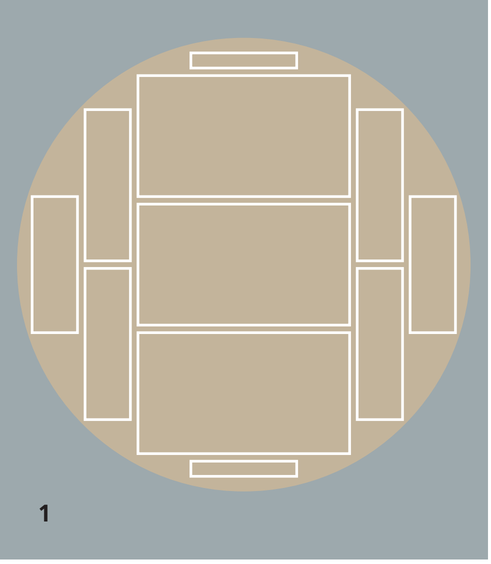

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OPTIMAL SOLUTIONS FOR CUTTING PROBLEMS

1 Sectional view with maximum yield

2 Wooden boards of different dimensions

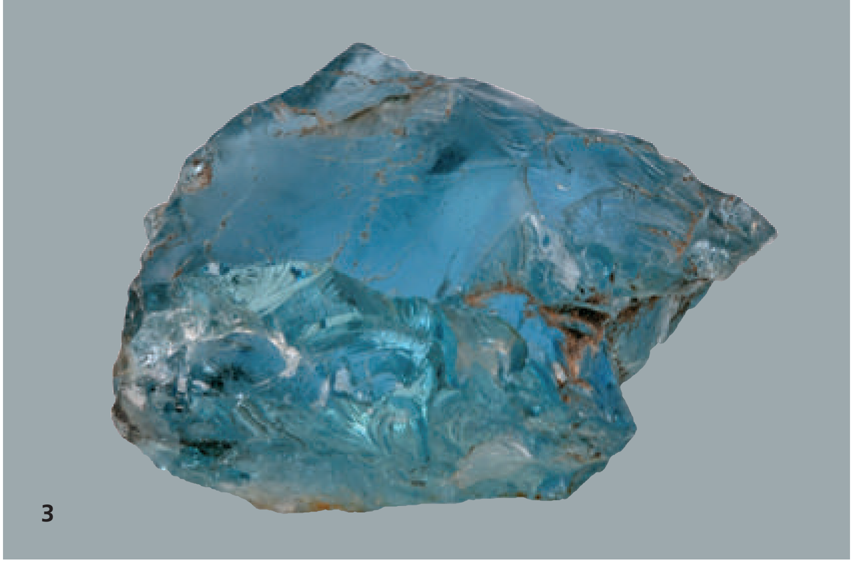
An integral part of many production processes is the cutting of blanks into products. In the wood processing industry, for example, logs and shelves are sawn, in the metalworking industry different components are stamped out of metal plates, and in a variety of industries coils of different materials are tailored. For all these jobs, quite different cutting tools are used, such as circular and band saws, water and laser beams or die-plates. In many applications, however, the blank cannot be completely converted into products, but useless waste is created that ought to be minimized. The department is currently working on several such cutting problems and develops innovative solution methods for various applications. It considers not only the actual cutting problem, but also analyzes it holistically, embedded in the respective production process.

These approaches go far beyond traditional methods for/of modeling and solving cutting and packing problems, which can be divided roughly into three categories:

- From a given selection of products, place as many as possible in a blank of fixed dimension.
- Place a selection of products in a blank of minimal size. The size and shape of the blank are, subject to certain restrictions, variable.
- Place a selection of products in a minimum number of blanks of fixed dimension.

Typically, the products and blanks for these tasks are simple geometric objects such as circles or rectangles, or can be approximated by such. Also the permitted designs are often subject to strong restrictions. For example, one often requires that the designs form a guillotine pattern. Such an arrangement can be achieved by a sequence of straight end-to-end sections, so-called guillotine cuts. The exploration of such problems has a long tradition in mathematics, which accordingly led to the development of a variety of exact and approximate solution methods. Due to the size of many practical problems one can often only apply randomized search procedures and metaheuristics.

A typical example for practical cutting problems considered in the optimization department is the problem of minimizing waste in sawmills, where boards of different grades and different dimensions are cut from logs. The cutting process is relatively complex and involves a large number of conditions that must be considered in the placement of the boards within the log. To minimize waste one has to decide which boards to place within which region of the log. In addition to that, one has to care about a variety of further information such as different quality levels, stock information and sales forecasts. Furthermore, it is necessary to consider the waste minimization problem in the context of the whole production process. A waste-optimal cutting pattern can often only be achieved with considerable additional expense. Hence, whenever



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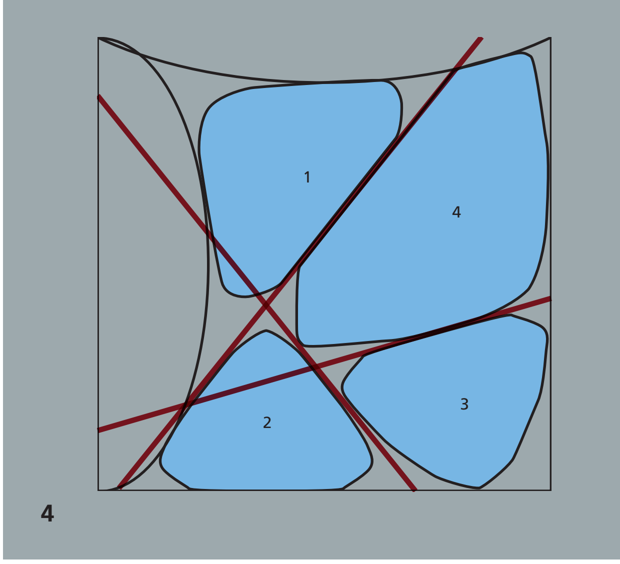

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appropriate, it makes sense to allow for a little more waste, but at the same time reduce production time and costs and thereby increase efficiency. This requires not only modeling the actual cutting problem, but also modeling of the complete production process and thus leads directly to a variety of competing objectives, which have to be solved in a multi-criteria optimization problem.

Another example of a cutting problem considered in the optimization department is the computation of decompositions of a raw gemstone in blanks that maximize the yield of the resulting jewels. For this purpose it is necessary to avoid inclusions as far as possible, or to place them at inconspicuous places in the final products. In contrast to the classical cutting problems, gemstones have irregular shape and the jewels are described parametrically and by restrictions on the size and shape. For example, it is required that the ratio of width and height of a gemstone must be within a predetermined interval. This directly requires to model aesthetic issues, since they have a significant influence on the value of the jewels. While minimizing waste the number of jewels and their geometries are calculated on the basis of aesthetic aspects. These issues can successfully be modeled and solved as general semi-infinite optimization problem. The department is strongly involved in both advancing the theoretical boundaries and the practicable implementation of the process.

In the context of these and other projects, the optimization department gathered expertise in modeling and solving cutting problems. While each question requires an individual approach, synergies can always be found. In some of the practical cases, and especially for gemstone cutting, the developed approaches lead to a revision or even reformulation of the production processes.

3 *A raw gem to be cut*

4 *Volume maximal guillotine pattern of four gem design in a two-dimensional container*