SMC TECHNOLOGY 4.0: NEW ROADS FOR COLLABORATION IN THE AUTOMOTIVE VALUE CHAIN

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AT THE VDI CONFERENCE IN MANNHEIM EARLIER THIS YEAR, DAIMLER, ALIANCYS AND MENZOLIT TOGETHER GAVE AN INTERESTING PRESENTATION ABOUT THEIR SUCCESSFUL IMPROVEMENT OF SMC TECHNOLOGY FOR USE IN TOP-RANGE MERCEDES PASSENGER CARS. THE COMPANIES WERE ABLE TO MINIMIZE PRODUCTION WASTE, IMPROVE QUALITY CONSISTENCY IN A MAJOR WAY, AND MAKE SMC THE TECHNOLOGY OF CHOICE FOR MANY NEW CAR SERIES TO COME.

During their presentation, Daimler, Aliancys and Menzolit showed the positive results of an intensive multi-year collaboration. They explained how they fine-tuned their combined manufacturing operations for making the Mercedes SL Coupé deck lid, through a project that featured very open data-sharing throughout the entire value chain and an in-depth analysis to define parameters for process improvement.

SMC has been used to manufacture car body panels in the automotive industry already for many years. The SMC process is considered to be mostly economical for small production series like utility vehicles and sports cars. In some cases (e.g. deck lids) it is also attractive for higher production series, where the higher costs compared to steel are compensated by additional benefits like the ability to make unique shapes and to have radio transparency. The earlier generations of the Renault Espace, with its complete body shell made of SMC, are the vehicles with the broadest scope of application of SMC so far.

SMC applications in automotive body construction

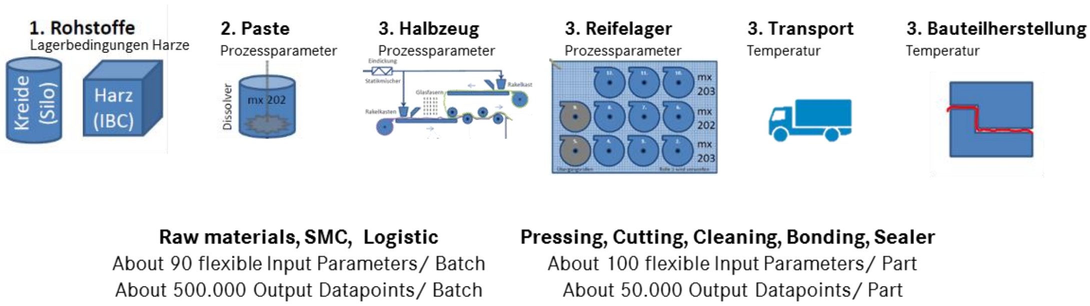
The SMC deck lid of the Mercedes-Benz S-class Coupé in 1999 was the first part where SMC technology was used for a premium segment car. This large, horizontal and highly visible part had very high demands for surface quality (specifically the waviness had to be similar with surrounding metal parts) and perfect color match. Crucial for the decision to use SMC was the design and shape of the deck lid, which was hardly feasible with steel and not at all with aluminum. In addition, with SMC the antenna systems could be located completely inside the deck lid permitting an uninterrupted accentuation of the elegant lines of the car.

SMC deck lids of the S-class Coupé

In order to achieve a perfect surface finish and color match, deck lids were mounted to the body-in-white and ran through the complete painting process. Temperatures of approximately 200°C were used for the e-coating process step. Parts were covered with an In-Mold-Coating during molding to avoid outgassing. Open edges from the de-flashing process were sealed with a special sealer.

Experience with this rather complex process revealed that the level of development of the technology at the time was not yet sufficient to enable a stable part production with constant and high quality. Scrap rates could be erratic and sometimes very high. In view of the relatively low production volumes this may have been acceptable at that time, but these scrap rates were clearly not considered to be economically viable. Improvements in raw materials and compounds as well as in the production process itself, resulted in incremental gains in efficiency. However, these did not yet lead to a sustainable process.

Stimulated by an article about the use of process data evaluation through data mining tools (used for the optimization of the manufacture of semiconductor chips), the idea was born to try a similar comprehensive approach for SMC part production.



Main steps of SMC process chain from raw materials to part

With the so-called CCC project (Compound Characterization and Consistency) already presented at this conference in 2004, characteristic data of raw materials and process parameters over the entire production chain were collected, combined and correlated with part quality (mainly waviness). The participants at that time (DSM [now Aliancys], Menzolit, Peguform and DaimlerChrysler) agreed to reveal numerous details about their products and processes, including potential weaknesses.

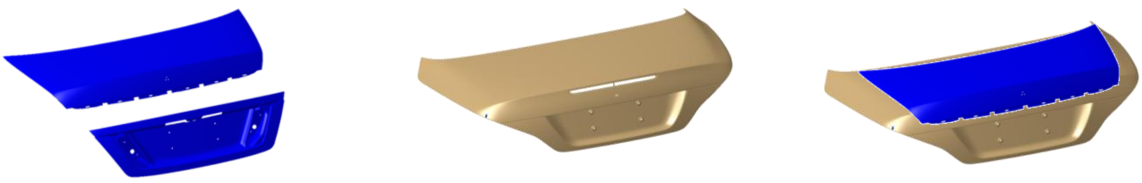
While the ambitious program proved to be a real challenge, everyone involved understood that it was the only way to achieve the necessary technological advancements for widening the application scope of SMC. Over the course of the project, approximately 5 million data points were collected at various points along the process chain during the manufacture of close to 10,000 parts and evaluated with data mining tools. Based on an analysis of the data correlating to the parts with the best properties, the factors most strongly influencing part quality were determined. Some previously hypothesized parameters influencing quality could now be formally confirmed, while others were completely new – for example:

- Reproducible placement of the charge pattern in the mold
- Ideal mold temperature within a specific tolerance
- Specific start-up procedures for the compound production
- Specific and controlled temperature conditions along the complete process and logistic chain (compound maturation, transport and storage of resin and SMC)
- Automated production process for compounding with multi-level process control (component dosing, mix sequence, engine control)
- Traceability of single raw material batches/ process parameters from SMC to the finished parts

Other quality criteria that proved to have no significance were eliminated from the list. After this analysis the implementation of numerous individual measures reduced the scrap rate measurably and allowed for the reduction of quality variations in a major way.

CCC in 2004 was initially a limited program to help in assuring the premium quality level expected for Daimler products and parts. In 2008 this approach was applied to the in-house process for the S-Class Coupé model upgrade. In addition to the elimination of potential quality variations resulting from manual process steps (e.g. the reproducible positioning of the charge pattern in the mold), an automated, comprehensive use of process characteristics and data measurements were introduced as standard mode of operation. As a result, process drift and trends could be quickly recognized and corrected. Furthermore, additional points for potential improvement were revealed and implemented. With scrap rates considerably below 5%, quality figures were achieved previously considered impossible for such a demanding part.

While outer body panels for deck lids are normally designed in 2 pieces (an upper horizontal and a separate license plate area), the deck lid of the current Mercedes SL Roadster introduced in 2012 was envisioned as a one-piece solution in order to eliminate the cost of producing a separate part for the license plate and the bonding of the 2 parts together.



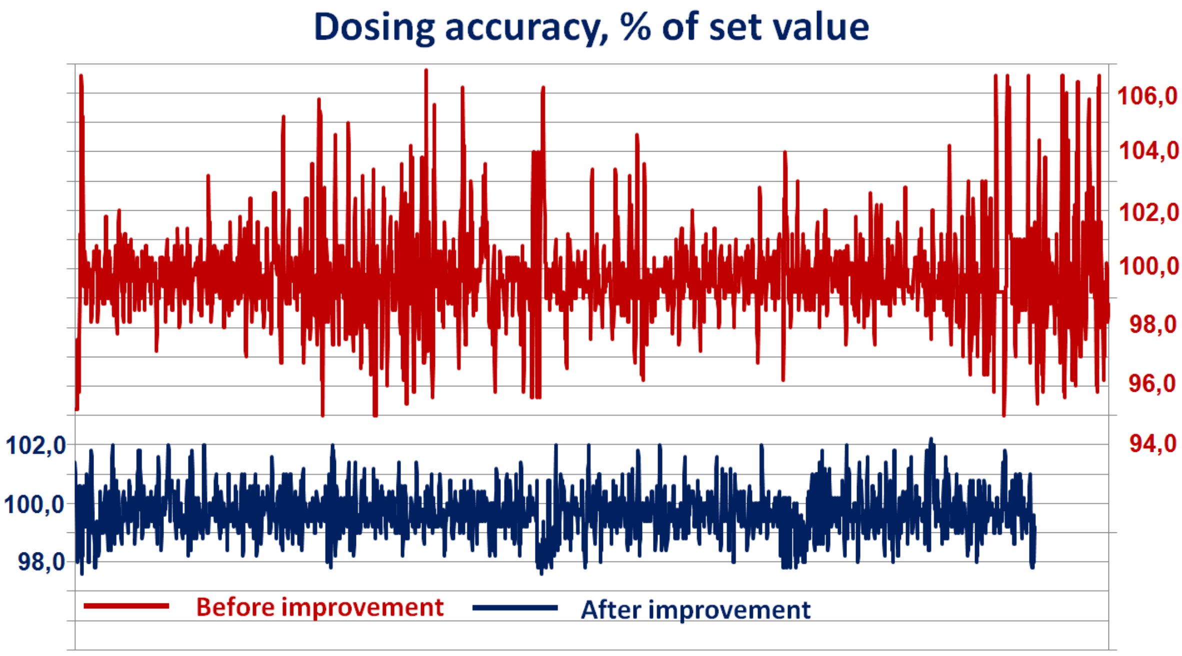
S-Class Coupé | Current SL Coupé | Size comparison

More complexity through progressing technology

This much larger in-mold-coated part presented new major challenges for production, resulting from the extremely long flow paths from the injection point in the middle of the license plate area to the edges.

Again the flow behavior of the compound often lead to inacceptable quality levels with some of the batches, mostly visible as waviness and/ or porosity. Again, Daimler, Menzolit and Aliancys took on the challenge to investigate the root cause of the problems. Thanks to the availability of a complete set of process characteristics and process data measured throughout the entire production chain, combinations leading to truly understanding optimal part properties were rapidly established.

In addition to the narrowing of specific tolerances required for attaining a high level of reproducibility in quality, the approach also provided insight into other process improvement options. This increases process flexibility to a large extent and reduces cost.



Example of process optimization leading to more stable quality

Narrowing process tolerances for certain parts of the supply chain may require a higher investment in resources and process cost. However, it has been our experience that process consistency can be significantly improved for the value chain in its entirety (combining both process flexibility and robustness), leading again to interesting reductions in waste and significant cost savings.

A general framework for collaboration is now existing involving all key partners in the supply chain. This allows all of this to be done with much less effort than during the original CCC project in 2004. Sensors and software for data collection and processing are now affordable. The handling of immense amounts of data ("big data") and data exchange in real time via internet are no longer a problem. Furthermore, the development of powerful analysis and optimization algorithms has made unbelievable progress, which is opening up a wide variety of new opportunities.

For a project like this, several conditions must be met before the project can become a success. First, in a series production with all of its possible combinations of material and process tolerances, it must be possible to distinguish the "good" from the "bad", which means finding a clear agreement on the definition of imperfections for intermediates and final parts, as well as measurement procedures. Additionally, all parties involved need to be convinced that the required efforts make sense without having a clear cost-benefit analysis up front. The cost-benefit analysis can best be done afterwards.

Most important are the absolute openness, transparency and an unlimited will to support all partners. This requires a belief that a cooperative partnership which provides benefits for all is more important than the fear for creating a competitive disadvantage resulting from the exchange of sensitive information. This has worked out outstandingly well in this case, where all partners participated in the project with an open mind. All are deeply convinced of the benefit and that the methodology can be successfully transferred to other complex applications.

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