3 Class A-surface

3.1 Introduction

The german term „Strak“ (in English: Class A-surface) has its origins in the ship building where complicated free form surfaces were described with vertical, longitudinal and cross sections (frames). In the automotive sector this method was adapted for the generation of all non-planar free form surfaces in the exterior and interior work. Before CA-tools came into play design surfaces were based on so-called „sections“ which reflect the main curves (character lines).
For the last 20 years we have been generating surfaces with the help of CA-tools. In this context, the software „ICEM-Surf“ established itself to be the standard tool for surfacing, where different analysis methods like highlights, isometric lines as well as curvature guarantee the surface quality in real time.

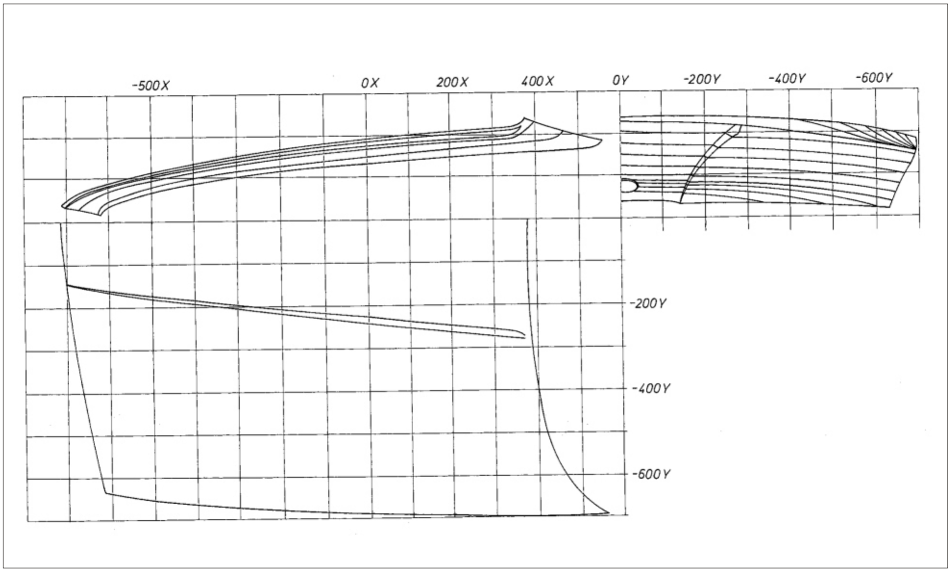

Figure 3.1 ”Sections” on a bonnet outer shape

Class A-surfaces are the conversion of styling data into technically realizable surfaces.

In this chapter we exclusively talk about subjects concerning the outer skin (exterior work), but the described processes as well as the methods can be applied to the interior work or other design topics as well.

3.1.1 The design process of Class A-surfaces

The first step in a development process consists in finding the design of the new product. Starting from initial outlines a physical model is formed. In order to process this model in CAD we need CAS data or a metrological capture of the shape. The Class A-surface designers have to convert the digitised points or the CAS data into manufacturable surfaces in order to deliver data for the following design steps, the strength calculation and the manufacturing. The development of a vehicle is divided into different periods.
The illustration below shows an overview of the different levels.

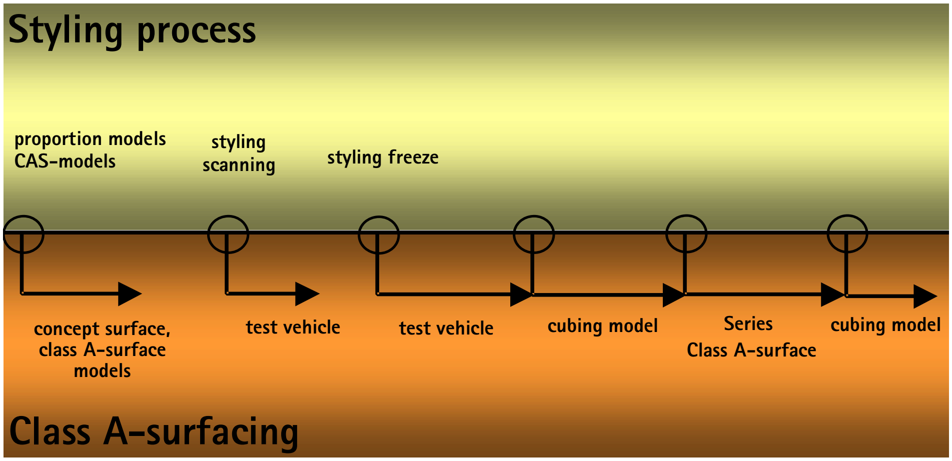

Figure 3.2 Schematic diagram of the design process in ”CLASS A-surfacing”

At concept level different concepts are to be examined concerning their feasibility. In addition to this, first economic evaluations and production schedules are done. At this point the Class A-surfaces are not of very high quality, we rather need quickly designed surfaces in order to describe the different concept models. Once this level is terminated, we obtain one favourable concept. The surfaces necessary for the test vehicles are designed based on their scanning.
In this case, the quality of the Class A-surface concerning manufacturing and mounting has to be increased. In the confirmation period the experiences resulting from the tests are processed. Moreover, manufacturing lines and tools for the serial production are planned. At that level, the description of Class A-surfaces gets more and more detailed, the design of the joints starts. Based on the designed surfaces a hardware model is milled, well known as cubing model.
At the end of the car body development process serial Class A-surfaces are generated. The quality of these data has to be on highest level, and at this point we talk of „Class A-surfaces“. Finally, a serial cubing model is presented.

3.1.2 The styling data related component design process

When we talk of CATIA V4, the styling data related component design process is a nearly serial one. In given cycles the surfacers are provided with styling data. Here the surfaces are designed and passed on to the component designers. In any case, I don´t want you to get the impression that these jobs were not done simultaneously. But in a non-associative process like in CATIA V4, the surfaces subject to changes have to be redesigned in the following process. In an associative process CATIA V5 can assume many operations of the work flow in case of modifications or enables the component designer to work on assumptions at a certain time. Furthermore, he can work with substitute geometry if a certain maturity of data does not yet exist.

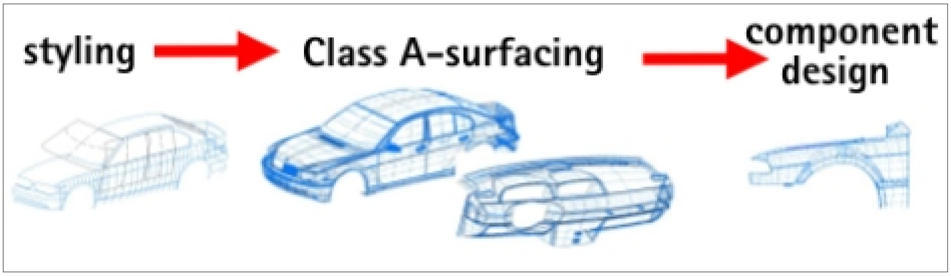

Figure 3.3 Design process ”Class A-surfacing” and component design

3.1.3 Reorganization of the design process

In an associative process we reorganise the workflow, because only by this we are able to reduce the time necessary for development. This has an impact on the following topics:

- The contents of Class A-surfaces
- Class A-surface conventions
- The styling data related component design process
  - Co-operation between 2 assemblies
  - Co-operation within an assembly
- Usage of the adapter model as a design buffer
- Dividing the components into
  - directly Class A-surface depending components
  - indirectly Class A-surface depending components
- Adapting the design method applied at component level to
  - sheet-metal components
  - volume based components

3.2 The Class A-surface related component design process

Due to an **associative design process** we are able to restructure the development process between Class A-surface and component design. In the following chapters the innovations will be described.

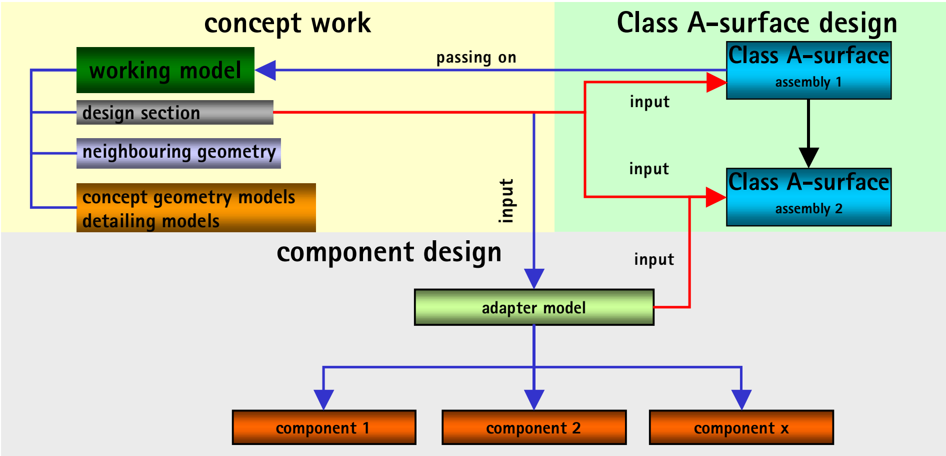

Figure 3.4 Co-operation between concept work, surfacing and component design

The illustration above shows the data flow between the 3 design processes. The red arrows represent the input, i.e. the process gets data from his process partner in order to evaluate and to work on them. The blue arrows show the passing on of data to the design steps to follow.

3.2.1 The design process between 2 component assemblies

The following illustration shows the temporal development process between 2 component assemblies. For our new alignment let´s have a look at the process between a virtual assembly and the first hardware assembly.
The 4 bars describe the workflow of the involved design steps (Class A-surfaces, concept work, component design, outer skin and component design and indirectly dependent components). The upper bar represents the time schedule (synchro points) describing in different colours the start and the end of a period. The yellow triangle refers to the Class A-surfaces, the blue one on the concept work and green one on the component design.

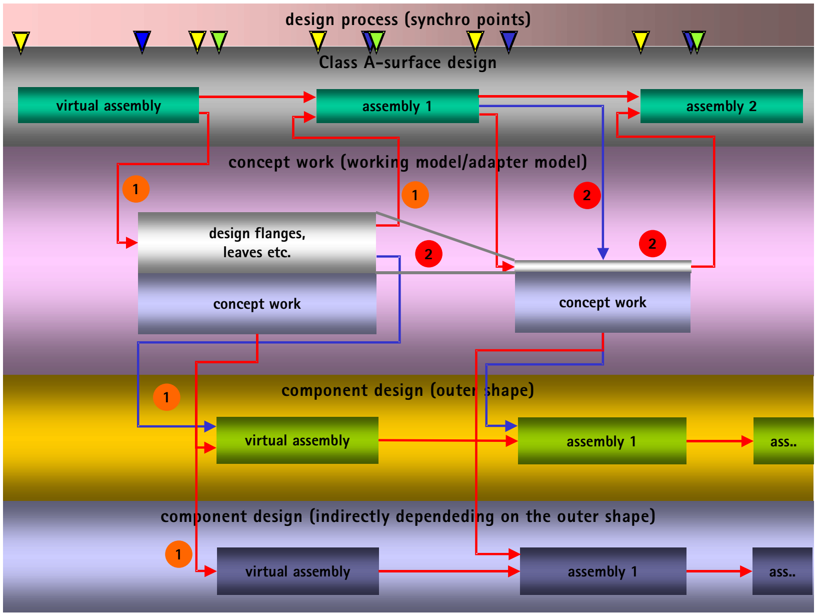

Figure 3.5 Design process between surfacing and component design

The single steps which are marked with ①, ② will be explained on the following pages.

In order to put this process into practice, we have to define new premises.

1. The component designer determines the flanges, hem radii, etc. and the surfacer integrates these requirements into his Class A-surfaces!
2. The components depending on the outer skin (CATParts) are always provided with the same input in the form of surfaces. This means: Missing specifications have to be worked in!

Step ①

With the beginning of an assembly, the surfacer gets new CAS data as design input. Based on these data the main surfaces are designed at first. After their completion the surfacer passes on a rough surface to the design. Now the designer begins with his concept work in order to work out the needed flanges and concepts. The surfaces necessary for this are generated in the adapter model as buffer design (chapter 5.9, 5.10).

After having reached an agreement with the package area colleagues, the data are passed on, as parameter or surface to the surface design on the one hand, and with the help of the adapter model to the component design on the other hand. The surfacer can still integrate the feedback from the design or, if this step is not necessary, the data serve as basis for the next component assembly.
Now the component design is ready to start. Outer skin depending components are directly designed based on the styling data, indirectly depending components are designed with modified styling data (offset, cutting).

For the duration of the surface design this process is a permanent iteration between Class A-surface and component design.

Step ②

Now we begin to design the next component assembly (component assembly 2). Basically, the process is identical, the concept work is the only difference. The buffer design job in the adapter model mentioned above decreases, because the surfacer has all the necessary information about the flanges, etc. from the previous component assembly are thus is able to integrate these information immediately in the form of geometry. Furthermore, the input of the design contains substantially more precise information.

So we see that from now on the buffer design with serial surfaces gets superfluent and consequently, the additional effort in the concept work is not necessary any more.

3.2.2 Design process within a component assembly

Here we take a closer look on the development process within a component assembly. If we precisely study the illustration, we see the contents of the development process between two component assemblies. In the upper bar the time schedule (synchro points) is illustrated again. The yellow triangle refers to the Class A-surfaces, the blue one to the concept work and the green one to the component design.
Now I would like you to focus on the development process between the Class A-surfaces and the concept work.

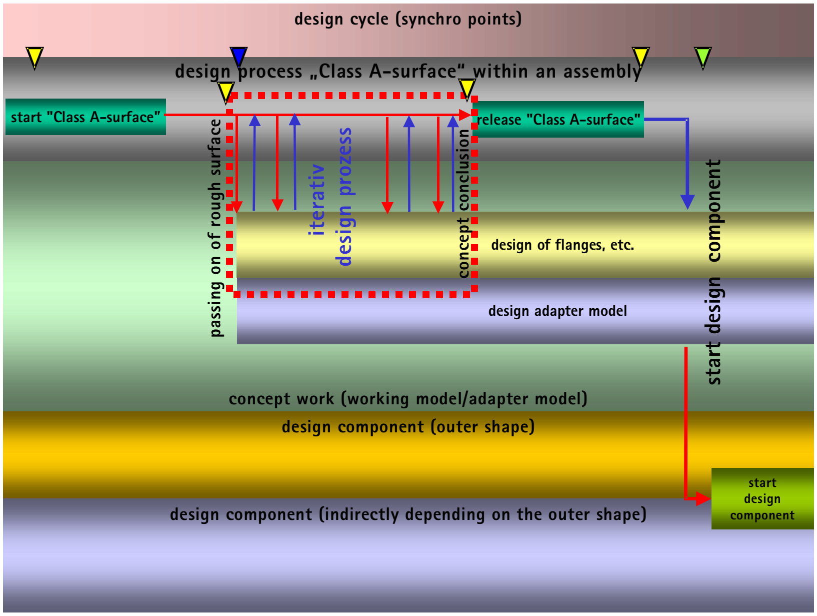

Figure 3.6 Iterative process between surfacing and component design

In order to guarantee a better understanding for the illustration, we assume a duration of 12 weeks for the surfacing job. The faster we are able to deliver a rough surface (we need about 4 weeks), the more time remains to do the concept work together with the design. To enable the surface designer to integrate the results from the concept work, a certain time has to be fixed, when the output from the design has to be delivered (ca. 4 weeks before releasing the Class A-surfaces).
Now 1/3 of the time still remains for the iterative design process between Class A-surfaces and design. If we consciously underpin the following methods and processes with capacities, a substantial acceleration of the development process can be reached!

3.3 Contents of Class A-surfaces

In the associative process we deal with immature, incomplete and assumed data, too, so the contents of the Class A-surfaces have to be named and underpinned with conventions. We have 3 types of Class A-surfaces: the concept surface, rough surface and the serial Class A-surface. Basically, the conventions listed in the following apply to the serial Class A-surface, because only they totally satisfy the requirement **„Class A"**. Concerning the rough surface and concept surface, the involved parties have to find an agreement with respect to the development period. Fundamentally, the following rule is applied to these surfaces: as rough as necessary and as precise as possible.

3.3.1 The concept surface

Once the product features and the rough vehicle dimensions are defined the concept period begins. So the styling makes up his mind about the appearance of the vehicle and the design begins to develop technical concepts.
Due to the fact that the surface design (Class A-surfaces) reflects the interface between design and technics, we face with the **concept surface** at concept level.

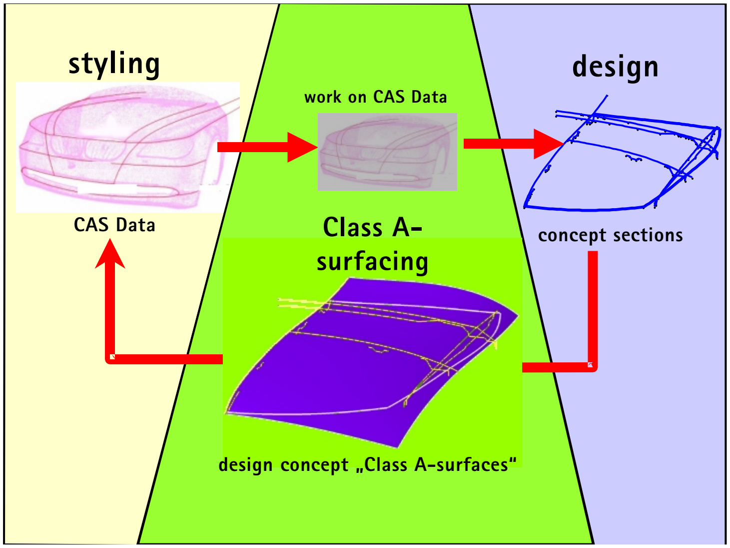

Figure 3.7 Work flow at concept level

☝ The aim of the concept surface and the respective concept sections is to harmonize design ideas with technical requirements!

The process of co-operation looks as follows:
To a certain development destination, the design provides the surface design with „CAS data“ (STL, scannings, Alias surfaces). Here the data are examined with respect to precedent data and prepared for their further usage.
Afterwards, these are passed on to the design. Now, based on these surface data, the concept sections are generated. If divergences come up which do not allow to maintain the concept, the designer illustrates his proposal, e.g. in another concept section using another colour.

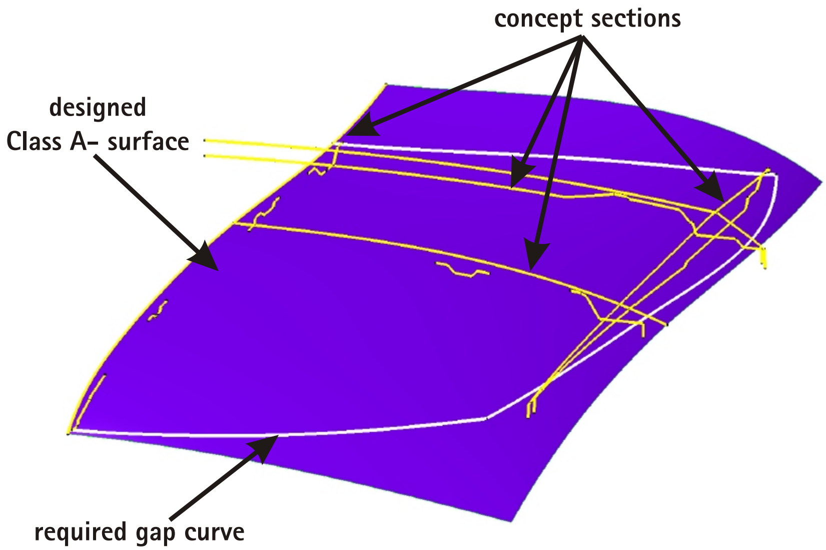

Figure 3.8 Concept surface "bonnet" with concept sections

In the following the concept sections with the divergences are delivered to the surface design. Here, the original CAS data are literally „dragged“ until they fit to the concept sections. When this step is done, the concept sections and the concept surface are passed on to the design and are subject to discussion.

The real process is not as simple as described above because important topics like overall package and a consistent body in white design were not considered. When you put this process into practice, your internal process chain has to be included.

The **concept surface** is based on **concept sections** and not vice versa!

3.3.2 The rough surface

The rough surface contains no „Class A-surfaces", but is an approximate description of the desired design contents. In fact, they are derived from the „real" Class A-surfaces. This deduction starts with the design of the first component assembly and ends with the release of the Class A-surfaces. This is not to say that between the component assemblies the component design receives only rough surfaces as input, but: If a subject is worked into in the Class A-surfaces, they are released.
For a better understanding let´s have a look on the following example, the front bonnet. When the „Class A-surface" of the bonnet is geometrically described together with the gaps and the flanges, the „Class A-surface" can be released, though the data of the front light or the side panel are still immature (highlights, gaps).

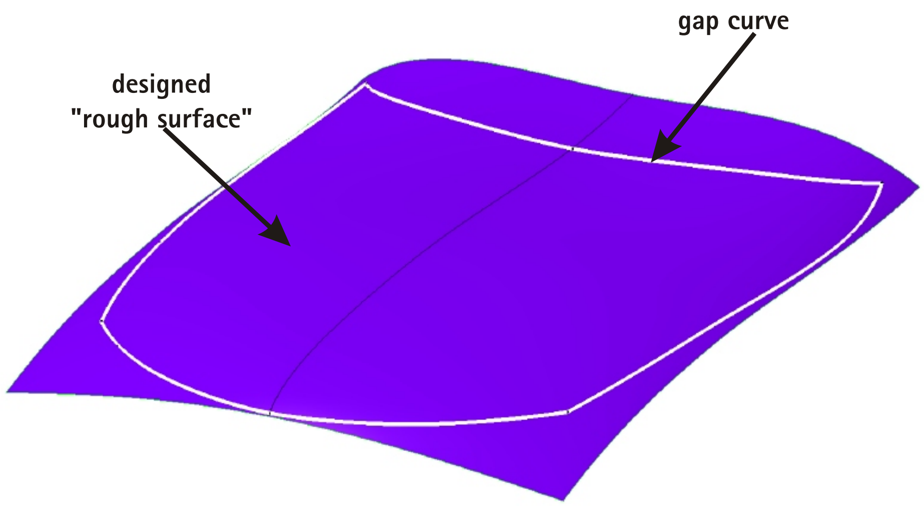

Figure 3.9 Rough surface of the bonnet in the first virtual assembly

This was all mere theory, the practise looks as follows: Due to the fact that in the different component assemblies we receive a rough surface as input for the component design, we are able to adjust the technical topics again and again on its changes or to have influence on it.
Exactly this iteration is called „design technics convergence".

The integration of Class A-surfaces into the component design will be treated in the chapters 5.9, 5.10 and 6.5, 6.6.

3.4 Conventions for the contents of Class A-surfaces

Class A-surfaces serve as input for the outer skin depending components, that´s why we need a global convention covering the whole impacted design process. In this context, I won´t consider every component or every design step, but I will offer an idea which enables us to install a stable **associative parametric process**.
These conventions are listed in the following and underpinned with an illustration. Especially the subject „**partitioning of Class A-surfaces**“ requires a lot of effort, because all Class A-surface depending components have to be evaluated.

3.4.1 Surface quality

The surface quality of Class A-surfaces is already standardised and fixed in the „VDA guidelines“. At this point the tolerance values regarding point and tangent continuity are only mentioned as reminder. As far as the curvature continuity is concerned, we have to define new quality requirements, especially for variable fillets continuous in curvature, their value often lies under a certain minimum value. The limit for this minimum value is the thickness of the component plus 20% of tolerance. In any case, all **form-giving radii** are **excluded** from this rule, for example the radius of the varnish dividing joint which is part of the bumper.

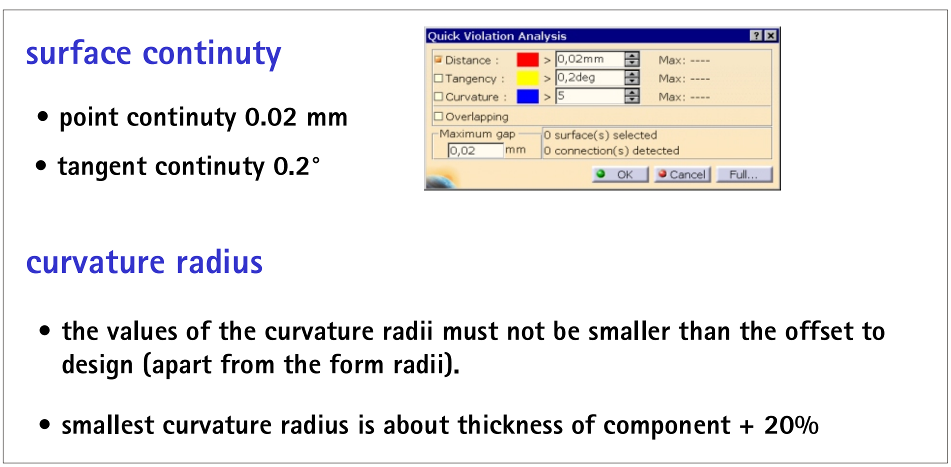

Figure 3.10 Surface quality standards

3.4.2 Partitioning of Class A-surfaces

The partitioning of Class A-surfaces played no role in CATIA V4, because all surfaces existed and after the creation of a SKIN were topologically splitable into the different components. And if they did not exist, we could generate them by facing the already existing surfaces and copying them into the component.
With the application of CATIA V5, we can benefit from **two new methods**:
First, the Class A-surfaces are linked with the component, or, if they exist in the form of V4 geometry, we know which *SKI was used for which component. The advantage lies on the hand: In the following development process it is evident which surfaces were used.
The **second** method refers to an **associative link** between Class A-surfaces and components. In this case, the Class A-surfaces have to be prepared in a way that enables us to use them directly in the component design.
This is illustrated in the following example.

"Class A-surfaces" rear bumper system

Partitioning of the surfaces:

Surface.1 [part "inner towing eye"]

Surface.2 [part "exhaust system"]

Surface.3 [part "outer towing eye"]

Surface.4 [bumper left side]

Surface.5 [part "park-distance-control"]

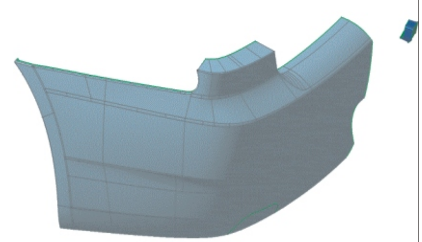

Figure 3.11 Partitioning of Class A-surfaces into several single areas

We see that the bumper has several cut-outs reserved for the towing eyes, the exhaust system and several park distance control units. If we exclude these cut-outs from the complete Class A-surface, we get a closed surface which in general is even symmetrical to the XZ-plane. The resulting surfaces can now be delivered to the component design, either as *SKI or as surface (see the illustration above). In consequence, the offset as well as the split operations in the component can be carried out more easily.

This method has another advantage: If the Class A-surfaces are partly subject to changes, only the **impacted domains** lose their validity, but not the **complete component**!

3.4.3 Flanges with oversize

The component designer determines the length (nominal length) of the flanges in his concept, of course in agreement with the surfacer. In order to ensure that the flanges can be split in the following design process, an additional extrapolation value is determined in agreement with the surfacer, who has to extrapolate the corresponding surfaces. That is to say that the flanges becomes longer than previously determined in the concept.
According to our formula the extrapolation value is 10% of the nominal length.

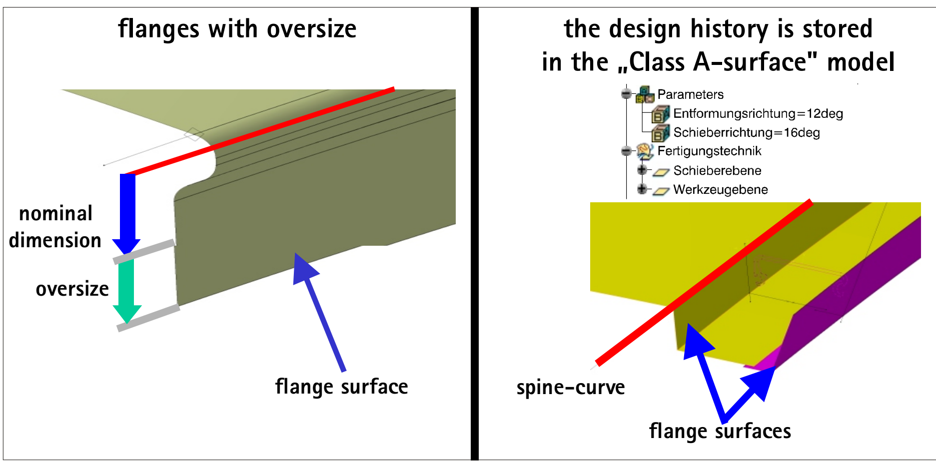

Figure 3.12 Convention for flanges with oversize and their design history

3.4.4 The design history is stored in the Class A-surface model

In many cases the component designer needs the design history, therefore the surfacer should store these input elements in his model. Generally, these are spines, reference surfaces for the flanges and the theoretical corners (curves) on joints. In fact, these theoretical curves are the most important input elements, because they are often used as base curves for splitting the neighbour components (e.g. outer skin and inner panel).
As shown in the illustration, numerical values like the angle of a flange surface to the base surface or geometry indicating the die face as well as the cam direction should be considered, too.

3.4.5 The representation of hems

In this context we have to be aware of two conventions, the hem radius or the hem process on the one hand and the geometrical representation of the pipe on the other. If we integrate the hem process into the generation of the concerned Class A-surface (hem pipe) as shown in the illustration, a convention for the representation is enough. In case of a normal hem, the value of the hem radius is equal to the offset of the hem. In consequence, we need exactly the half representation (=180°) of the hem pipe in order to design the offset surface.
In case of a rope or a stepped hem we have to make sure that the hem pipe is designed with = 270°, because the offset surface has to be filleted with. If we now find an agreement with the surfacer concerning the applied hem process, we always get the proper hem pipe.
But still take care when designing tailored blanks!

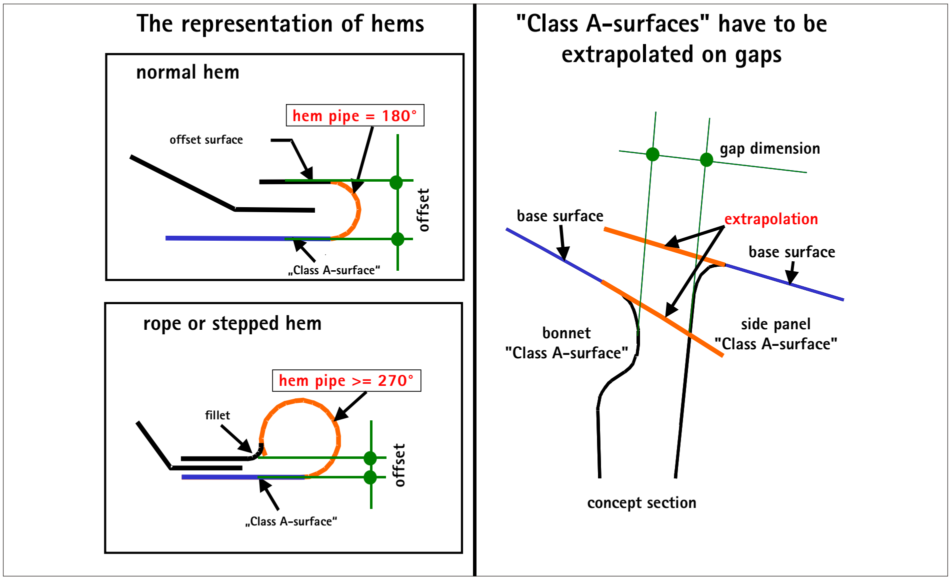

Figure 3.13 Convention for the hem process and gaps

3.4.6 „Class A-surfaces" have to be extrapolated on gaps

In our design process we often need the non-filleted base surfaces. We use them for offset operations in the component design or in the tool design for the die holder. In both cases the designer has to extrapolate them, because they are mostly too short.

The surfacer himself has to make sure that when extrapolating the base surface it is still continuous, in curvature as well as in tangency. The extrapolation value corresponds to the length of the gap, but can even be higher!