THE ROLE AND POSITION OF THE NESTING SOFTWARE IN PRODUCTION TECHNOLOGIES

ULOGA I POZICIJA „NESTING“ SOFTVERA U PROIZVODNIM TEHNOLOGIJAMA

Senita Čanić
Faculty of Mechanical Engineering
Zenica

Edin Begović
Faculty of Mechanical Engineering
Zenica

ABSTRACT
In the past, the only way to carry out the process of nesting was manually. Now, however, there is a wide range of software on the market which provides automated nesting. Over six decades of cutting and packing research of nesting, a number of algorithms and techniques have been developed, and therefore, the preview of the research is given. Afterwards, typical functionalities and items to consider when making a purchase decision are shown. Each nesting program comes with its own advantages, but basic advantages that apply to practically any nesting software are also presented.

Keywords: nesting, software, cutting

REZIME
U prošlosti, jedini način vršenje optimalnog rasporeda (gniježđenja) dijelova za sječenje je bio ručno. Sada, međutim, tržište raspolaže širokim spektrom softvera koji omogućavaju automatsku optimizaciju rasporeda. Više od šest decenija istraživanja optimizacije rasporeda kod sječenja i pakiranja dovelo je do razvoja niza algoritama i tehnika te je u radu dat pregled istraživanja u ovoj oblasti. Zatim su prikazane tipične karakteristiske i stavke koje je potrebno uzeti u obzir kod nabavke datih softvera. Kako svaki program ima određene prednosti, u radu su prikazane i osnovne prednosti koje se odnose na praktično svaki softver.

Keywords: raspored (gniježđenje), softver, sječenje

1. INTRODUCTION
Creating new products often means machining a number of parts from a block or sheet of material of larger dimensions. Whilst it's difficult to avoid creating some waste in manufacturing, it is possible to reduce the amount of waste. One way of achieving this reduction is through nesting. The goal of a nesting strategy should be to place the parts in an economical fashion using the highest level of automation to maximize the utilization of the sheet or plate, producing as little scrap as possible. This has a positive impact both on the company and the environment.

In today's highly competitive industrial environment, it is very important to reduce production costs. Since material costs are the major part in production of parts, nesting will reduce the trimming losses, scrap material and reduce overall production cost.
When it comes to an ecological aspect, in addition to recycling, it is also necessary to control the consumption of the material. Better use of materials will save resources, reduce electricity, chemicals and water costs in producing materials, reduce waste and protect the environment.
Among manufacturing processes, nesting software may be used in water jet, plasma cutting, laser cutting, oxyfuel, routers, knives and punching machines.

2. THE HISTORY OF NESTING SOFTWARE

Before the advent of PCs, cutting machines were programmed using lengths of perforated tape generated by mainframe computers. In the early 1980s, when CNC for cutting machines became available and the PC became more commercially viable, the idea of developing nesting software to run on a PC platform was born. The core objective for nesting software was to leverage the mathematical processing power of the PC to optimize material usage and reduce cost [1].
Over six decades of cutting and packing research termed nesting, a number of algorithms and techniques have been developed. Beginning from the earliest research in the field by Gilmore and Gomory (1961), which proposed a solution for one dimensional nesting problem, the research works then moved on to two dimensional nesting problems from regular orthogonal parts to highly irregular part nesting [2]. Approaches as heuristic, metaheuristic and hybrid have helped to generate very effective solutions.

Table 1. Research Works and different Approach followed [2]

Researcher	Year	Approach	Remarks
Gilmore and Gomory	1961	Linear programming method	Dealt with one dimensional problems only
Albano and Sapuppo	1980	No Fit Polygon for irregular packing problem	Profile simplification to reduce complexity in geometry
Marques, Bispo and Sentieiro	1991	Simulated annealing approach to reduce complexity	Approximate density of 69% was achieved for the given length
Fujita, Akagi and Hirokawa	1993	GA combinational search and local minimization function	Appropriate for convex shapes to reduce time delays
Oliveria and Ferreira	1993	Simulated annealing algorithm	Faster solutions but suffers inaccuracy
Dowsland and Dowsland	1993	Jostle algorithm	Produced excellent results when an existing nest was tried to get improved
Jakobs	1996	GA to improve orthogonal parts	Specific to stamping /punching operations
Dighe and Jakiela	1996	Complex genetic algorithm	Approach avoids overlapping to a higher extend
Bounsaythip and Maouche	1997	Genetic algorithm	Extended work of Fujita, Akaji and Hirokawa (1993)
A.Ramesh Babu and N.Ramesh Babu	1999	Combination of a Heuristic and Genetic algorithm with bottom left filling.	Approach meant for different rectangular parts in several rectangular sheets of different size.
Oliveira, Gomes and Ferreira	2000	No Fit Polygon	Proposed for irregular parts nesting
Hopper	2000	Genetic algorithm with bottom left filling technique	Proposed for both orthogonal and irregular nesting problems

S.K. Cheng, K.P.Rao	2000	Combination of compact neighbourhood algorithm and GA	Faster computational speed
A.Ramesh Babu and N.Ramesh Babu	2001	Combination of a Heuristic and Genetic algorithm with bottom left filling.	Approach meant for different irregular 2-D parts in several multiple 2-D sheets of different size.
Jeffrey .W.Herrmann and David.R.Delalio	2001	Dynamic Programming algorithm	Specific to sheet metal punching ,it considers specific orders to be punched later and produces customized nests
Gomes and Oliveira	2002	Shape ordering heuristics	Manipulation of the order of shapes which needs to be further nested was made possible
Tai-His Wu, Jeng-Fungshen	2003	IBH algorithm embedded in SA algorithms	Proposed to utilize unused areas in material plates further
T. F Lam and W.S.Sze	2007	Minikowski sum tool	Limited to polygons with straight line edges only
Heng Ma and Chia - Cheng Liu	2007	Greedy method and semi discrete representation, part sequencing using GA	Iterative method
Wen-Chen Lee, Heng Ma, Bor- Wen Cheng	2008	QLM algorithm	2 level approach that includes shape conversion of irregular part to be nested and for finding the optimum position in the sheet.
K. Siva Saravanan, A.Rajasekhar, N.Ramesh Babu	2012	Combination of Genetic and Heuristic approach	Semi discrete representation scheme is utilized
Alexandros Siasos, George-Christopher Vosniakos	2014	Hybrid GA heuristic algorithm	Developed for cutting stock problems in a textile composites industry
K.Ramesh , N. Baskar	2015	Simple GA	Meant for blanking operation

Today's nesting software is much more sophisticated than initial versions, and its role in lean manufacturing has grown significantly. Nesting problem is of interest within the wood, garment, sheet metal, plastics, ship building, footwear and glass industries.
Software technology now can emulate how humans made decisions when creating a nest manually [3], where software through new mathematical algorithms can see how multiple shapes fit together.
No matter which software is used, material utilization is just one part of the overall picture. Prioritize parts by schedule, geometry constraints, punch tool orientation, metal's grain orientation required, and other limitations can be just as important.
Software also takes into account the limitations and features of the machining technology in use [4].

3. BASIC FEATURES OF NESTING SOFTWARES

In recent years, due to higher companies requirements and changes on the market, these software are constantly being upgraded. Although optimal use of materials is still the main task, software have additional roles in three other areas: integration, automation and part quality.
It is important to check out and be sure which software is fitting the needs before buying it or subscribing. Therefore, some of the basic features and items that should be considered when purchasing software are listed below:

3.1. CAD Import

Most, if not all, nesting software programs are able to import and work with DXF and DWG files. Some programs also can automatically flatten 3-D part, which eliminates the manual intermediate step of producing 2-D files. Automatic CAD error correction tools and tool-pathing capability provide additional automation during the CAD import process [1].

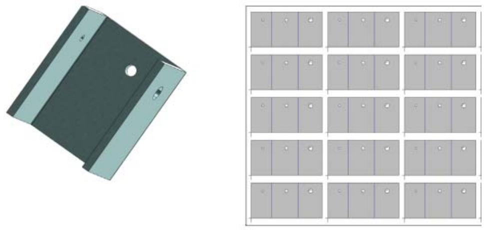

Figure 2. 3-D part flattening [5]

Process Parameters- The parameters that need to be applied depend on the cutting process used. With a plasma machine, for example, varying the feed rate and kerf compensation and enabling automatic height control lockouts, are just some of the factors that need to be implemented to achieve good-quality holes. A laser machine may require the activation of a pulse pierce with a proper cut condition. Cutting sharp corners with a water jet machine requires a ramp-down of the cutting speed going into the corner and a ramp-up coming out of the corner. On the other hand, lasers may benefit from specific corner-radiusing techniques to achieve the same goal [1].

Automatic Nesting- Advanced mathematical algorithms now are employed to create highly efficient nests automatically, including space-saving techniques such as part-in-part void filling and look-ahead logic. Advanced nesting systems allow for and alter nesting techniques based on an assortment of variables, such as material type, thickness, clamping, and repositioning requirements [1].

Productivity Tools- Whether used with common-line cutting to reduce cutting time on a water jet, collision avoidance to prevent part tip-ups on a laser, or chain cutting to eliminate costly preheat cycles on an oxyfuel machine, nesting software offers a variety of beneficial features, no matter which process is being used [1].

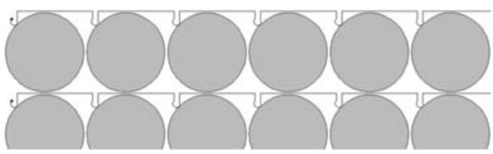

Figure 3. Chain cutting [6]

Chain Cutting connects multiple part profiles into one continuous cut. Reducing the number of pierces will increase consumable life and, for oxyfuel, Chain Cutting eliminates the pre-heat cycle by cutting multiple parts with a single pierce [6].

Bridge Cutting, as the name implies, leaves a tiny “bridge” connecting each part. This technique may be ideal when cutting a number of the same part on the same sheet, and these parts need some sort of secondary processing. This can result in significant time savings [6].

With Common Line Cutting, common edges of adjacent parts can be easily shared. Common Line Cutting allows users to fully customize the tool path on all parts, maximizing efficiency. Fewer pierces and reduced cutting distance will maximize productivity and consumable life. At the same time saves material by eliminating the separation between parts that otherwise becomes scrap [5].

Material and Inventory Optimization Tools- Very useful tool is the ability to nest a partial sheet or plate and then save the digital remnant or skeleton for later use with another nesting job. Such systems require a facility wide commitment to inventory control, but can yield excellent material savings. Since not all material remnants are conveniently stored in digital format, the ability to use nesting software to create the remnant or import it as a CAD drawing is very useful [1].

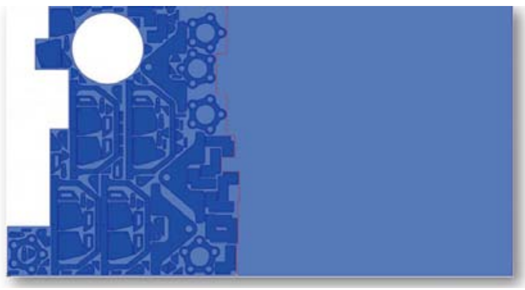

Figure 4. Nesting a partial remnant sheet [7]

Tool Path- Generating an optimized tool path for the nest is a goal for every job, but the specific objective may vary based on cutting process and application. Intelligent sequencing at the nest and part level can reduce unnecessary production downtimes, reduce heat distortion issues, and help minimize plate warping. Automated lead-in/-out styles and positioning also assist with common problems such as poor part quality, part movement, and head crashes [1].

NC Output- The primary function of any nesting software is to create the appropriate NC file that will enable the functional code to be sent to the cutting machine. A nested file containing material type, thickness, amperage, and cut/shield gas information can be sent to the CNC, which in turn relays instructions to the power supply and automatic torch height controller on how the job should be cut. This type of automation not only saves time, but also ensures consistent part quality and reduces processing errors by eliminating unnecessary decision-making on the shop floor [1].

Management Reporting- Understanding what is going on in a company's production operation is important to lean manufacturing, whether it is related to capital equipment purchase, staffing issues, and so forth. Nesting software that offers quality reporting, including nest utilization, production time, part, and job costing, and inventory status, can make production more visible. Part and plate traceability via traditional labels and bar codes also is available with some programs [1].

Business System Integration- Leveraging modern data exchange technologies, nesting software can connect to ERP and MRP systems and significantly contribute to a lean manufacturing business approach. Integrating the software with other business systems can empower the software and allow it to become the heart of a fabrication or material processing operation [1].

4. POSITIVE EFFECTS OF NESTING SOFTWARE

Each specific nesting program has its own advantages and modules that may ease the process of nesting. The software differs in a complexity and the approach. Except purchasing software, free online versions can also be found that can provide acceptable results. Some of the manufacturers also offer the services of creating a nest without buying the software itself.
However, virtually any nesting software that can be found on the market results in:
Less waste- Wasting less means getting the most out of the materials used, and it reduces the amount disposed. Nesting software can also offer ideal solutions that may not normally come to mind [8].
Cost savings- Wasting less material means purchasing less of it in the first place. This can mean more money in the bank for the business, providing up to 20% material savings. In turn, this reduces costs in a wide range of areas, such as machine usage, time, storage, logistics, and disposal [8].
Environmental benefits- Of the three R's (reduce, reuse, recycle), reduce waste is the most important, because everything that is thrown away, first of all had to be made. This means that nesting doesn't only help the company, but it also helps the planet.
Speed- Manual nesting is, to some extent, a process of trial and error. This means that it often takes a lot of laborious work to find a good cutting pattern. Nesting software practically eliminates the need for this step, saving valuable hours of labour [8].
Improved productivity- Nesting software can create cutting patterns for a large number of complex parts, increasing production and machine parts in high volumes. It also helps ensure more accurate calculations, reducing the number of incorrect and damaged parts [8].

5. CONCLUSION

The purpose of the nesting software is primarily to save material, but by development of new algorithms, optimization of the technological parameters of an operating system has been made. Software no longer provide a purely geometric solution, but become a key component of the entire operating system, from bidding to parts design, reporting and inventory management, and also connections with ERP / MRP systems. The software may also contain certain modules or techniques for improving the cutting process, such as common-line cutting, chain and bridge cutting, which reflects in reduced number of pierces.

A variety of software may be found on the market, from the simplest to a high advanced. The more sophisticated ones have to be used if the parts have a complex geometry or large internal openings that can be utilized. They also differ in approach, where besides purchasing software, online or free trial versions can be used.

Nesting software may reduce losses, damages and overall production costs, and besides the economic aspect, also has a positive impact on the environment because the less input material for a product or service, the more efficiently resources are used.
For companies with economical approach to production, advanced nesting software can significantly contribute to achieving high end product quality while improving efficiency and cost savings.

6. REFERENCES

[1] Weston, Derek. Nesting software: A tool for lean manufacturing, 2008. [Online] Available:https://www.thefabricator.com/article/cadcamsoftware/nesting-software-a-tool-for-lean-manufacturing (07.01.2018)

[2] Francis, J., & Umaralli, K. (2017). State of the art of nesting. International Research Journal of Engineering and Technology (IRJET), 2048-2054.

[3] Kettenhofen, Erik. Software evolves to take a humanlike approach, July 2009. [Online] Available: https://www.thefabricator.com/article/cadcamsoftware/software-evolves-to-take-a-humanlike-approach (23.04.2018)

[4] Nesting (process). [Online] Available: https://en.wikipedia.org/wiki/Nesting_(process) (21.11.2017)

[5] Common Line Cutting, ProNest optional module. [Online] Available: https://www.hypertherm.com/Download?fileId=HYP116246&zip=False (05.12.2017)

[6] Chain and Bridge Cutting, ProNest optional module. [Online] Available: https://www.hyperthermcam.com/files/documents/datasheets/pn/optional_modules/chain_and_bridge/BR_896990_R0_ChainBridgeCut.pdf (05.12.2017.)

[7] [Online] Available: https://www.sigmanest.com/2013/02/remnant-tracking-management/ (23.04.2018)

[8] Nesting – Everything You Need to Know, 2017. [Online] Available: https://www.scan2cad.com/cnc/ everything -about-nesting/ (21.11.2017)

[9] SOLIDWORKS® software interface, 2016. [Online] Available: https://www.hypertherm.com/Download ?fileId=HYP116988&zip=False (16.01.2018)