OPTIMAL CUTTING AND NESTING PROBLEM IN MANUFACTURING PROCESS OF RUBBERED STEEL RULE DIES

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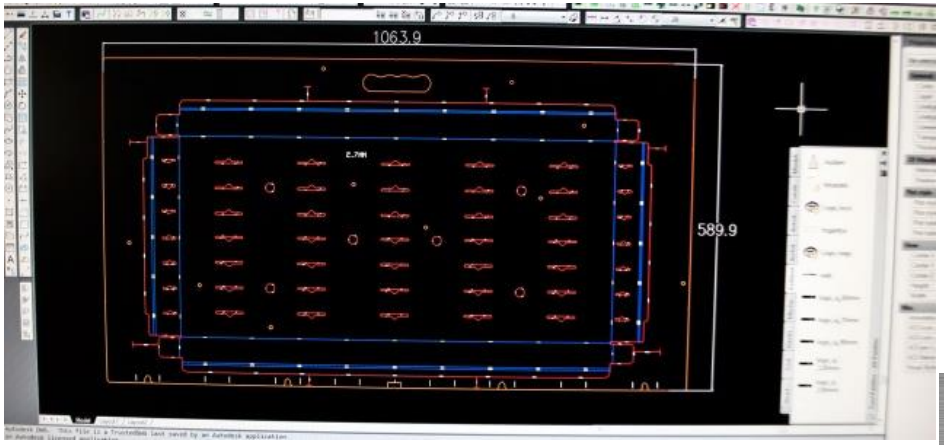
BEFEKTETÉS A JÖVŐBE

STANCFORMA LTD.

- Stancforma Ltd. is a professional and financially stable family enterprise
- The firm is interested in continuous innovation
- Production mainly consists of making cardboard cutting stencils
- The partnership goal is to optimize the production process
- Making of stencils takes one day from the order
- The firm’s major advantage is the fast and reliable delivery

MANUFACTURING PROCESS

DESIGN BY CAD

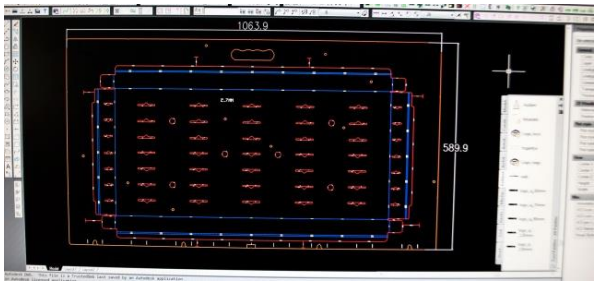


CUTTING BY CNC

MANUAL ASSEMBLY

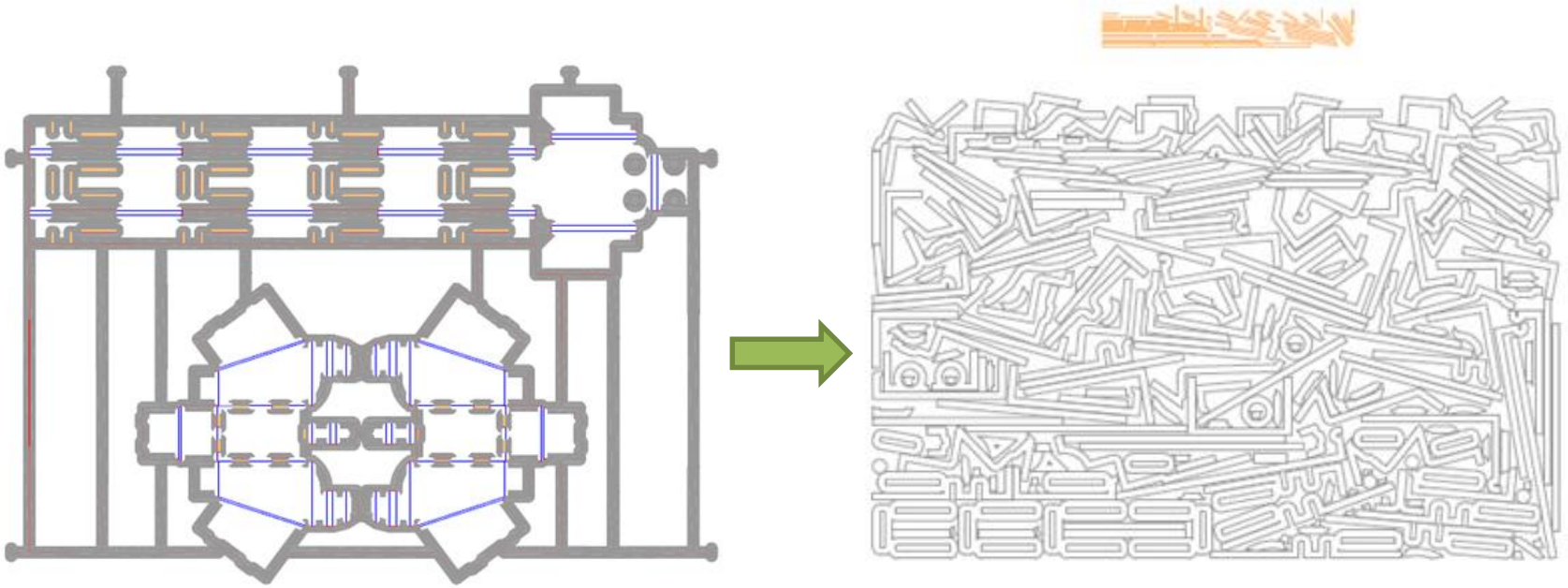
MANUFACTURING PROCESS

- An incoming CAD design specifies the necessary cuts, placement of the blades
- Using AutoCAD's builtin functionality rubber supports are added to the blades
- Human workforce splits the supporting rubber in the design
- Using the builtin optimizer of AutoCAD the split rubber parts are layed out on stock ruber sheets
- A water jet cutter produces the rubber parts
- Human workforce glues the rubber parts onto the stencil which has the blades installed

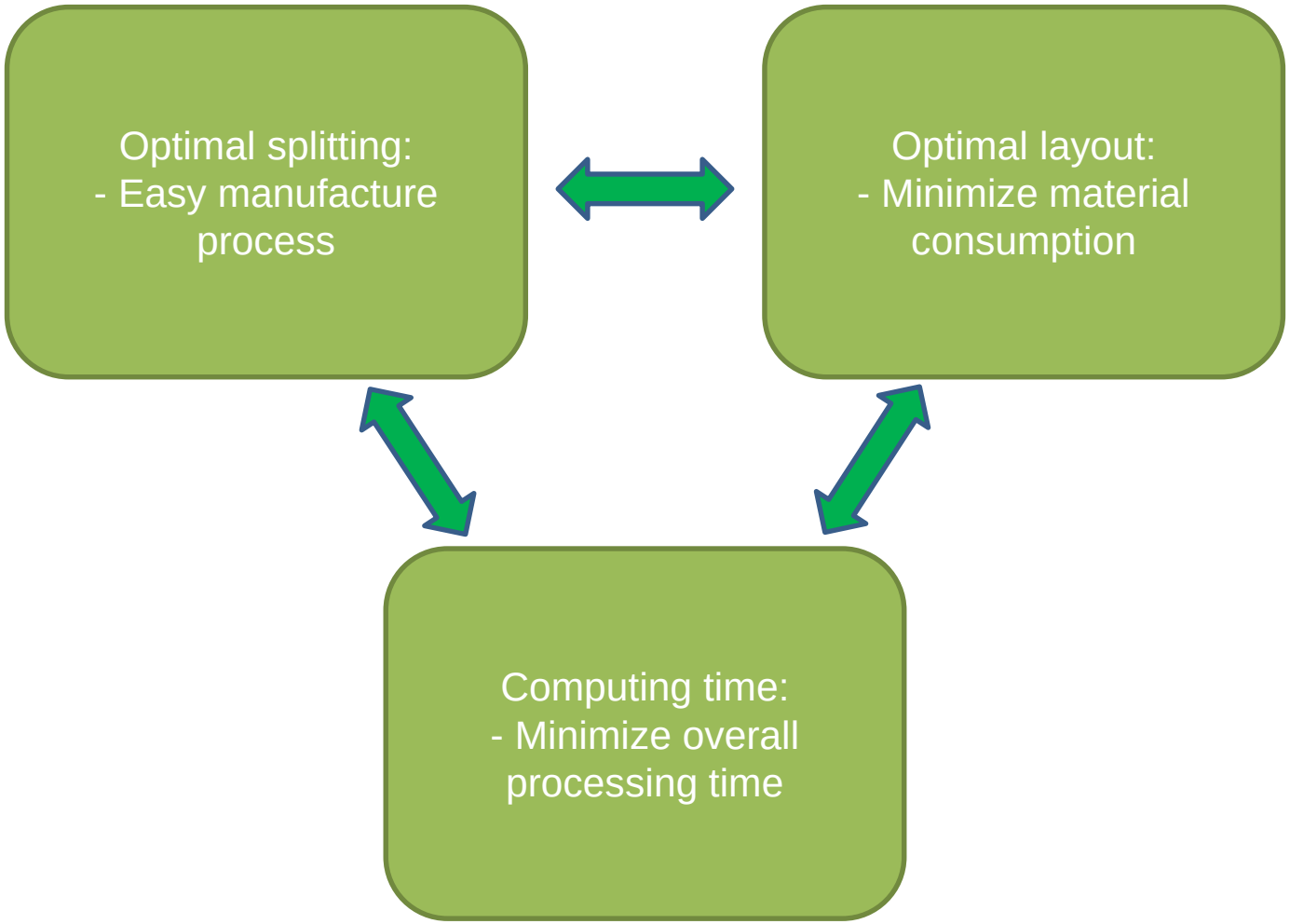


AIMS

- Problem illustration
  - left, the stencil design with supporting rubber (gray and yellow)
  - right, the split and layed out rubber parts
- Our goal is to speed up and automate the design process
- the development of a software to automate the rubber splitting and layout processes

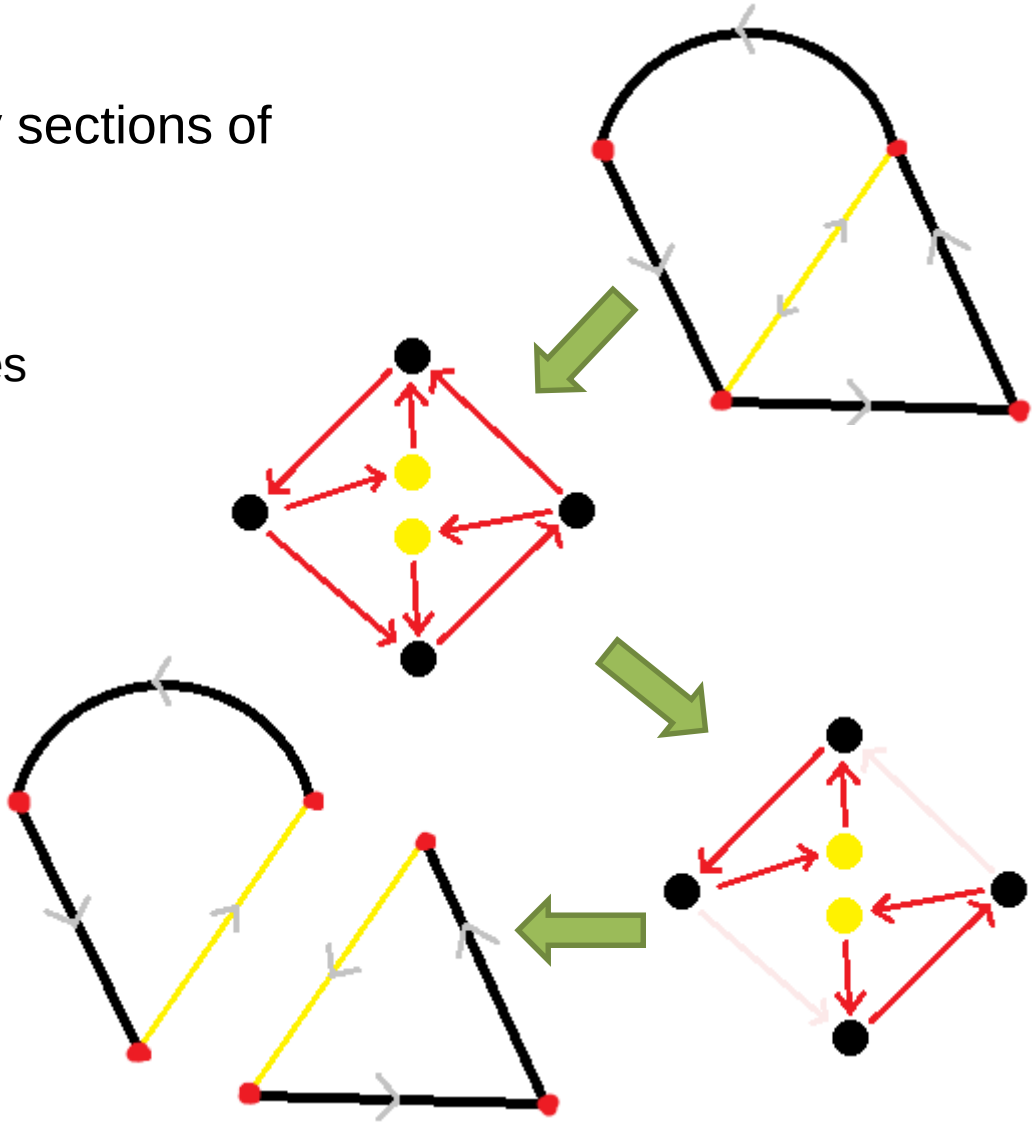


AIMS


Optimal splitting:
- Easy manufacture process
Optimal layout:
- Minimize material consumption
Computing time:
- Minimize overall processing time

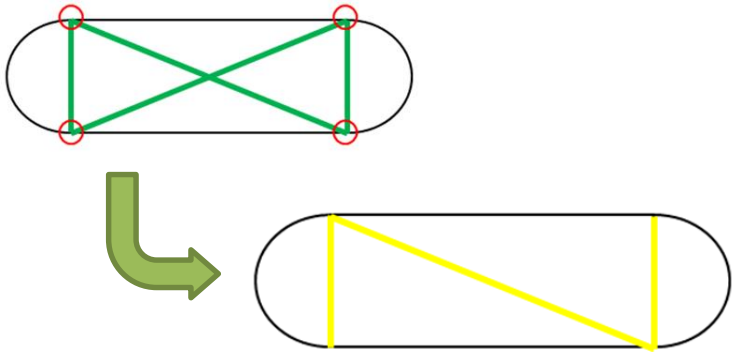
EDIT SHAPES

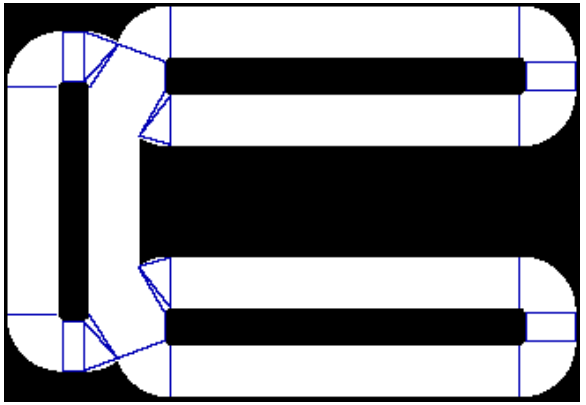
- Shapes are 2D, defined by sections of
  - Line
  - Circular arc
- Slicing
  - Add newly exposed edges
  - Create continuity graph
  - Find valid loops in graph
    - Always turn left
  - Assemble the valid loops
- Gluing
  - Remove glued edges
  - Create continuity graph
  - Find valid loops in graph
    - Always turn left
  - Assemble the valid loops



SLICING-GLUING

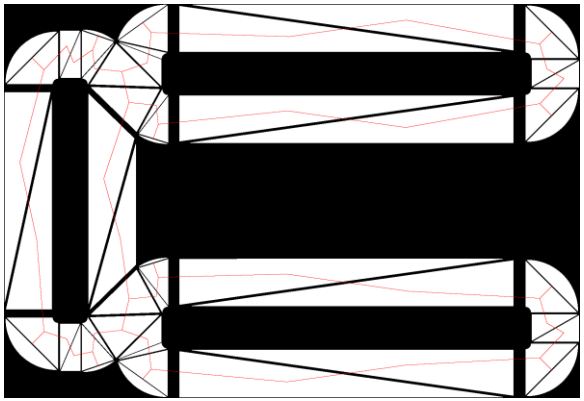
- Joint points
  - Endpoints of sections
- Possible cutting edges
  - Straight lines
  - Inside the shape
  - Defined by two joints
- Set of cuts
  - Shorter cuts are prioritised
  - Cuts can not intersect
  - Cut length is limited
- Slice the shapes along the set of cuts

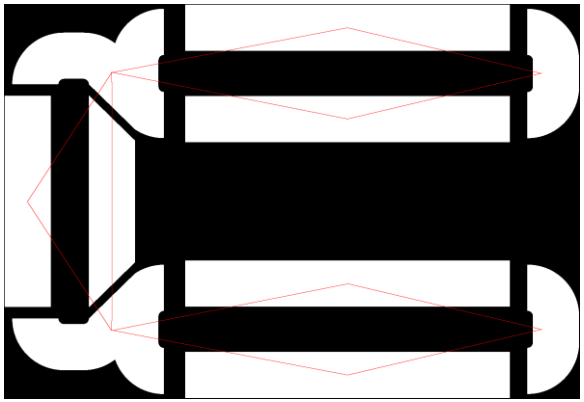




SLICING-GLUING

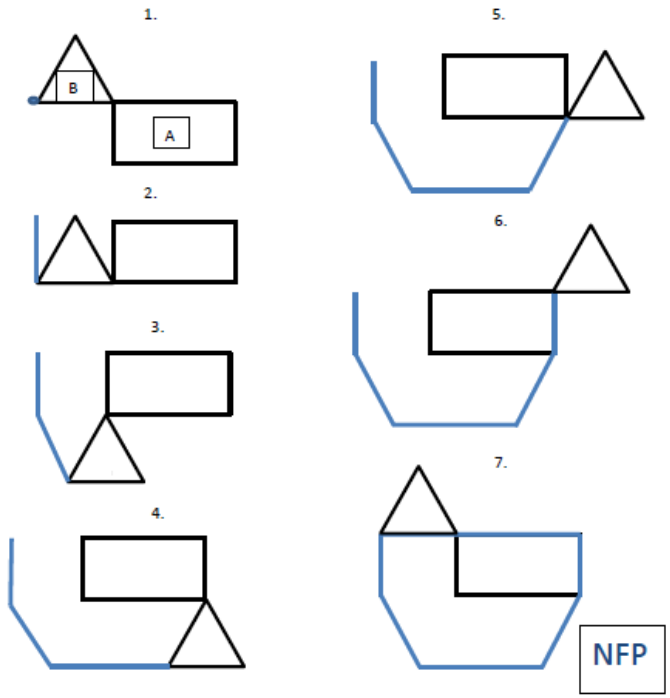
- Firstly glue shapes with too small area
  - Choose the best possible gluing
- Then glue shapes of acceptable area
  - Choose the best possible gluing
  - While the shape is improved by gluing
- Limit maximum size per dimension
  - Avoid too long shapes
- Score of a shape is the ratio of the
  - Shape’s area
  - Area of the shape’s smallest enclosing rectangle
- Score of a gluing
  - Score of resulting shape - average score of source shapes





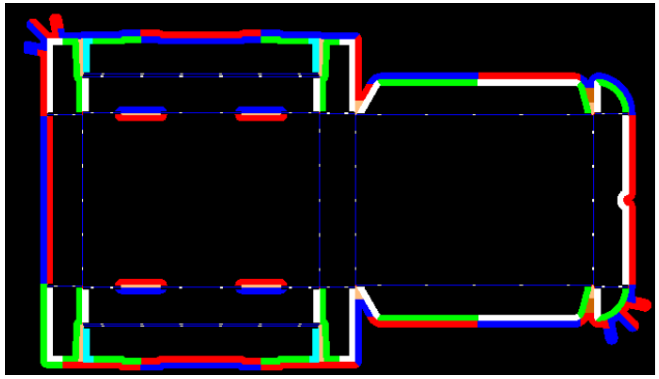
LAYOUT OPTIMIZATION

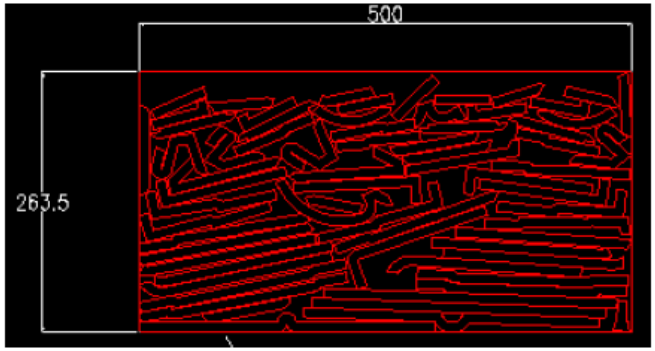
- Nesting optimizers are common
  - No need for custom implementation
- We choose SVGnest
- Solves a bin packing problem
- Creates and merges polygon orbits to aid greedy placement
- Genetic Algorithm
  - Genes consist of rotation and placement order
  - Targets are minimal bin count, minimal „width” of a used bin
- Has lots of parameters:
  - Minimum distance between shapes
  - Number of rotation angles
  - Parameters of the GA

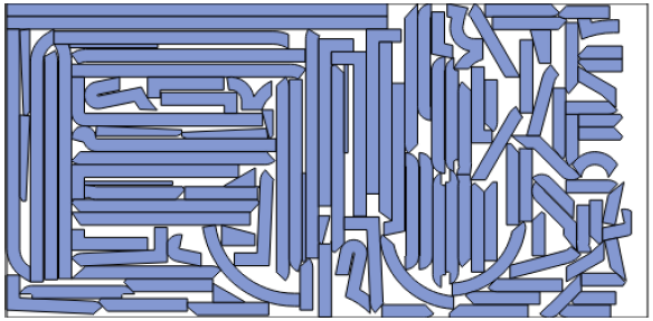


SOLUTION OF A REAL PROBLEM

- Splitting design of human worker (top)
- Layout on rubber with AutoCAD (middle)
- Splitting and layout of the proposed algorithm (bottom)
- Rubber piece count and characteristics of the pieces are similar to the original solution
- Number of split parts can be set by tuning parameters
- Generally the results are promising
  - The workers approved our splitting results
  - Runtimes are reasonable, even with no intentional code optimization







RESULTS ON ONE DAY WORKLOAD

Job number	Manual time (min.)	Automatic time (min.)
Sz-M-2018-10-0482	18	6,47
Sz-M-2018-10-0558	10	1,04
Sz-M-2018-09-0450	8	1,22
Sz-M-2018-09-0451	13	3,68
Sz-M-2018-09-0452	9	1,37
Sz-M-2018-10-0418	20	6,52
Sz-M-2018-09-0453	12	2,31
Sz-M-2018-10-0504	5	0,4
Sz-M-2018-10-0419	16	8,87
Sz-M-2018-10-0420	14	7,85
Sz-M-2018-09-0454	10	1,57
Sz-M-2018-10-0523	23	2,32
Sz-M-2018-10-0461	33	5,88
Sz-M-2018-10-0513	22	2,31
Sz-M-2018-10-0274	20	1,15
Sz-M-2018-10-0454	17	4,03
Sz-M-2018-10-0579	12	0,63
Overall work time:	**262**	**57,59**

- Processing time for one day workload in minutes, with human workforce (left) and the proposed algorithm (right)
- Only the relevant processing time is recorded for the manual work

CONCLUSION

- We developed an application that is capable of processing significant steps of the fabrication process automatically
  - Data import from the CAD files is implemented
  - Splitting of the rubber parts is functioning
  - Data export for the nesting algorithm is implemented
  - Optimization of the layout is functioning
  - Export of the layout is implemented
- Work in progress
  - Exporting the resulting layout in CAD format
    - The water jet cutter currently functions based on the CAD file

THANK YOU FOR YOUR ATTENTION!

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Optimal cutting and packing of the supporting rubber parts for punching health- and transportation industrialgoods

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