RAPID DIE FACE DESIGN IN THE CORPORATE PLM ENVIRONMENT

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ABSTRACT: With the widespread adoption of forming simulation the overall tooling development lead time has been reduced significantly in the last 10 years. Subsequently the focus has moved to die design as the next bottle neck. To answer this need, rapid die face design software has been a growing trend particularly in the die engineering process of Automotive OEMS and tier suppliers over recent years. These systems have provided a significant business benefit by allowing die addendum concepts to be evaluated for feasibility in forming simulation software, at a very early stage in the development process, avoiding significant costs in rework but also avoiding significant hidden costs in CAD modeling and remodeling work. The limitations of such systems have always been that they are external from the main corporate CAD or **P**roduct **L**ifecycle **M**anagement (**PLM**) system, meaning that engineering changes or updates cannot be automatically integrated, and that they have been designed to produce output suitable for simulation, or at very best perhaps for prototype die machining. Such systems had significant drawbacks in terms of data consistency and geometry update on one side and surface quality on the other side. They lacked the precision to allow them to be used in the final die design CAD modeling stages. So in a certain sense, there has always been a need to redo a significant amount of work again in the CAD/PLM environment, perhaps reusing some principal surfaces such as blankholder, or some key sections, but not more.

Emerging onto the market now is a new generation of rapid die face design software, but now completely integrated in the host PLM/CAD system, inherently overcoming the limitations of managing engineering updates, and avoiding the need to re-work or remodeling, by utilizing the power of associativity within the host PLM environment. Other business benefits include the reduction of impact on the user, as the graphical user interface is familiar, with only the need to learn a few additional functions as opposed to an entirely different program, but more importantly there is no interruption in the data flow, with all die engineering and design iterations being maintained within the PLM, but still delivering fast connection to the simulation world for rapid feasibility assessment.

KEYWORDS: PLM, Die Design, Simulation, Springback Compensation

1 INTRODUCTION

Rapid die face surfacing tools began to emerge onto the market about 10 years ago, in order to provide a way for tool engineers to short cut the time consuming CAD die surface design process, which had become a highly iterative process coupled with forming simulation or as it has become known ‘Virtual try out’, the main effect being that all tooling modifications were needing to be done in CAD, rather than directly modifying a tool shape in ‘physical’ tryout.

This genre of software tools is entering a new phase, moving from standalone solutions aimed at satisfying the need for fast geometry modification as part of the die feasibility simulation process, to take a position directly in the mainstream engineering development process by integration into corporate PLM solutions. This is the logical extension of the trend which began with the

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integration of inverse (or one step) solvers for cost estimating and blank shape prediction into corporate PLM solutions, the authors anticipate that this trend will continue with further integration of die engineering tools into the future.

2 CHANGING PERSPECTIVES

During these last years the increasing use of these rapid surface creation tools has highlighted the main limitations of the process, i.e. that these tools are generally 'stand alone' or integrated into the simulation software, but in either case, they are divorced from the main corporate CAD or PLM data stream, and the quality of the created surfaces is generally not of an adequate standard for downstream processes such as solid model based die design and CNC milling of the die face. This has meant that although considerable time and cost benefits have been achieved by speeding up the modeling for simulation[1], there remains significant scope to further improve the efficiency by trying to remove the duplication of effort which exists today. After completion of the 'final' die shape in the rapid modeling system, and validation of that die shape with forming simulation software, there then exists the need to reproduce the same design to a much higher standard within the corporate PLM system. Currently only a few details, perhaps sections of the odd surface are retained from the rapid model, and used as guidelines for the full CAD model, which is then used within the PLM for the downstream processes of 3D solid model tool design, and CNC milling of the die face.

We are now beginning to see the emergence of the second generation of rapid die face design software, which will overcome the inherent limitation of the existing solutions by virtue of the fact that it will be fully integrated into the corporate PLM solution itself. The benefits of integration are manifold and varied. Of course avoiding the duplication of creating the final die shape is an obvious benefit, as is the avoidance of data transfer between different systems, but perhaps one of the most significant benefits is simply that there is no interruption of data flow, meaning that the die engineering can be linked to the product engineering, and updated by taking advantage of the associativity which is in itself a major benefit of modern PLM systems. Typically this saves a considerable amount of time, as it avoids recreating the die with each new release of product engineering data.

Other benefits include a reduction in training requirement, and reduction in complication for the users, as they are able to remain in one consistent working environment, needing only to learn a few new functions, rather than learning a completely new piece of software. Additionally there is significant benefit in being able to take advantage of existing powerful CAD tools, allowing the user to mix and match between the specific Rapid die engineering functions and standard CAD functions as required.

2.1 OTHER TOOLING CONSIDERATIONS

The creation of the working faces of the draw die is a significant consideration, however when creating these surfaces, there are a significant number of other factors which a die process engineer will be considering, and wanting to assess. Many of these additional considerations are neglected by the current crop of rapid die face creation software, tools to assist in the making of such assessments are simply not provided, however the task still has to be done, and is currently done in the CAD environment, creating a 'disconnect' between the draw die surface engineering and the entire process feasibility engineering. One of the most important considerations during method planning is the trimming analysis. There are several aspects which have to be taken into account: normally an angle of 15 degrees between the effective direction of the trim steel and the sheet metal surface must not be exceeded in order to guarantee the mere feasibility of the trimming operation and also to avoid the risk of injury for persons handling or using the product. Fully automated mass production requires absolutely safe scrap disposal. Neglecting this demand inevitably causes cost intensive downtimes or even severe damage to the tools during production. These two examples already demonstrate to which extent the different operations and other boundary conditions influence not only the die face design but the whole process of method planning. Tools facilitating these necessary analyses are either provided in the environment of the PLM system, where they access standards and guidelines (such as press books and design rules), or by the die face creating tool itself. In any case, bringing them all together in the PLM environment opens the door for a really simultaneous approach to the die engineering process.

2.2 SPRINGBACK CONSIDERATIONS

Although not originally considered to be part of the conventional die design process, the adoption of higher strength steels in vehicle construction has meant that springback can no longer be considered an issue to be resolved in tryout, but rather one of the main focuses of the evolution of the die face design. Environmental considerations are driving weight saving initiatives in all vehicle manufacturers, meaning that the use of such high strength material will continue to become more prevalent over the coming years.[2]
Consideration of the springback can have a fairly dramatic effect on the shape of the die face, this is

a very strong link between forming simulation and design, and is often a highly iterative process, reinforcing the need for very close integration between simulation and geometric modeling, by integrating into PLM. [3]

Currently, forming simulation technology allows to predict the distortion related to springback with reasonable accuracy. Recently several software tools had been released which enable springback correction and compensation of the original die in order to minimize the distortion and meet the target tolerance.[4] Finally, today technology allows to retrofit the required modifications into the original CAD geometric models.

2.3 SURFACE QUALITY EVOLUTION

When rapid die face creation was first conceived its purpose was simply to allow simulation to take place, and as a result the quality of the surfaces created was aimed at meeting the requirements for speed rather than accuracy. All simulation tools currently work with mesh or surface discretisation anyway, so a high level of surface accuracy was meaningless in meeting the needs at the time.

The evolution of requirements has resulted in the need to directly use the created surface for all downstream processes, including 3D solid modeling for the tool construction, and CNC machining of the die face surfaces. Such downstream processes require the surface definitions to be of significantly higher quality, and easily re-used as standard CAD entities.

Typically there are targets for surface connections, with gap and overlap tolerance of 0.01 mm and tangency constraints of 0.2 degrees. Whilst this doesn't meet the constraints of the so called 'class A' surfaces, it is well within the target tolerances for solid modelling and CNC machining.

3 WORKFLOW

The main focus of rapid die design was as an enabling technology to support simultaneous engineering, allowing die feasibility to be assessed earlier in the process. This resulted in a workflow which can be represented in the schematic below.

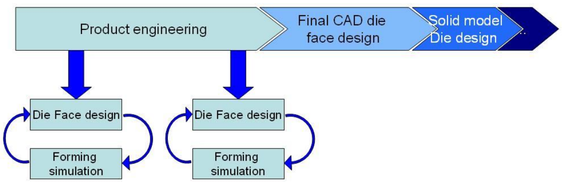

***Figure 1:** Existing workflow*

The change in the workflow as a result of integration into PLM allows a more meaningful simultaneous engineering approach, as the entire stage of 'Final CAD die face design' can be eradicated, the die face design is evolving with the product engineering in a truly simultaneous interactive consolidated process, resulting in the ability to reduce the overall lead time by some considerable margin.[5]

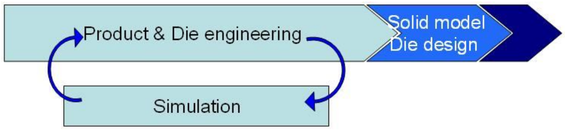

***Figure 2:** Workflow for PLM integrated die face design solution*

The 'new' workflow presented above in Figure 2 shows a meaningful advantage over the previous, but is not yet optimal, as it still relies on a connection to the 'simulation' world which remains external to the PLM data stream. The effect of this sub optimal workflow is minimized by the development of bespoke 'rich data' transfer 'bridge' technology to connect the PLM die design to the simulation in the most effective way possible, meaning that the transfer is not only of the geometry needed for the simulation, but also additional useful data which is already stored in the product definition of the PLM, typically this can be tool names, blank thicknesses, blank shape, offset information draw bead geometry to calculate equivalent draw bead forces, locator pins or material data, just to mention a few.

4 OUTLOOK

We are now at the point in time where the second generation of rapid die face design software is being released onto the open market, after development behind closed doors in collaboration with major automotive OEM partners. The scope of the solutions being provided now is likely to be just a starting point, and will increase dramatically over the coming years, to include the simulation itself. At first glance it may not seem obvious that there will be significant benefit in the integration of the simulation activities other than the single environment / usability aspect, however a more substantial benefit can be envisioned in terms of reduction in workload for simulation iterations, and consistency of data, and traceability through the inherent associativity offered by the PLM environment. Technically there are some challenges in terms of providing adequate post processing and visualisation functionalities inside the PLM, but these will be overcome relatively quickly.

Furthermore the task of forming feasibility is intrinsically linked with the geometrical aspects of the die face design, not simply the initial draw die design, but many other considerations too, the geometric representation of the equivalent drawbead models used in simulation, and the compensation of die face surfaces to correct for the effects of Springback or even assembly distortions show the multifaceted nature of the bilateral connection between CAD and Simulation, making the full integration of all simulation activities into PLM the logical ultimate objective.[6]

ESI Group is pleased to be among the first to provide a PLM integrated solution based on CATIA V5 from Dassault Systemes. Based on very clear requirements from the automotive OEM's a completely new concept of rapid Die face design solution has been created, which takes the 'best' from both existing design solutions (Rapid standalone, and Detailed CAD) and integrates them into a hybrid solution: ***'PAM-DIEMAKER for CATIA V5'***.

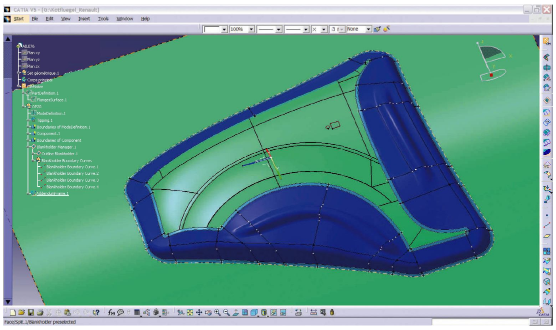

Figure 3: *Screenshot of parametric die design with PAM-DIEMAKER for CATIA V5*

It retains the powerful parametric addendum shape definition, and combines it with the inherently more accurate surface creation of the CAD system for specific features such as die entry radii. The new approach is able to satisfy the demands coming from simulation for rapid modification & iteration, but also meets the needs of the downstream processes for surface quality, joinability, and consistency

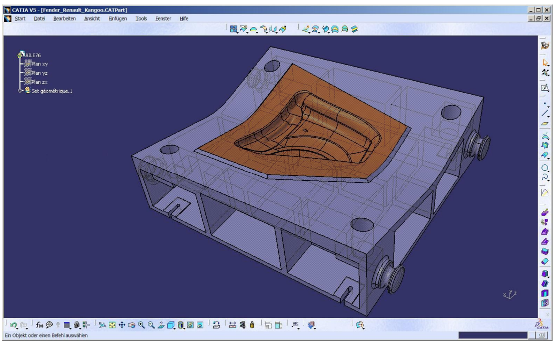

Figure 4: *Screenshot of solid tool design after rapid die engineering.*

5 CONCLUSIONS

Some aspects of the currently ongoing integration of rapid die face design into corporate PLM systems and its improvement in terms of quality as well as its extension towards covering all related operations were pointed out. Several major improvements of the current process were identified, promising benefits in terms of simultaneous engineering, thus enabling the user to improve the quality and to reduce time and cost of the process development at the same time. A first step has been made, other required developments will be performed in the near future, consequently leading to full integration of method planning and simulation of the manufacturing process into PLM.

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