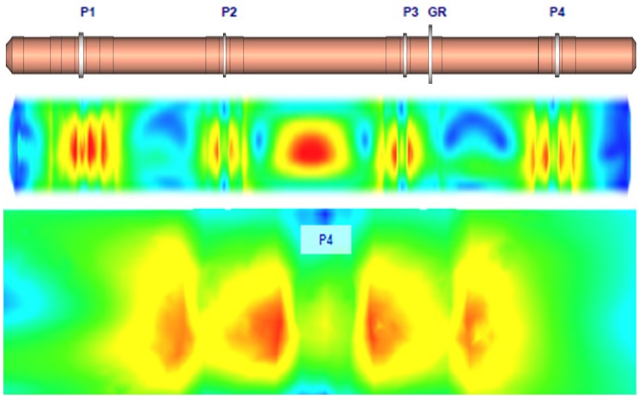
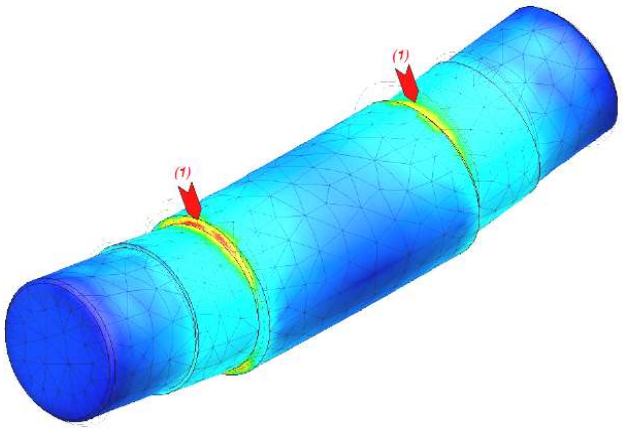
NUMERICAL STRENGTH CALCULATIONS



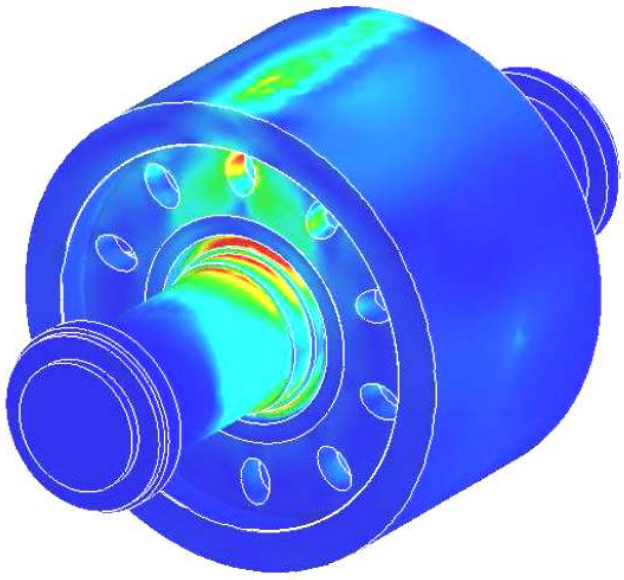
ROTARY DRUMS

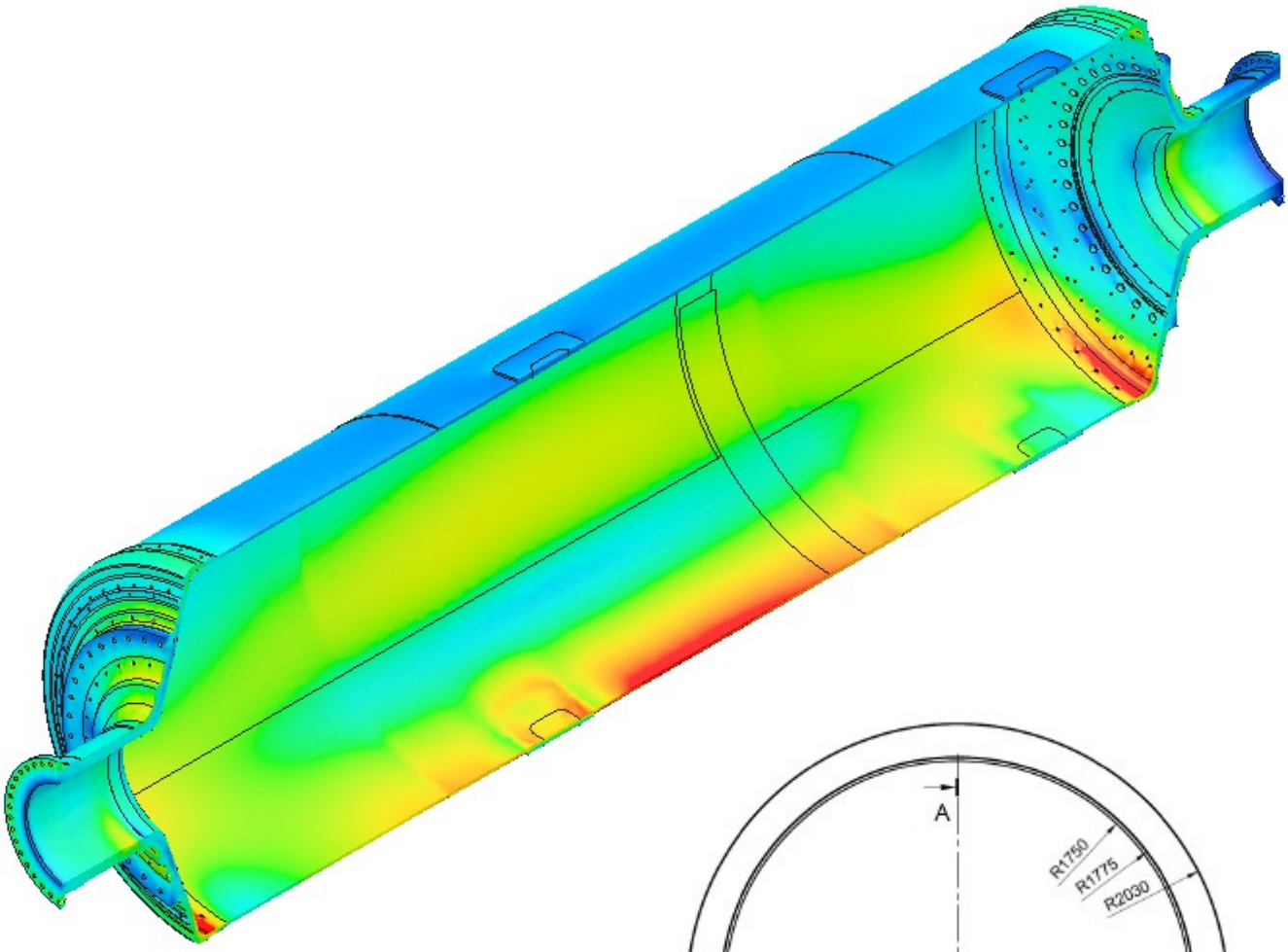
In many cases, the elements necessary to carry out detailed diagnostics of a rotary drum are strength calculations of its components. They make it possible to clearly distinguish whether the possible failures of the object are related to improper conditions of its operation, or to errors in the manufacturing of a given detail, or to design errors caused by improper load assessment.

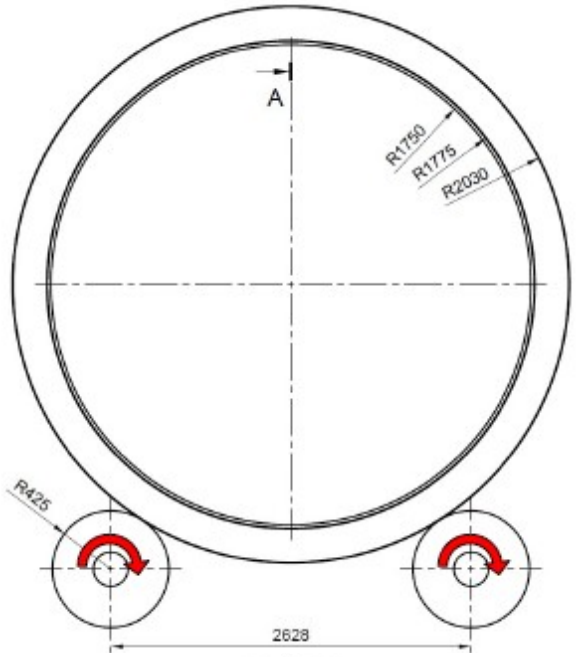


As part of the diagnostics of rotary drums, shell stress analyses are routinely carried out for objects considered as flexible. They are performed using the FEM method (Finite Element Method), most often in a simplified manner, based on the beam model, in accordance with the assumption that the stress state is decisively influenced by normal stresses caused by the bending moment.
The deformation state of the shell is determined by the value of the deflection arrow of its axis. This parameter is necessary to determine the correct positions of the support rollers. In addition, in some cases, as part of the inspection data analysis and as part of guidelines development, the following are additionally calculated (using generally available analytical formulas): stresses in the shafts of support rollers and raceways of the live rings, as well as surface stresses in the contact zone of the rings with the support rollers.
For most applications, such simplified calculations prove to be completely sufficient.
However, this approach is not fully satisfactory where we are dealing with complex strength, and the simplifications used in classical methods are ignoring this fact.
To the factors influencing the accuracy of the mapping of the actual load conditions in the mathematical model we can include:

- notch phenomenon, i.e. the impact of local and rapid changes in the shape of a detail on the stress concentration within the area of these changes; this influence is not taken into account in the beam model or in classical analytical methods, or it is taken into account by means of factors the values of which are only determined experimentally;
- the effect of the method of supporting / fixing of the detail, which in fact has a surface, not point character as it is assumed in the analytical method or numerical analysis based on a linear model;
- influence of load distribution, where in simplified methods the load is most often replaced by a force or a concentrated moment applied in one or more points of the model;
- contact between details; in strength calculations we use the mean load model without taking into account local effects and the permissible surface pressure, taken into account in the linear model, is not the same as the stress in the contact zone, calculated on the basis of a three-dimensional nonlinear model.



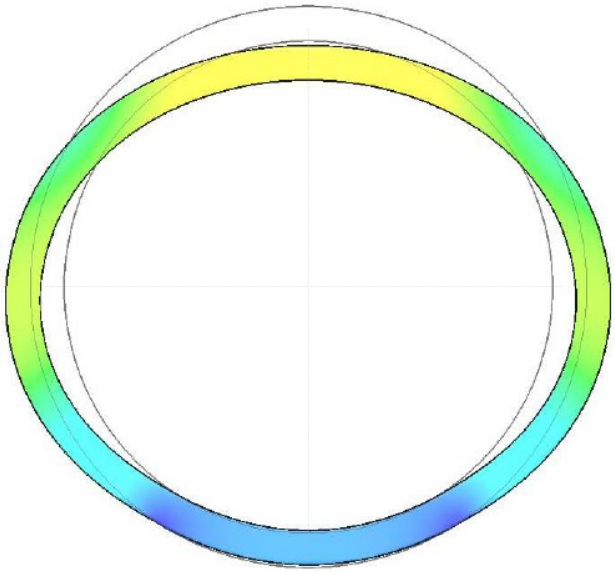


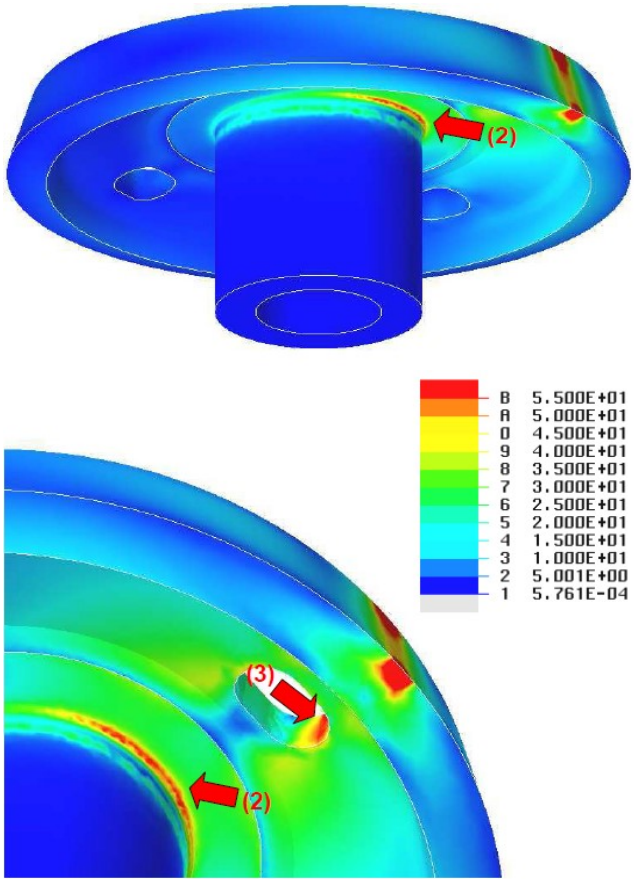


The aspects listed above are included in the finite element method using multi-node spatial three-dimensional elements (so-called **3D FEA**).
This method, available in the form of complex engineering software, provides the possibility of very detailed determination of the stress distribution in each of the drum elements. It also enables the determination of deformation / strain / displacement in any cross-section of a given detail and its influence on the load on other details.

The key to obtaining correct results is the appropriate identification of the model and faithful representation of it in the form of a three-dimensional solid, on which surfaces should be placed loads, correctly identified in terms of their value and direction (including thermal loads), and the solid itself should be properly "anchored" in space by assigning to it the movement limitations (by the so-called taking away the degrees of freedom).
It is not an easy job. It requires many years of systematically gained experience, including the right selection and a thorough understanding of the essence of the numerical method.
We can proudly point out that ZMP engineers have both the appropriate spectrum of software (we mainly use Auto-desk products) and the necessary many years of experience acquired in the implementation of this type of work.

We carry out strength calculations from the first years of the company's existence.

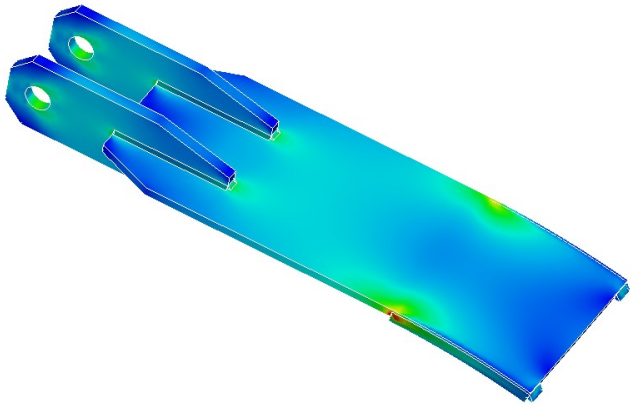




Application

- determination of stresses and deformations, including the comparison of the obtained results with the permissible values for the materials used, both in terms of temporary and fatigue strength, in relation to:
  - drum's shell, focusing on sensitive places in the form of manholes, support places, under-ring areas, etc.,
  - support system (live rings and support rollers, journals, sliding bearing bushings),
  - bottoms and bushings (mainly for ball mills),
  - elements of the drive sections (gear rim / pinion of the open gear),
  - couplings, bearings and other transmission components;
- determination and analysis of contact stresses (mainly in relation to the contact area of the support roller with the live ring or the teeth of the open gear),
- proposing design and / or material changes in order to adjust the stresses to the limits resulting from the allowable stresses for the used or newly proposed materials;
- verification calculations to confirm the effectiveness of proposed or already implemented changes;
- analysis of the influence of fits in the connections of details (applies to assemblies of the shaft - raceway of the support roller, shell - live ring);
- on the basis of the above, the selection of standardized machine parts (e.g. couplings, bearings, motors, reducers).

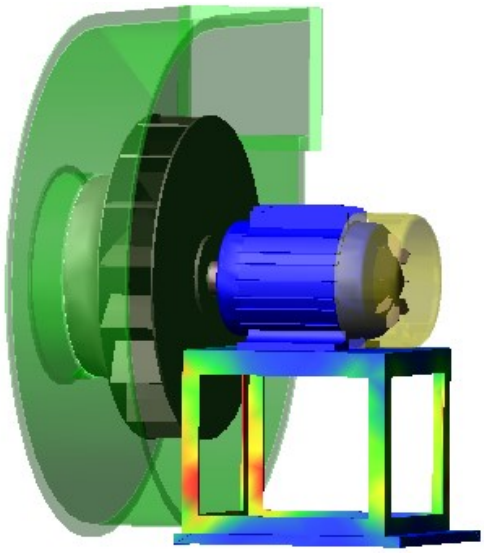
We offer the above services both for new or planned objects (as **verification**) and for the already existing ones (in terms of determining the degree of use of their strength limits and in order to propose **modernization improvements**).



OTHER TECHNICAL OBJECTS

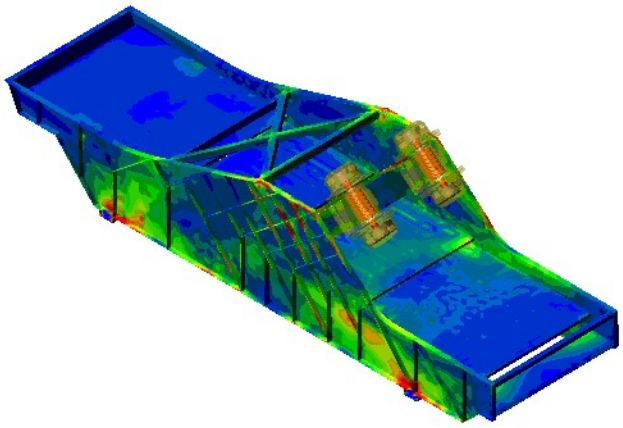
Based on many years of experience from the strength analyses of rotary drums, ZMP engineers also undertake similar analyses in relation to other technical objects.

In addition to purely static or quasi-static strength analyses, we also perform **dynamic calculations** in which the temporary variability of loads is taken into account. This is important for diagnosing the condition of rotating machines, machines with rotating structural elements, or machines with a percussive nature of work (sifters, vibration separators, etc.).

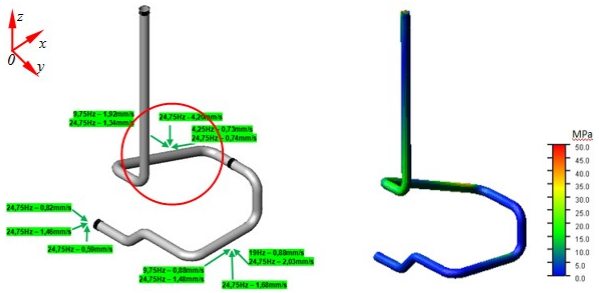


Machine vibrations are usually a disadvantageous phenomenon, that reduces the service life of structural elements as a result of impact and / or fatigue loads. Elements of a machine or structure subjected to static loads may have theoretically unlimited strength. Meanwhile, the variable load, with the amplitude corresponding to the value of the static load and the highly cyclical nature of the changes, will cause damage to the element in a finite time.

To correctly determine the cause and nature of the excitation, we perform modal and ODS (Operating Deflection Shape) analysis. These tests are supported by dynamic analysis, thanks to which it is possible to determine both the frequency of natural vibrations and the form of these vibrations. Determination of dynamic stresses in machines with a shock-like nature of work, as well as in vibrating pipelines, is an extremely difficult task, but possible with appropriate background and experience.



The use of numerical analysis allows to bypass the measurement limitations that occur when examining real objects.



For example, the vibration parameters of selected pipeline cross-sections can be measured without contact (with a laser vibrometer), even when these places are not easily accessible. However, the determination of the stresses occurring in these sections in industrial conditions is much more difficult. Fortunately, they can be determined using numerical analysis - made on the basis of vibration measurements.

In the absence of technical documentation of the object, or in the case of uncertainty as to its credibility, an indispensable element preceding the performance of strength calculations is the development of a three-dimensional solid model. In this regard, we use 3D laser scanning (see separate advertising materials).

More information about our firm's activity can be found on our Internet site **www.eurokiln.com**.