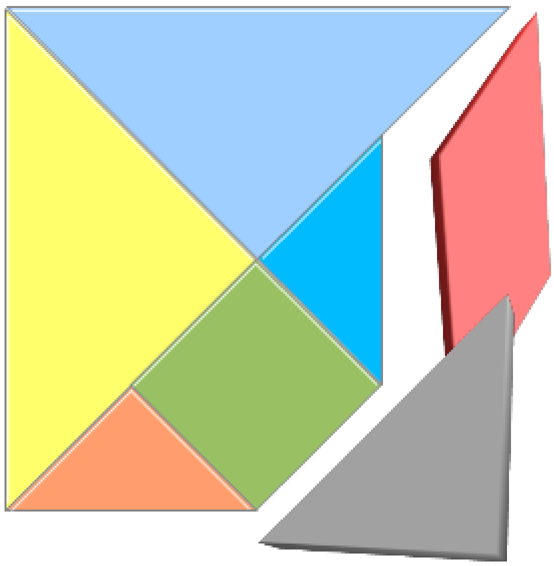
IBE Software



Nesting Strategies

Notes on Nesting Using IBE Programs

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Foreword

These days, modern control hardware makes it possible for CNC machinery to work a wide range of materials very precisely, wasting little. This possibility will only be realized, however, if the CNC nesting software can arrange your workpieces effectively and efficiently on the sheet materials. 'Nesting' describes a process whereby complex algorithms are used to calculate the arrangement of the parts on the sheets in a user-defined process.

Introduction

This document contains general observations on the nesting process. It aims to illustrate considerations which should be taken to increase the efficiency of each nesting method. The observations are relevant to IBE Software's programs, and seek to illustrate the many ways in which the user can influence the automatic nesting process.

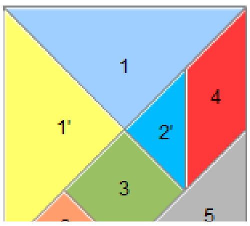
General Observations

Let's begin with some general notes on automated nesting, and its limits.

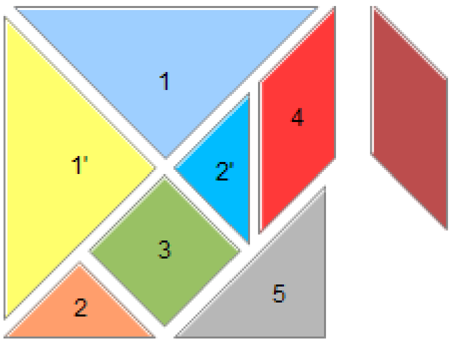
There are simple, straight-line nesting strategies such as grid nesting which can bring workpieces onto a sheet quickly with a minimum of effort. The pinnacle of nesting algorithms is true-shape nesting – a process whereby workpieces of the most varied types are nested tightly up to, and even within each other. The more precise the nesting method, the more calculation time is required to calculate and compare each possible layout.

A layman's example of nesting can be found in the Chinese game 'Tangram', whereby 7 different non-rectangular pieces are arranged such that they form a square. Do bear in mind that this is only an example; it would be easy to write a program which can solve tangram puzzles, but this would not necessarily be useful as a nesting solution!

Mathematical Observations

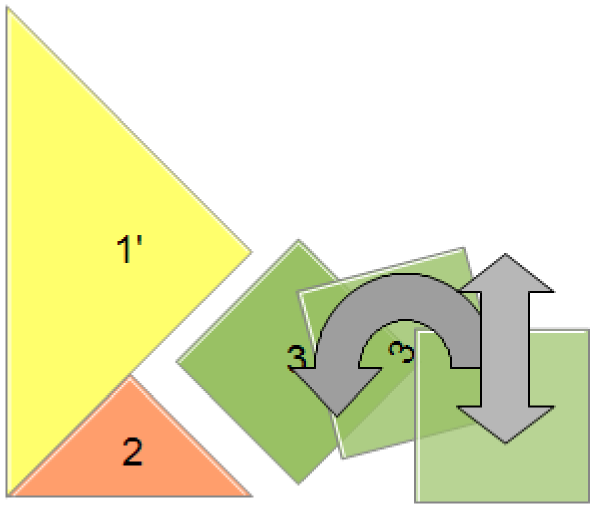


The tangram game consists of 7 building blocks (analogue to sheet metal workpieces), which have a calculable number of possible layouts. Mathematically, the total number of permutations for a game with *n* parts is *n!* In our example, this is 7!, which comes out at 5040.



Of course, some parts can then be turned on their heads, and so must also be checked when mirrored. In our example this only applies to part #4. With this considered, the new total number of permutations is 8!, or 40320. If only non-duplicate parts could be mirrored we would have 12! = 479001600 permutations, and if all parts could be mirrored we would have 14!, or 87178291200 possible layouts. These considerations would make no real difference in the game depicted, but serve well to illustrate the increased number of calculations required.

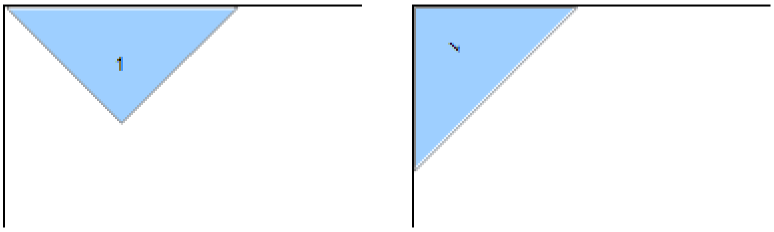
Process Steps when Nesting



The individual steps used when nesting are simple, but when considered in their thousands as illustrated above, complexity is important. Basically, there are only really 3 steps: turning, moving and mirroring.

In this illustration we can see that part #3 must be pushed along both the X and Y axes to fit between parts #1 and #2. As well as moving, the part must be tipped onto its corner to fit the gap tightly.

In such cases the 'resolution' or size of each movement or rotation step is important. If you enter a higher resolution (lower rotation angle at each 'try') then the calculation times increase rapidly as more and more steps must be tried. In our example we can see that we will only require rotation angles of 45°. Knowing this and entering it as a setting before nesting can dramatically reduce calculation times. We'll cover this in more detail later.



Here we see that even the first part must be nested onto the sheet, despite not having to fit in with any other parts. The most efficient use of material is illustrated by the example on the right hand side.

The Sheet is the Foundation

Before building a nest of parts, you'll need to set out a plot for them. In practice this means a piece of a suitable material from your stock, so we will be talking about sheets. The sheet's dimensions, thickness and material type and important factors when nesting. You must also consider any offcuts left over after cutting. Optimal material usage often means leaving rectangular offcuts which can be re-used. This can mean using what at first appears to be a less efficient nest, but gives a better result in the final counting.

First Conclusions

As shown by our example of the tangram, the desire for the most efficient use of material must be balanced with the requirement of reasonable calculation and so nesting times. On top of time, we also have countable costs such as labor, material and energy for cutting. An acceptable solution will only be reached if the user enters his requirements as nesting parameters.

Nesting Strategies

IBE Software's programs offer many methods of organizing your parts onto your sheets, from fully automated nesting based on your parameters to manual nesting with or without computer-aided positioning.

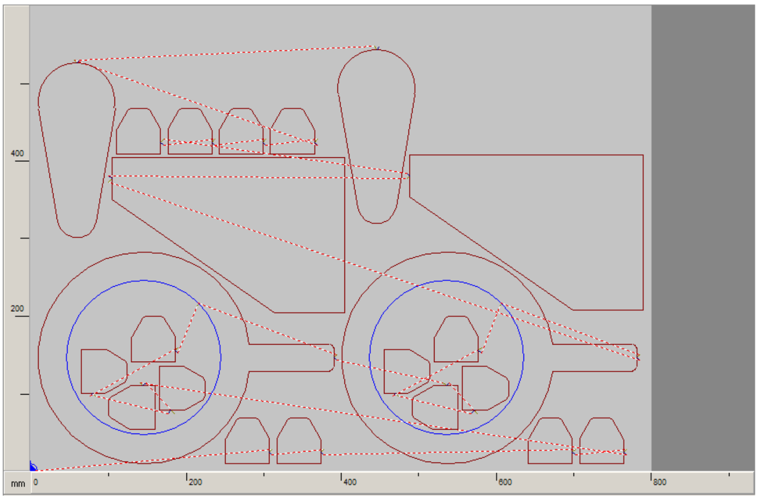
The goal of the automated routines is to arrive at useable results quickly. These are not always the best results, but they do allow you to get an overview, and quickly re-calculate using different parameters.

Nesting Parameters

You can influence both the nesting result and the calculation time using well-considered nesting parameters.

Here we will look at which of the software's nesting parameters you can influence, and give tips on how to use them.

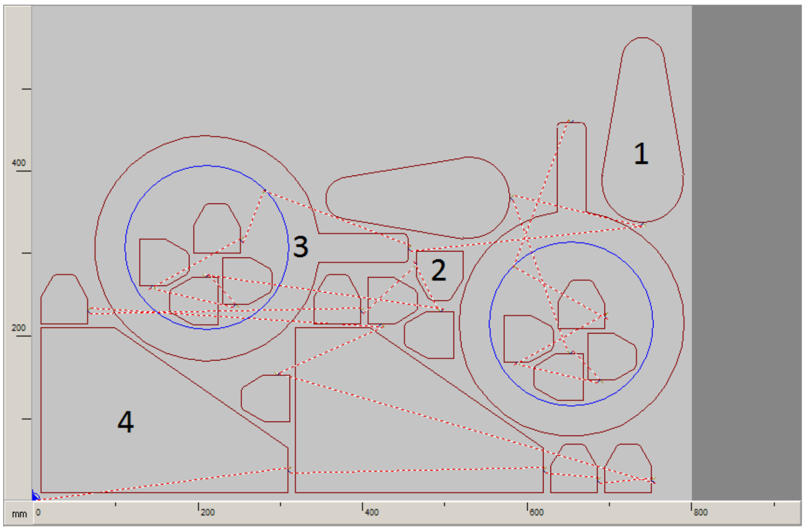
The plan to the right shows 4 different workpiece types, nested in a normal layout using a 90° step angle, with equal priority for every part, and no pair-building.

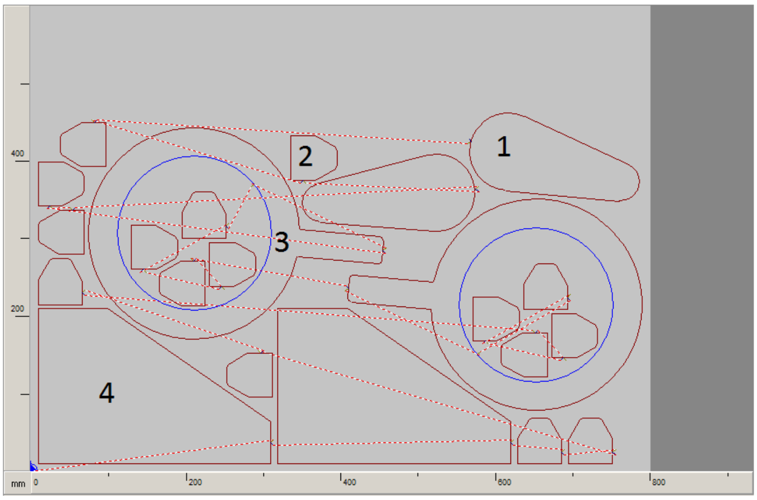


Priority

The nesting priority sets the order in which workpieces are placed on the sheet. Parts with higher priorities will be nested first. When allocating priorities it can be useful to nest the largest parts first and the smallest parts last. This allows the program to use small parts to fill any gaps which may have developed.

This plan shows a new nest where part type #4 was given a higher priority.





Step Angle

The step angle defines the angle by which parts are turned at each iteration when fitting into the existing nest. Entering a small value can dramatically increase the calculation time as many more 'fittings' must be tried before settling on one. The material usage is usually better.

Smaller step angles don't always find the best solutions though. For example, with larger parts which are rectangular, it can be useful to allow them to be turned by only 90° to ensure corners are filled.

In the example above we have allowed a smaller step angle of 5° for part types #1 and #3 only, leading to a marked improvement in material usage. To visualize this, imagine a vertical line across the top of the nest, above which we have a rectangular offcut sheet. It is clear that we would be left with more re-usable material than in the previous nests.

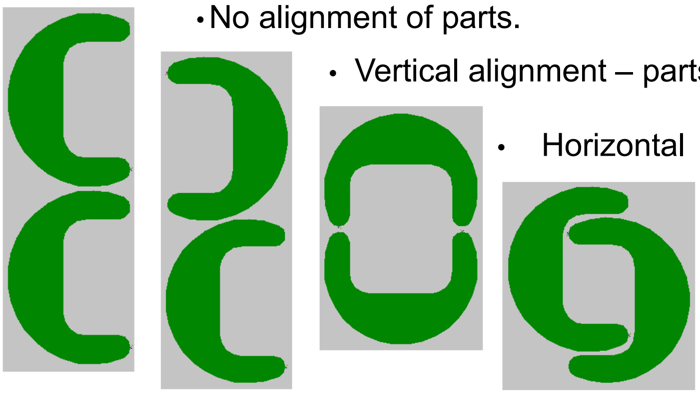
Fitting Type

The fitting type defines the position of the first part on the sheet. 'Normal' places the part in the first available spot. 'Center of Gravity' attempts to place the part in the optimal position. 'Grid' puts the first part in an imaginary rectangle, and aligns all subsequent parts to that.

Pair-Building

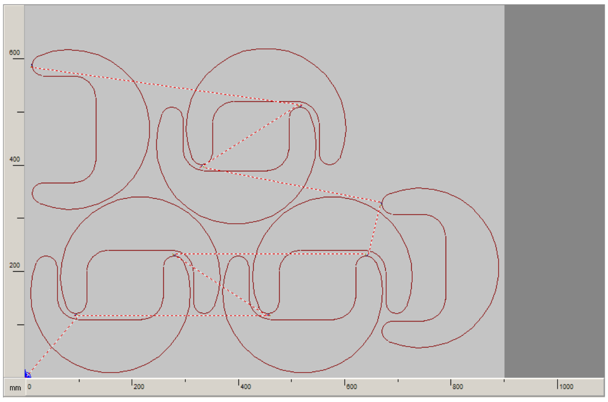
Pair-building allows you to define a pair of parts which should be nested preferentially, together in a pre-arranged alignment.

There are five methods of pair-building available. The goal of pair-building is usually to nest a pair of parts in the smallest possible box. Generally this goal will be reached by selecting the first method 'Best' and allowing the software to calculate for you. If you wish to try another alignment, you can select from the following four methods:

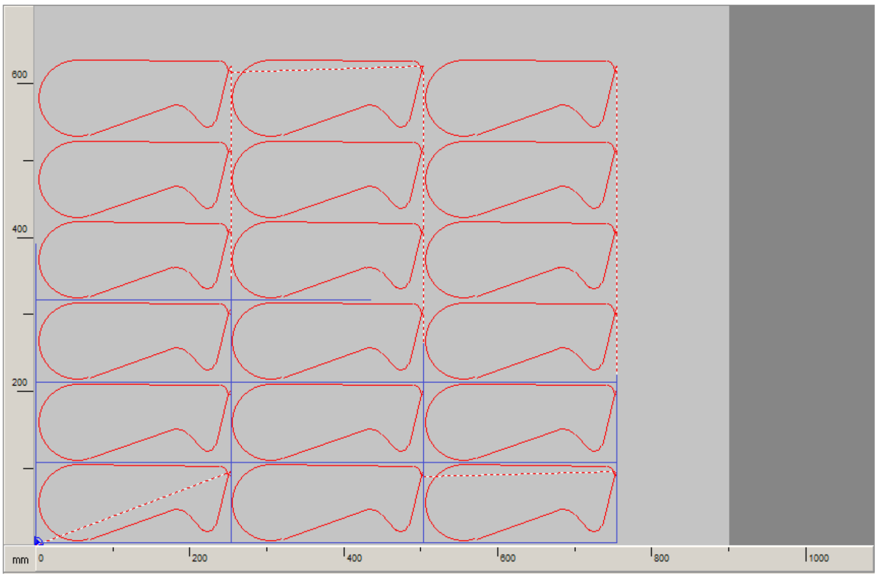


- No alignment of parts.
- Vertical alignment – parts are nested to the narrowest width.
- Horizontal – parts nested to the shortest height.
- Overlapping pair.

In this case vertical alignment would be optimal, and so if you ticked 'best' then this would be used. However, as shown here, the best pairing method does not always lead to the best material utilization. In the plan to the right we can see that overlapping pairs lead to a compact nesting result. You can always try various settings, and compare by checking how many sheets would be needed to nest all parts.



Nesting Types



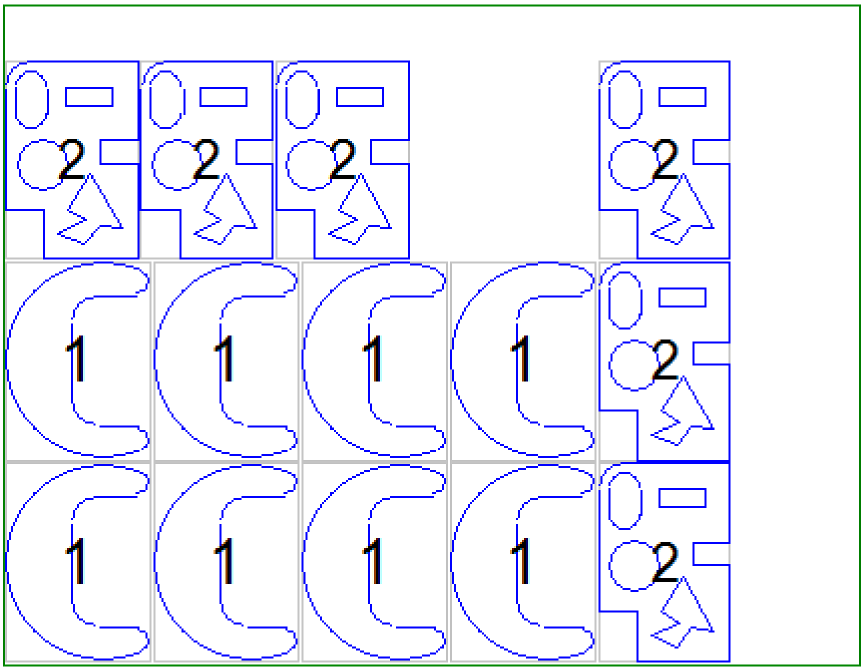
Grid Nesting

The grid nesting routine draws an invisible rectangular box around each part (added here in blue for clarity) and nests it based on that box. Grid nesting allows you to nest only one type of workpiece to each sheet.

Rectangular Nesting

Rectangular nesting also draws boxes around each part, but in this case parts can be nested within parts, and different types of parts can be nested.

A special type of rectangular nesting is 'guillotine nesting', whereby the parts are aligned such that they can be separated using a long guillotine blade.

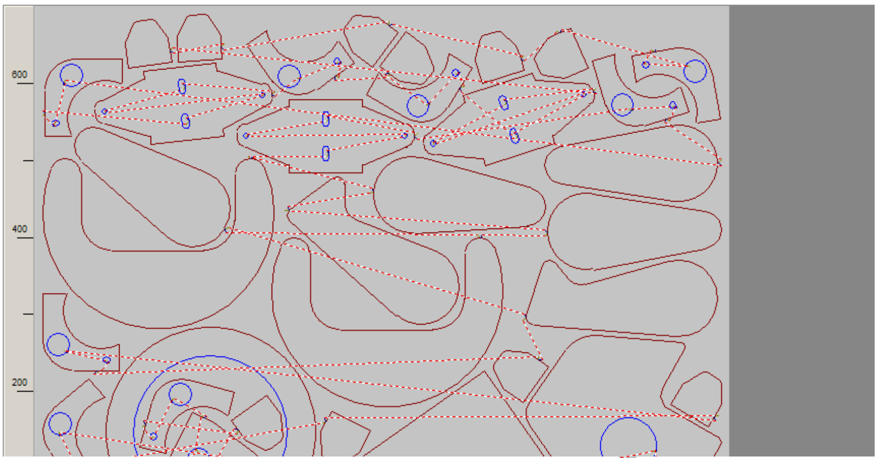


Parquet Nesting

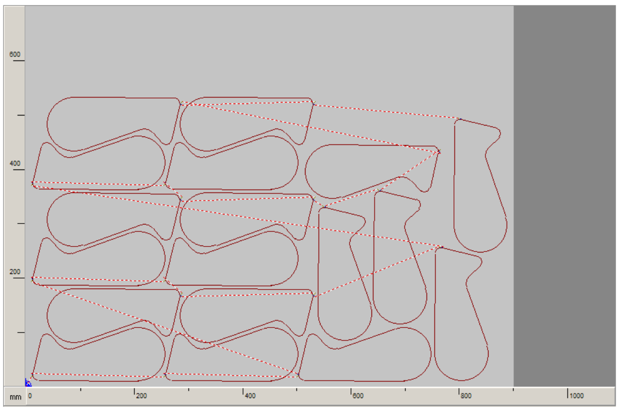
If you only wish to nest one type of part to your sheets, this is a good way to do it. Parts are nested tightly with overlaps as shown. A selection of possible nests is offered to the user, each listed by its material utilization.

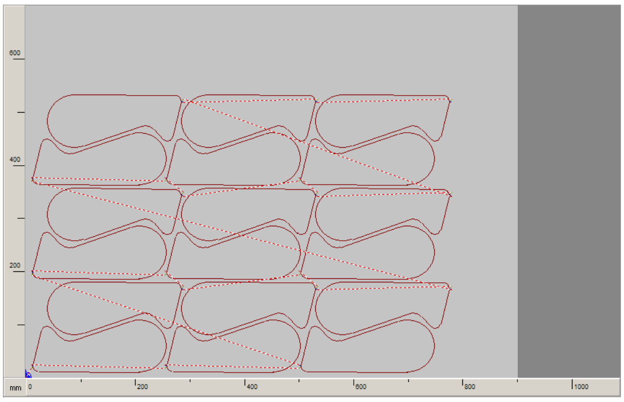
Parquet nesting only allows you to nest one type of part. If you wish to nest more than one type of part to your sheet, select true-shape nesting.

True-Shape Nesting



Workpieces of varying forms can be nested automatically to a sheet using true-shape nesting. Although this process is automatic, you can use the various parameters to define how you wish the nesting to be carried out (pair-building, priorities, etc.) so you can still maintain control.

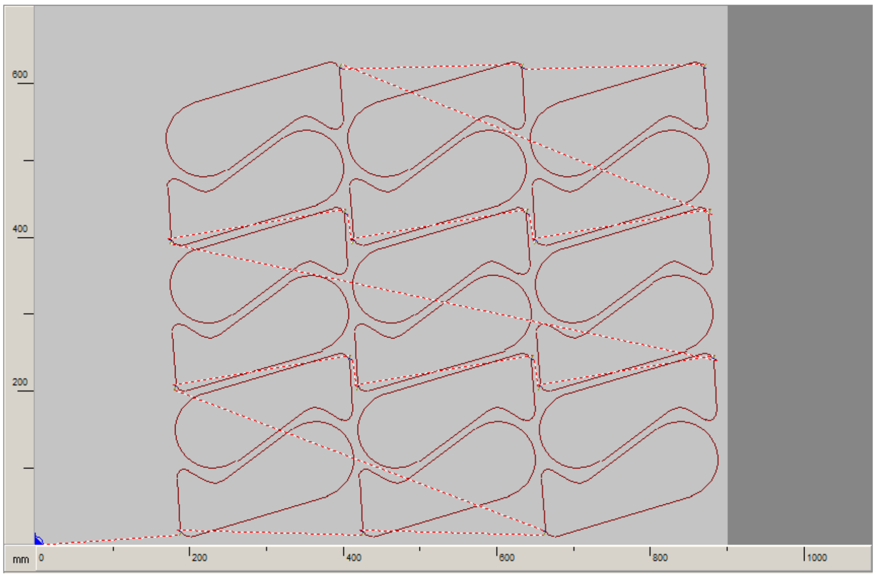




The layout to the right was created using a step angle of 1°. When true-shape nesting, bear in mind that a smaller step angle increases calculation time, sometimes dramatically. If you have any large rectangular parts, it may be best to set a step angle of 90° for these to help insure that your sheet's corners are filled. That said, we can see that the rectangle (with notch) in the middle at the bottom of the nest was integrated tightly into the nest using the step angle of 1°.

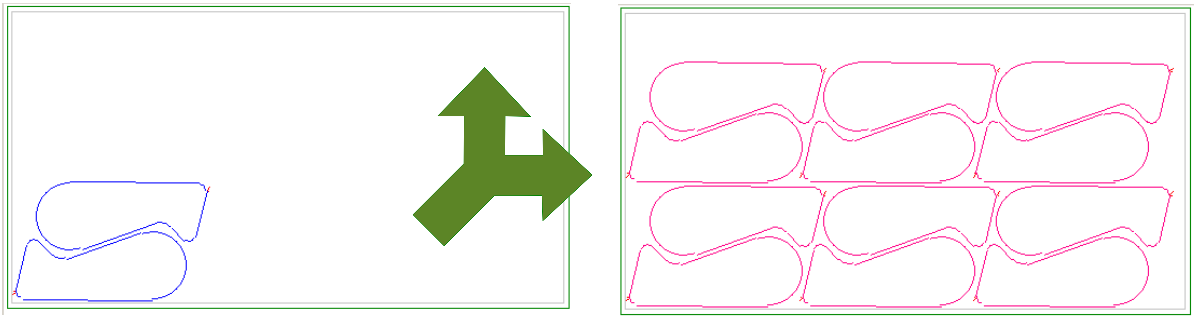
Of course you can also use true-shape nesting to nest multiples of just one type of part. The layout to the left was created automatically without user-defined parameters, while the layout to the right was created using overlapping pairs.

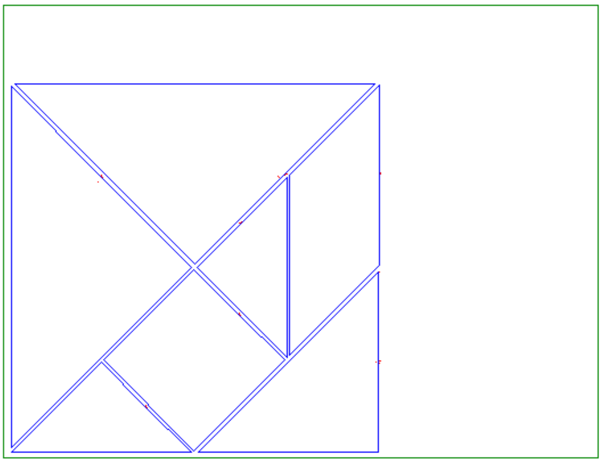
Manual Nesting



Manual nesting allows you to position multiple part types on your sheet by hand. You can make settings governing the turning and moving of parts when working manually. The program will help you maintain the optimal offsets between parts using its snap-mode. You can join multiple parts together to form a group. This group is then treated as a single part for each subsequent nesting action.

When nesting manually, you can stretch a box to show an area into which to duplicate areas which are already populated. The positioning of the original parts has a defining influence on the effectiveness of the nest. As shown below, when the first parts are set out well, an efficient nest can be created.





The Human Touch

Manual nesting allows you to create any imaginable nest forf your parts, including those which a computer would not be able to see – such as in our original tangram example.

Coil Nesting

'Coils' are rolls of metal sheet beaten out as a long band – imagine the paper used in a printing press. These are used in many industrial processes. As a rule these bands are very large and heavy, and whole coils can only be delivered by special trucks. These are then cut down to more manageable sizes for resale as strips or rings, which customers can order to their own dimensions as required.

Coil nesting is a special nesting type which allows you to determine the optimal width of a strip to order. This process lays parts out on a virtual sheet with a pre-determined length (required to keep the mathematics possible). From this nest, the software calculates the optimum strip width, and displays the utilization across this width. The software calculates the number of parts which can fit on a given length of material, and seeks the optimum.

Coil nesting will usually use parquet or manual nesting as the basis for it algorithms These methods allow for pair-building, and pairs can then be laid out optimally for coil nesting in strips across the material's width.

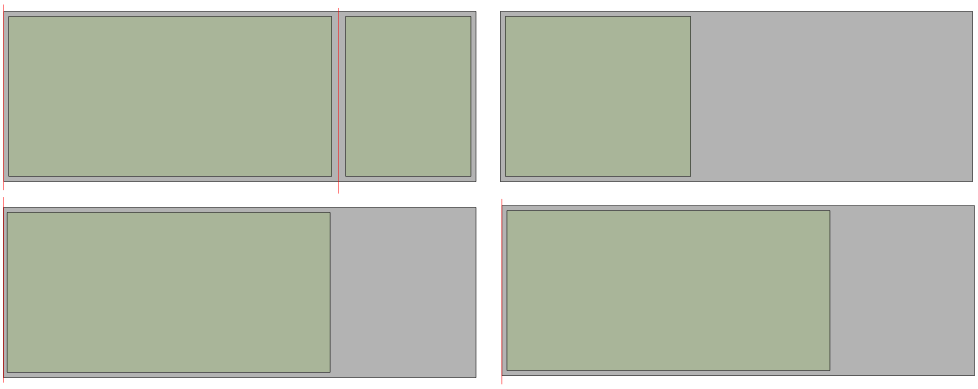
Parquet nesting always offers more pair-building options, but due to the nesting method these will always have a diagonal alignment. These pairs are well-suited as a basis for modifying to individual requirements using the manual nesting routine. Pairs from parquet nesting can be readily split in the manual nesting routine, edited and re-paired ready for endless processing from a coil.

Try out the 'stretch area' function. This can help you layout a part or parts group across a width, with a good level grouping line suitable for coil nesting.

When nesting you can also use a parallelogram. This can lead to better nesting results. Try nesting with both conditions to see which works best in any given case.

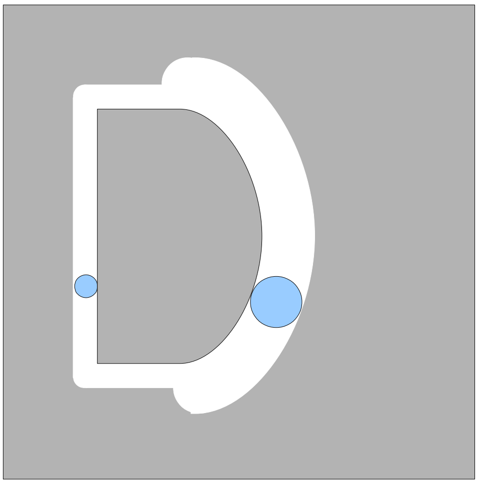
Commission Nesting

If complete assemblies are to be managed as commissions, then they can be nested dependent on each other. This allows you to set one commission’s priority at a given level, then all parts of it will be nested before moving on to the next commission.



When commission nesting, you can use parameters to draw the commission’s (imaginary) start line. This can begin either on a new sheet (bottom row) or continuing from a completed commission (top row). To increase material utilization, you can use parameters to allow parts of a commission to be nested in gaps within previously nested commissions.

Free Space Nesting



Certain machines such as stamping or beveling tools require you to use different-sized tools in order to allow free clearance space for the next tool to do its work. These free spaces may overlap each other, but may not cross into the actual workpiece.

Free-space nesting allows these requirements to be considered so that the stamps or beveling tools of different sizes can be used.

Multi-Torch Cutting

There are special considerations when using multi-torch cutting machines. Parts must be arranged in identical 'strips' across the sheet, with the total parts quantity calculated as a multiple of the torch count, with no remainder. An exception would be where torches can be switched on or off individually.

Conclusion

Nesting non-identical parts places great demands on nesting software. The quality of a nesting plan and the required calculation time are related through the step resolution the user defines. With skillful use of nesting parameters such as switching mirroring on/off, part priorities, pairs-building, etc., the user can greatly reduce calculation time while improving the nest's quality.

A special feature of a good nesting program is the speed with which a nest can be generated. Quick recalculation of a nest allows the user to use nesting parameters interactively to improve their results.

IBE Software's programs represent particularly good and well-developed nesting solutions. Due to the high intrinsic value of these solutions, some few are bundled but many are offered as license-protected optional extras to the basic software.

Enhencement

Some programs allows you collecting nesting methods with different settings in a batch file and executing this batch for optimizing the nesting result. The purpose is, getting the best nesting result. You have to invest a lot of time in case of running such a batch file for optimizing the result, because it needs many time for every nesting process.

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