technet GmbH

TEXTILE GAS STORAGE SYSTEMS

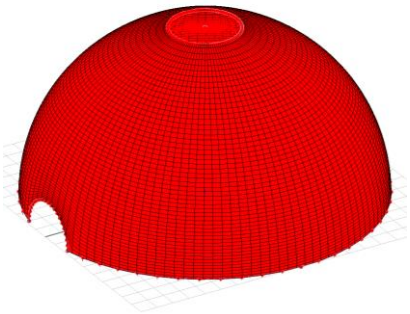
EASY SOFT-WARE

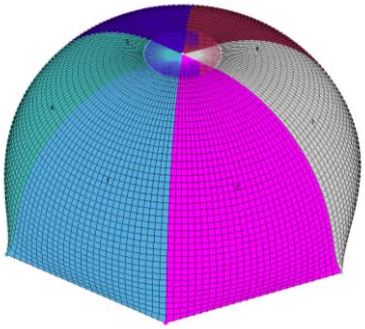
THE CALCULATION OF GAS STORAGE SYSTEMS

SHAPE DETERMINATION, CUTTING PATTERN GENERATION AND STATIC ANALYSIS

Today, computer models play an important role in the calculation of textile membrane and foil structures. In order to derive high-quality results from a model, the software used must enable a description of a structure that is as accurate and complete as possible. For pneumatically tensioned structures, the creation of the models and the static calculation is a challenge in many cases.

Special requirements for biogas plants were developed by the company technet GmbH as part of the research project "Research into new solutions for textile biogas storage" funded by the Federal Ministry of Food and Agriculture (BMEL) and integrated into the existing software product Easy.



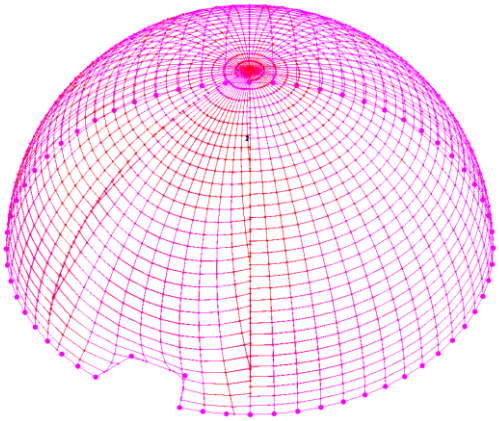


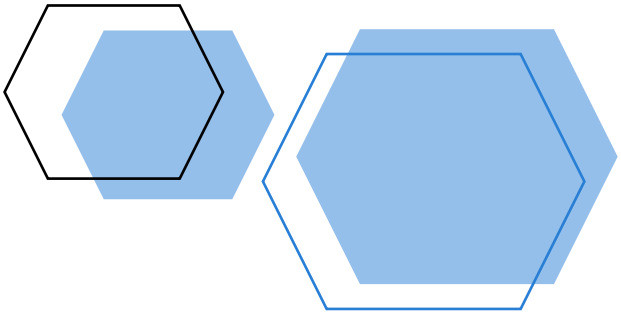
SHAPE DETERMINATION

STRESS HARMONIC SURFACES

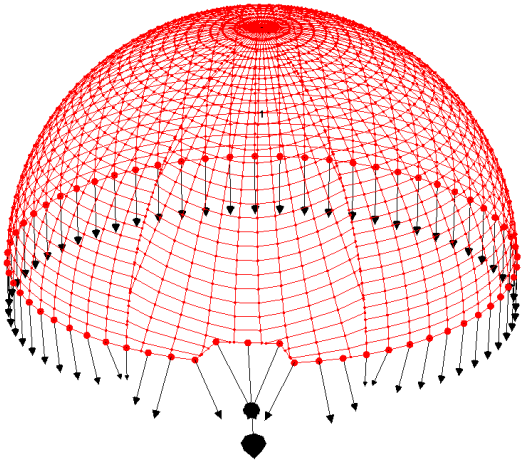
The shape determination is often underestimated in the calculation by determining the surfaces purely geometrically. However, a geometric determination is only possible for spherical sections. For all other geometries, such as polygonal "spherical edges", spherical surfaces disturbed by installations or shapes over rectangular ground plan, the purely geometric determination of the surfaces is always wrong.

Pneumatic membrane shapes are physically defined as prestressed surfaces under internal pressure - a fact that must be considered when finding the shape. This is important because otherwise unstressed surfaces with many wrinkles are created that are overstressed in other areas. This can lead to safety problems and to a shortening of the service life of biogas plants.





SHAPE DETERMINATION WITH DISTURBED SURFCAES



COMBINED MODELS

When using purely geometric functions to generate pneumatic models, it must be ensured that the resulting shapes can be formed pneumatically. If this is not the case, the non-linear static calculation may lead to no result or the result geometry of the static calculation without external loads may be very far from the originally desired geometry. Only a few geometric functions such as spheres, cylinders and segments of these shapes are useful.

Surfaces disturbed by installations influence the form. To keep the manufacturing process simple and the production costs low, the Easy software package offers a possibility to carry out the shape finding process only for the interfering area and to assemble it later with the "undisturbed" rest to a new shape.

STATIC ANALYSIS

$$\boldsymbol{\sigma} = \begin{bmatrix} \sigma_u \\ \sigma_v \\ \tau \end{bmatrix} = \begin{bmatrix} m_{11} & m_{12} & 0 \\ m_{21} & m_{22} & 0 \\ 0 & 0 & m_{33} \end{bmatrix} \begin{bmatrix} \varepsilon_u \\ \varepsilon_v \\ \Delta\alpha \end{bmatrix} = \mathbf{M} \cdot \boldsymbol{\varepsilon}$$

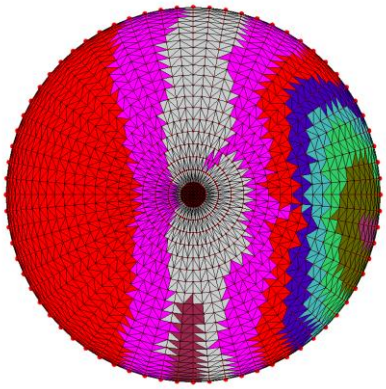
σ_u	Stress in warp direction
σ_v	Stress in weft direction
τ	Shear stress
m_{12}	Crimp
m_{11}	Stiffness in warp direction
m_{22}	Stiffness in weft direction
m_{33}	Shear stiffness
ε_u	Strain in warp direction
ε_v	Strain in weft direction
$\Delta\alpha$	Shear deformation

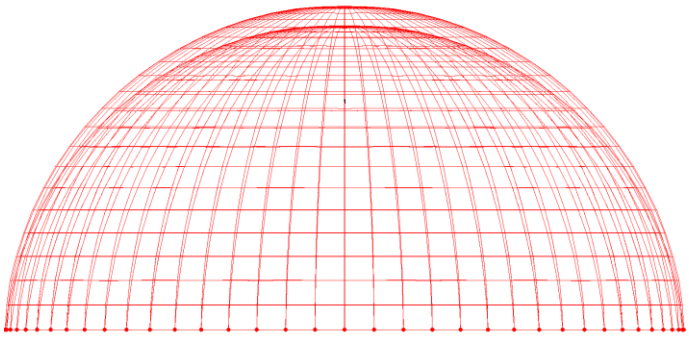
GAS LAW AND MEMBRANE CONTACT

A static calculation for membranes and foil structures is geometrically non-linear. The calculation requires the unstressed geometry and the material properties for all elements of the model. For the load case calculation, the external loads and, for pneumatic structures, also the internal pressures or volume data are required. Additional boundary conditions for pneumatic structures are that the loads are deformation-dependent and that the gas law must be considered in certain load cases.

Not all software packages are able to provide reliable results because the consideration of the gas laws is unavoidable in certain load cases.

In the case of double membrane storage tanks, the air volume between the outer membrane and the gas membrane and the gas volume influence each other. The Easy software package takes this relationship into account. Easy also deals with the possible contact between the outer and inner membrane that occurs, for example, with wind loads.



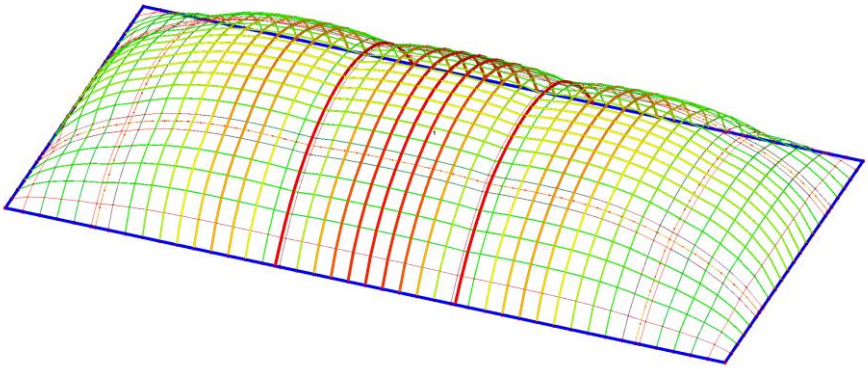


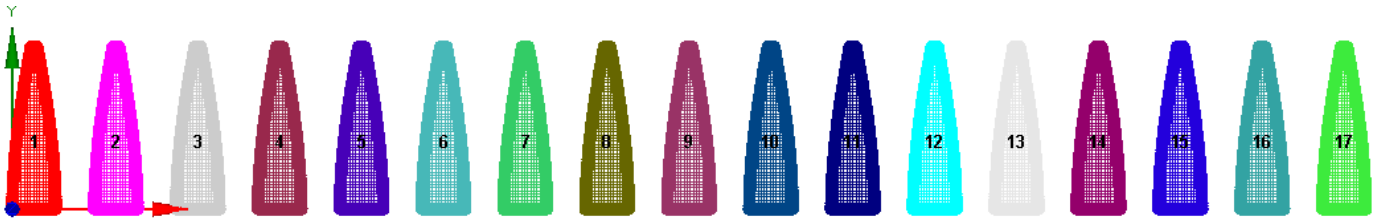
CABLE NET REINFORCED GAS STORAGE

CONTROL HIGH MEMBRANE TENSIONS

If the stresses in the membrane become so big that even the strongest membrane material can no longer bear the stresses, then the membrane must be reinforced with cable nets.

Our system is able to let the cable nets " slide" on the membrane surface. The membrane can be calculated and analysed together with the cable net in one model.





CUTTING PATTERN GENERATION

AUTOMATIC GENERATION OF THE PATTERNS

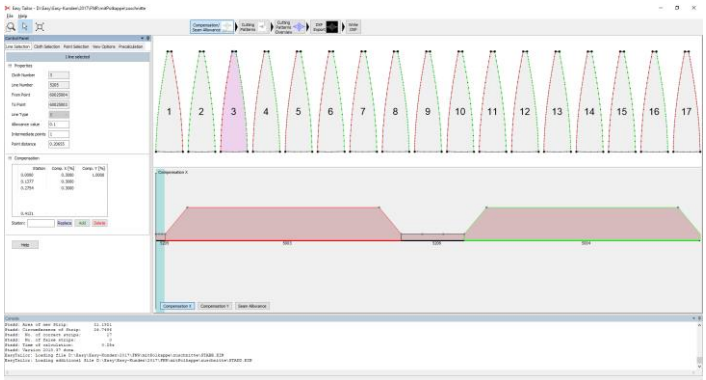
The creation of cutting patterns is an essential part of the technical process in textile architecture. The task is to bring a usually double-curved, pre-stressed surface onto a flat material with a limited width in such a way that, after welding the strips and building up, exactly the shape is created that was previously modelled in the computer.

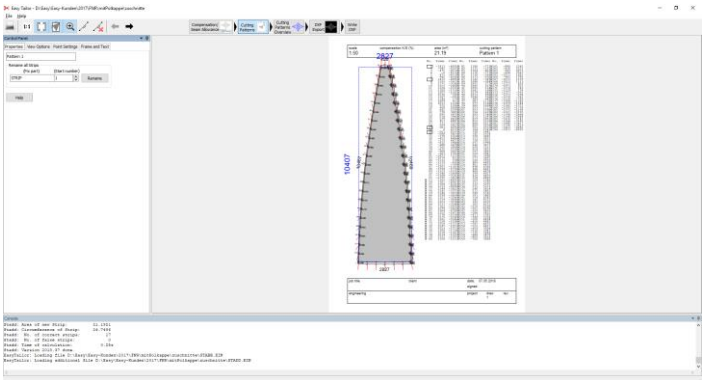
The generation of the cutting pattern is influenced by the following factors:

Since doubly curved surfaces cannot be mapped into the plane without distortion, efficient flattening strategies must be used.

- To minimise waste, the planar strips must be as straight as possible.
- To minimise work, the widths of the plane strips should be as wide as possible. The maximum strip width depends on the roll width of the material used. Nevertheless, the deformations during the mapping process must be kept as small as possible.
- The geometrically created surface must be corrected (compensated) to obtain the correct prestressed surface.
- To avoid problems when joining the strips, the corresponding seam lines of the individual strips must have the same length.

Automatisms can be used to generate cutting patterns in a few seconds. The result can be sent directly to the cutting machine.





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