be defined as done, and the Developer responsible for tool design can move forward with the mold's simplified project.

All the other items in the backlog must also be done during the 7 days defined for the Sprint, but the use of the framework has already allowed, for the Developer responsible for operating the software, to complete an important step towards the conclusion of the miniature project (Sprint 1) that aims to unblock material purchase faster and without overlooking the final quality goal.

To monitor the development and progress of the Scrum team, a widely used tool is the KANBAN board, which facilitates visual management of activities and their status in a simple and direct fashion.

This board visually depicts the various stages of the Sprint and the evolution of the items that compose it, allowing the whole team to always be aware of every status and making it easier to detect if corrective actions are needed. Figures A - 4 to A - 9, in the Appendix exemplify how such tool could be used to aid in the completion of the first Sprint.

Even though the remaining items will not be discussed in this article, the case study, as conducted thus far, was successful in demonstrating that the integration between casting simulation projects and tool construction projects has great potential in reducing the overall development time.

Summary/Conclusions

The analysis of GDC and HPDC schedules allowed us to conclude that, although casting simulation is part of the definition of mold designs, the activities of mold design and simulation are not integrated.

A WBS was proposed for casting simulation projects with the purpose of maximizing the answers obtained through simulation, in order to increase the robustness of the final project, taking into account the product requirements.

An Agile project management concept that allows the integration of simulation-development and tool-building stages was presented through the SCRUM framework. The application of the proposed framework allows for the optimization of the total project time and maximization of its results.

In addition, the use of the Scrum framework facilitates the integration and combination of stages from different developers, in order to increase the delivery of value to the final customer.

Finally, the use project management methods, that integrate simulation studies with production steps, either conventional or agile, should be considered by foundries to improve their lead time without compromising product quality.

References

[1] Jalaj B., Dhyan V., Akshat R., M Somasundaram, et al., "A systematic review on methods of optimizing riser and gating system based on energy Nexus approach", Energy Nexus doi: 10.1016/j.nexus.2021.100002.

[2] Hahn, Ingo and Sturm, Jörg. "Simulation evolves to autonomous optimization." Magmasoft. Accessed June 20, 2022. https://www.magmasoft.com/export/shared/.galleries/pdfs_publications/2015_Simulation-evolves-to-autonomous-optimization.pdf.

[3] Piazza, G., Job, R., Zanol L., Coutinho, G., et al., "Influência das tensões residuais e propriedades mecânicas, oriundas do processo de fundição, sobre a performance de um componente de sistema de suspensão". In 12° Colloquium Internacional SAE BRASIL de Freios & Mostra de Engenharia, 1–8. Caxias do Sul: SAE International, 2015.

[4] Ravi, Dr B. "Casting Simulation – Best Practices". Transactions of 58th IFC, Indian Institute of Technology Bombay, 2010.

[5] Gaware, Akash and Dr. Mahalle, A. K., "A Review on Investigation of Casting Defects with Simulation." International Journal of Innovations in Engineering and Science, Vol. 2, No.5, 2017: 15-19. http://www.ijies.net/finial-docs/finial-pdf/2603172017258.pdf.

[6] Vijayaram ,T.R., Sulaiman , S., Hamouda , A.M.S. and Ahmad, M.H.M. "Numerical simulation of casting solidification in permanent metallic molds." Journal of Materials Processing Technology, Vol. 178, No. 2006: 29-33. doi: 10.1016/j.jmatprotec.2005.09.025

[7] "The MAGMA Approach". Magmasoft. Accessed June 20, 2022. https://www.magmasoft.com/en/solutions/the-magma-approach/.

[8] GUIA PMBOK®. Guia do Conhecimento em Gerenciamento de Projetos. 6th ed. Newton Square, PA: Project Management Institute, Inc., 2017.

[9] AltexSoft. "Agile Project Management: Best Practices and Methodologies | AltexSoft," July 5, 2022. https://www.altexsoft.com/whitepapers/agile-project-management-best-practices-and-methodologies/.

[10] Pereira, P., Torreão, P., Marcal, A. S., "Entendendo Scrum para Gerenciar Projetos de Forma Ágil." Academia. Accessed June 20, 2022. https://www.academia.edu/28954250/Entendendo_Scrum_para_Gerenciar_Projetos_de_Forma_%C3%81gil

[11] "The 2020 Scrum Guide". Scrum Guides, 2020. https://scrumguides.org/scrum-guide.html.

[12] Colosseti, Adriane. Condutas ágeis: comunicação, inteligência emocional e técnicas de negociação. São Paulo: Sunsetti, 2022.

[13] McGreal, Don, e Ralph Jocham. The Professional Product Owner: Leveraging Scrum as a Competitive Advantage. Addison-Wesley Professional, 2018.

[14] Hobus, Thiago. "Etapas da fabricação de um molde". Ferramental, 100 maiores ferramentarias brasileiras, n.º 100 (2022): 112–13.

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Appendix

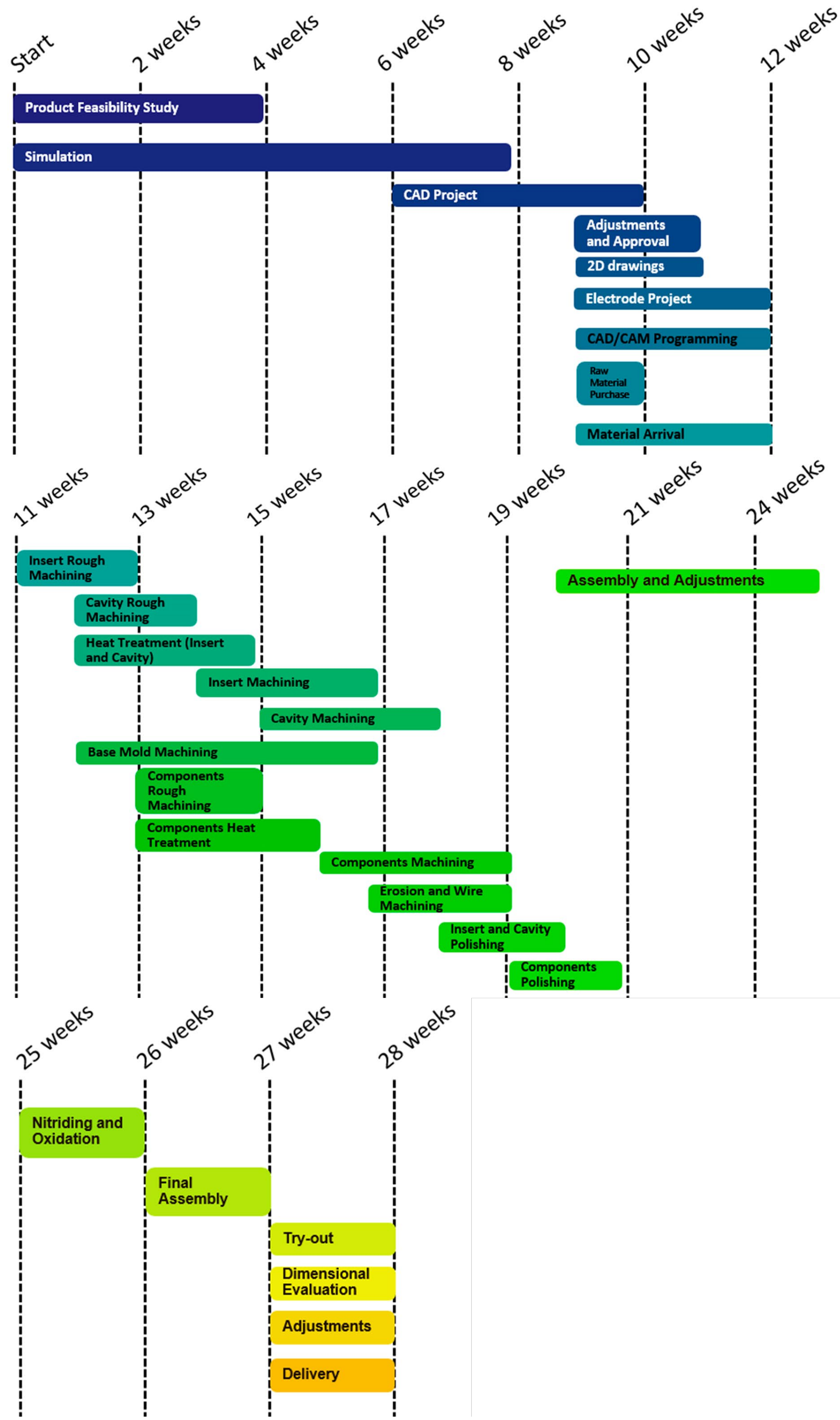
Start
2 weeks
4 weeks
6 weeks
8 weeks
10 weeks
12 weeks
Product Feasibility Study
Simulation
CAD Project
Adjustments and Approval
2D drawings
Electrode Project
CAD/CAM Programming
Raw Material Purchase
Material Arrival
11 weeks
13 weeks
15 weeks
17 weeks
19 weeks
21 weeks
24 weeks
Insert Rough Machining
Assembly and Adjustments
Cavity Rough Machining
Heat Treatment (Insert and Cavity)
Insert Machining
Cavity Machining
Base Mold Machining
Components Rough Machining
Components Heat Treatment
Components Machining
Erosion and Wire Machining
Insert and Cavity Polishing
Components Polishing
25 weeks
26 weeks
27 weeks
28 weeks
Nitriding and Oxidation
Final Assembly
Try-out
Dimensional Evaluation
Adjustments
Delivery

Figure A - 1. HPDC Tooling company schedule for tool construction.

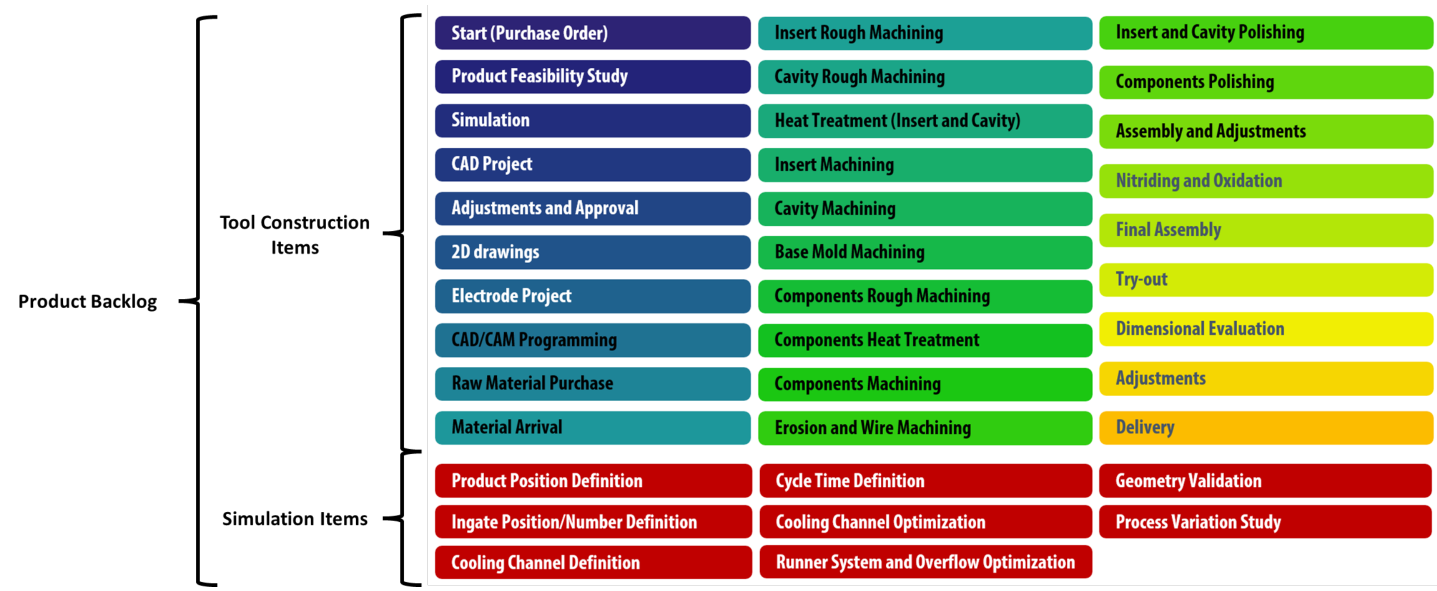

Figure A - 2. Product backlog, created from the Sum of the Tool construction items and the simulation project items.

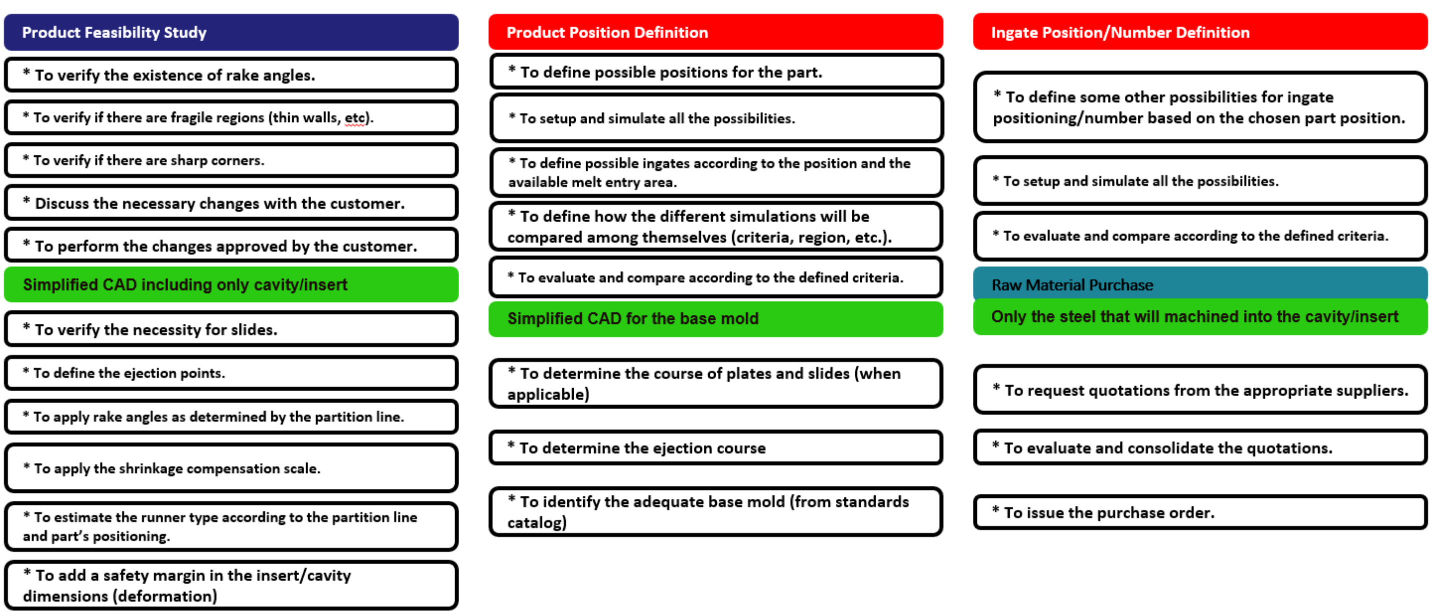

Figure A - 3. Detailing of the 1st Sprint's items and how to achieve them.

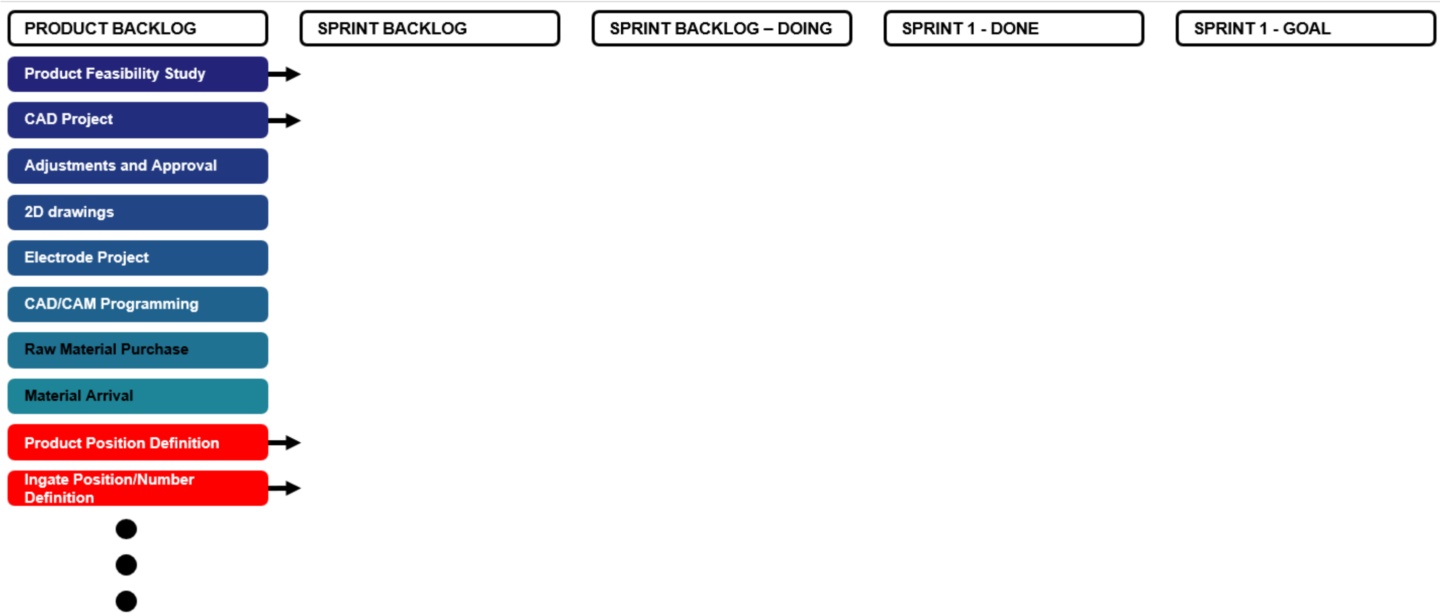

Figure A - 4. KANBAN board with product backlog. The prioritized items (what) will be moved for the Sprint 1 backlog.

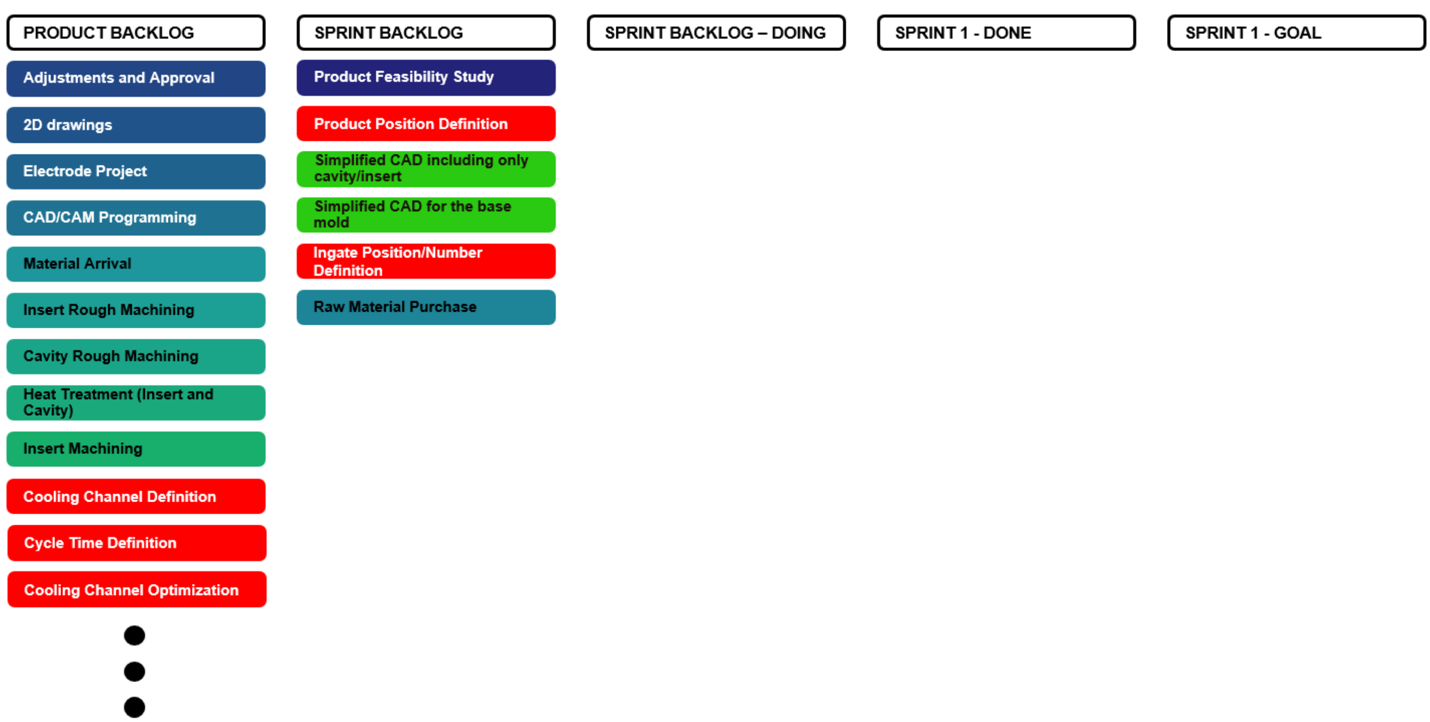

Figure A - 5. KANBAN board after the Sprint backlog items are moved to the correct column.

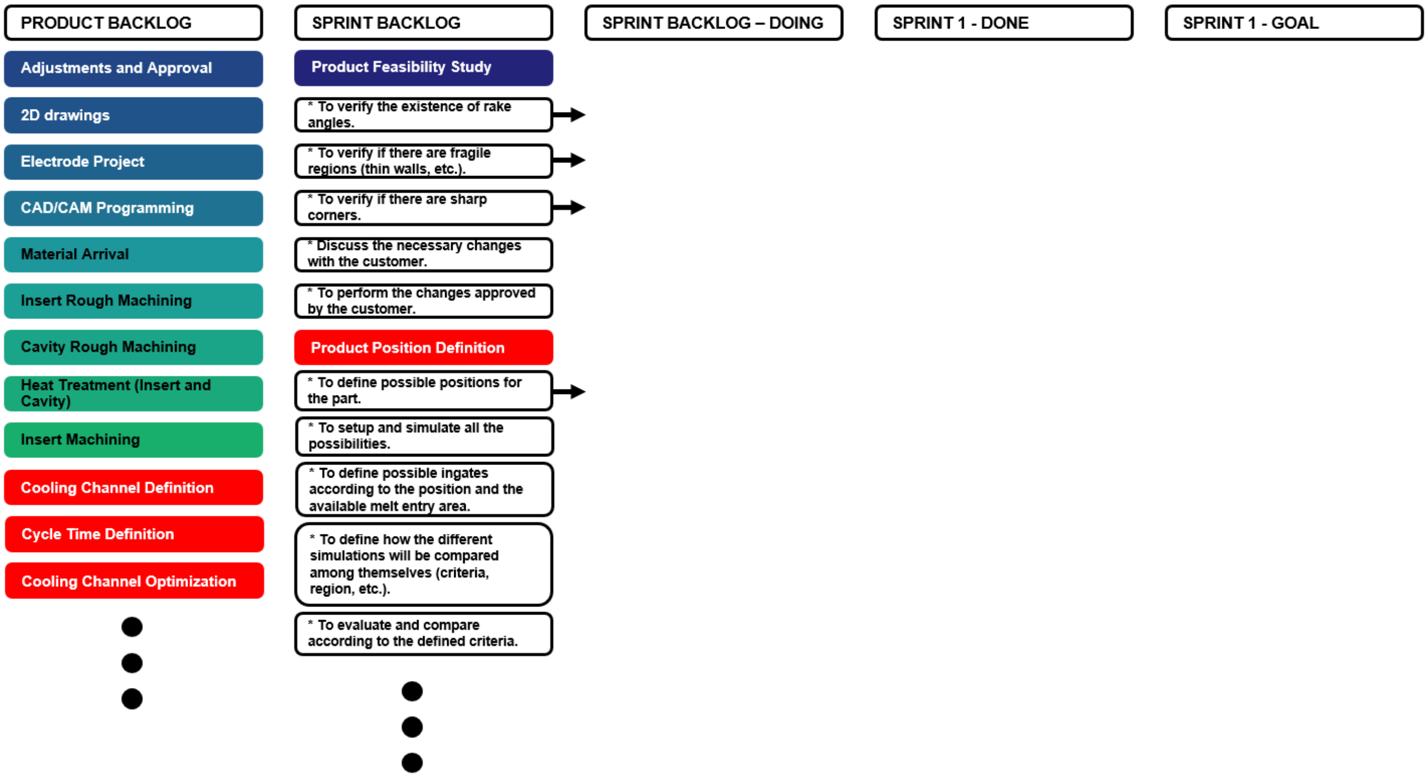

Figure A - 6. Detailing of the first Sprint's to complete the Sprint backlog (how).

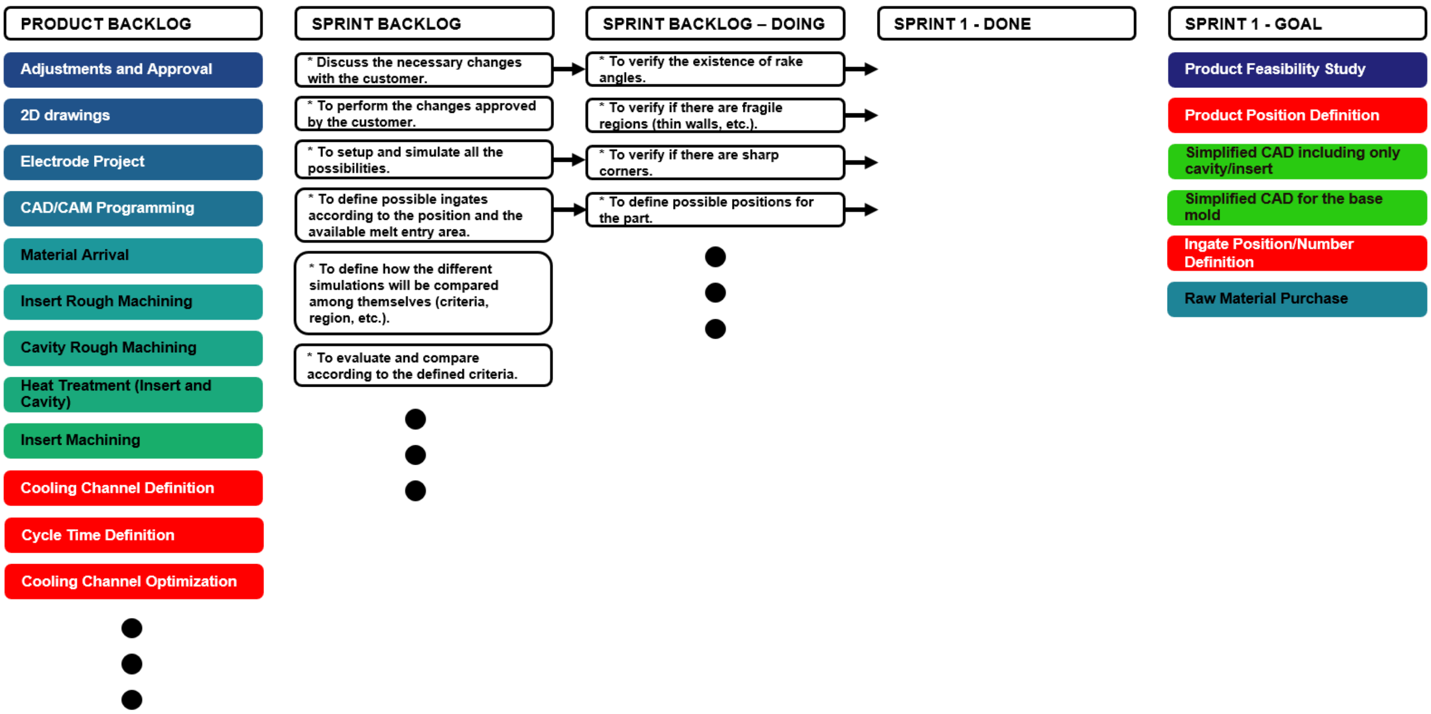

Figure A - 7. As the items are being worked on by the developers they are moved among the columns.

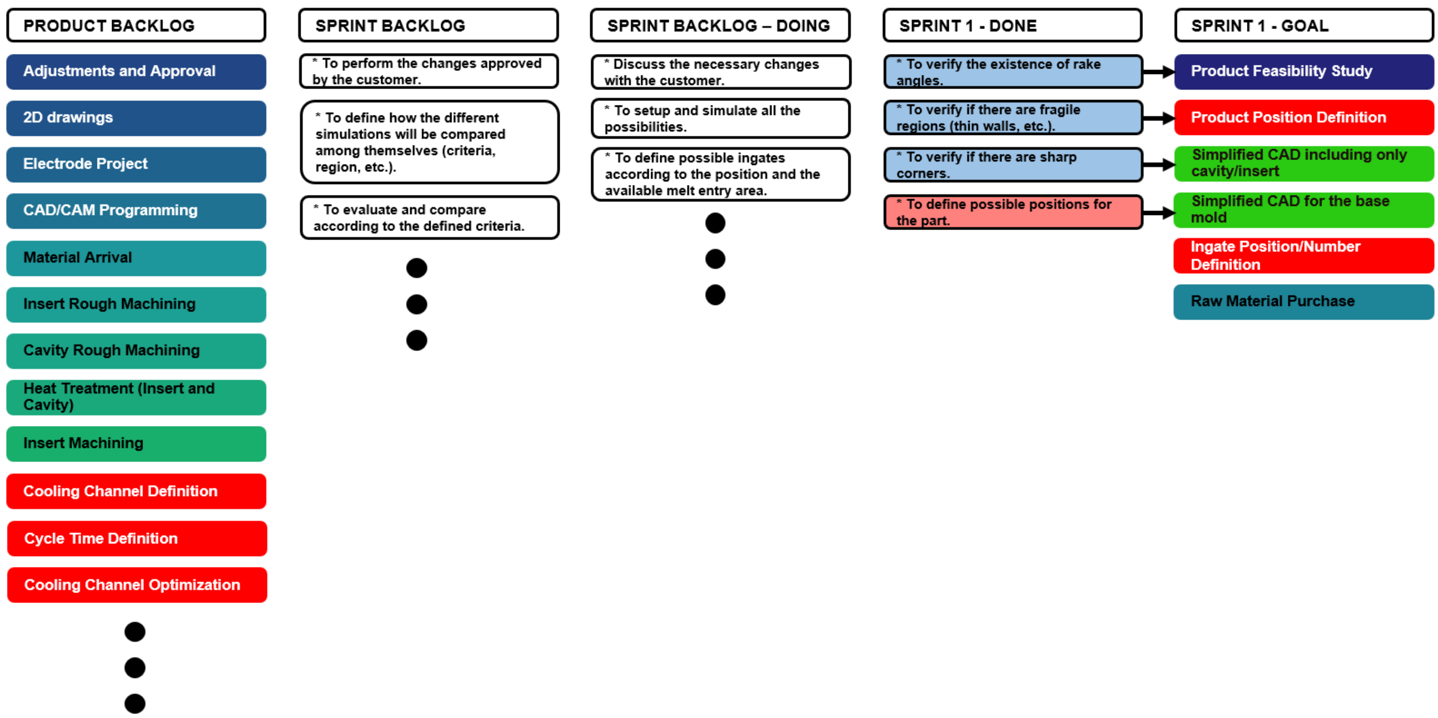

Figure A - 8. As the items gain the status “done”, they allow for other items (of the same Sprint) to be started.

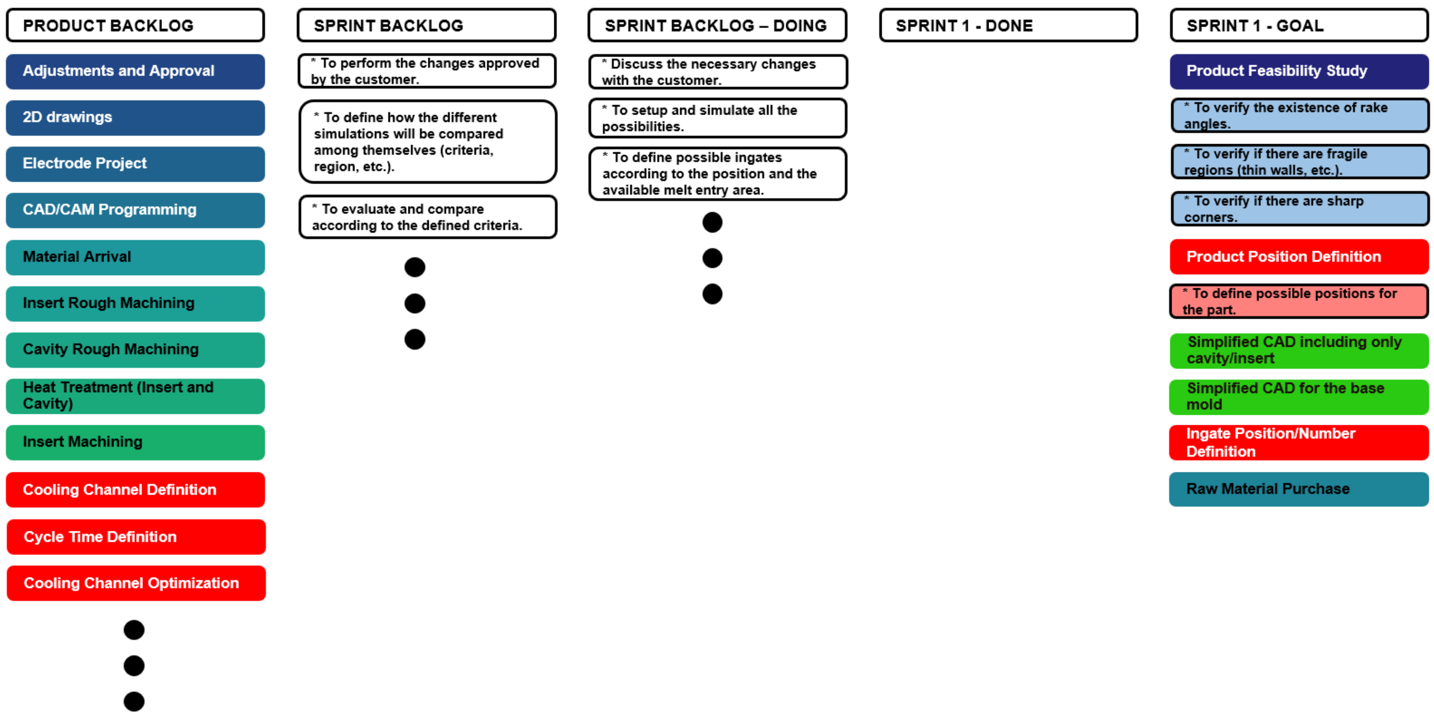

Figure A - 9. Once all the Sprint items are done, the sprint itself will be done and the goal achieved.

ISSN 0148-7191