Essity Tail Cutter Project
Senior Design Team #2020-09

April 16th, 2020

Acknowledgements

- Essity, our sponsor, for this opportunity
- Victoria Runner for her feedback and support
- Olivet Nazarene for providing tools and facilities
- Clay Bass for mentoring us throughout this process

Presentation Outline

Background
- Sponsor Background
- Current Process

Problem Statement
- Project Requirements
- Codes & Standards

Design Alternatives
- Traction & Transport Component
- Design Matrices & Selections

Final Design Description
- Current Working Model

Design Validation
- FEA
- Safety Factor

Conclusion
- Recommendations

Q&A

Team Formation

TJ Layne

- Background: Mechanical & Electrical Engineering
- Role: Team leader, aided in mechanical design & FEA processes

TJ Alexander

- Background: Mechanical Engineering
- Role: Maintained safety standards while aiding in the design process

Alika Kahāʻulelio

- Background: Mechanical Engineering
- Role: Maintained design timeline & aided in FEA testing process

Sponsor Background

Essity

- Global health & hygiene company
- Headquarters in Stockholm, Sweden
- Develop consumer tissue & paper hygiene products

https://news.cision.com/essity/i/essity-logo-colour-rgb,c2581695

http://reports.essity.com/2018/annual-and-sustainability-report/introduction/our-strengths.html

Sponsor Background (Cont.)

Subsidy - Neenah, WI

- Site developed in 1965
- Approximately 1,000,000 ft² total
- Contains 62 Converting Machines

Production

- Produce around 19.4 million cases a year
- Around 54,000 cases per day

https://www.tissueworldmagazine.com/departments/we-became-circular-before-everyone-else-thought-to-do-so/

Project Background

Parent Roll

- 4-ton roll of single ply tissue paper

Project Background (cont.)

Machine #515

- Converting machine - Converts tissue paper into paper products

https://www.essity.com/library/videolibrary/

Current Process

Current Process

- Parent roll runs low on paper
- Alert is sent to operator
- Operator shuts down process
- Locks & Tags out
- Enters cage

Current Process (cont.)

Current Process (cont.)

- Manually create slack by hand
- Roll is cut leaving slack behind
- Second operator replaces old roll with new roll using an overhead crane
- Splice old roll slack onto new roll

Need Statement

This current process takes around 1.5 minutes to do. We hope to shorten this by at least half.

Essity has asked ONU Senior Design Team #09 to design a new tail cutter that is time efficient, safe and automated.

Project Requirements

Design Objectives

- Should have a straight finished cut
- Should be an automated process
- Should have a roll-cut time < 1 minute

Project Requirements (cont.)

Design Constraints

- Must be small enough to not interfere with operation
- Must create at most 7 ft of slack
- Must not tear paper
- Must be safe on the ANSI B11 scale

https://www.rockfordsystems.com/machine-risk-assessment/

Project Requirements (cont.)

Functional Requirements

- Must not obstruct the operator or machine process
- Must leave enough slack to splice onto new roll
- Must save time on the entire process

Additional Realistic Constraints

Compatibility

- Ensure components are compatible with Essity's systems

Automation

- It is preferred that the cutting process is automated

Maintainability

- Blade and device must withstand repeated use

Applicable Codes & Standards

ANSI B11 Standard

- Standard for safety of industrial machines
- Requires general risk assessment when implemented

OSHA 1910 Section Q

- Standards for using a cutting device in industrial setting
- Used to assess our cutting device design

Deliverables

Essity has asked for the following deliverables:

- **3D Prototype of Design**
  - **Assembly of Parts**
- **Finite Element Analysis**
- **Integrable Concept of Design**

Initial Design Interpretation

Traction component

- Applies torque to roll
  - Torque creates rotation and slack

Transport Component

- Transports cutting device to roll
  - Initiates a cut after slack has been created

Design Alternatives - Traction Component

Thin Traction Wheels

- Two traction wheels
  - Placed on either side of roll
- Takes up less space
- More likely to tear the parent roll due to smaller contact area

https://www.indiamart.com/proddetail/cylinder-bush-11325037612.html

Design Alternatives - Traction Component

Wide Traction Wheel

- One traction wheel
  - Placed across face of roll
- Takes up more space
- Less likely to tear parent roll due to larger area of contact

https://www.indiamart.com/proddetail/cylinder-bush-11325037612.html

Design Alternatives - Traction Component

Traction Belts

- Pre-existing component
- Located under the roll
- Typically helps feed paper into machine
- Can be used to jog roll & create slack

Design Matrix - Traction Component

Traction Wheel Design Matrix							
	Traction	Space	Durability	Weight	Cost	Maintainability	TOTAL
Thin	4	7	4	1	2	4	22
Wide	7	4	5	2	2	6	27
Belts	8	7	7	3	3	6	34
Weights	8	8	7	3	3	6	35
How Points Are Assigned	Spins roll/No tears	Small size overall	Doesn't wear on roll	Low weight overall	Low cost overall	Easy to maintain	

Design Alternatives - Transport Component

Crane type

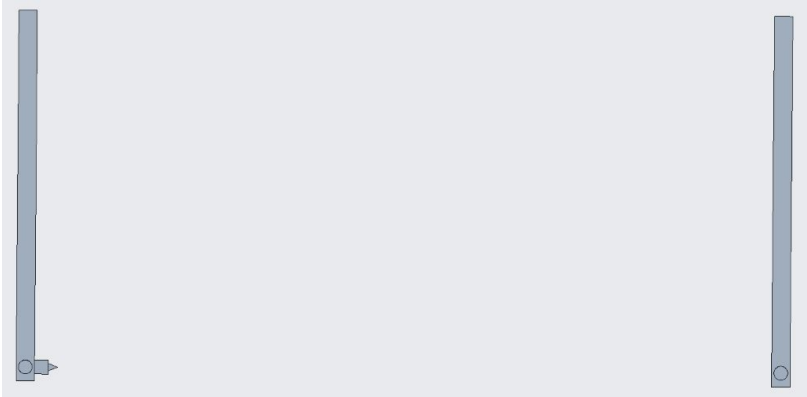
- Located above parent roll
- Lowers cutting device onto roll
- Cutting device is run across the width of the roll
- Rises back to stowed position

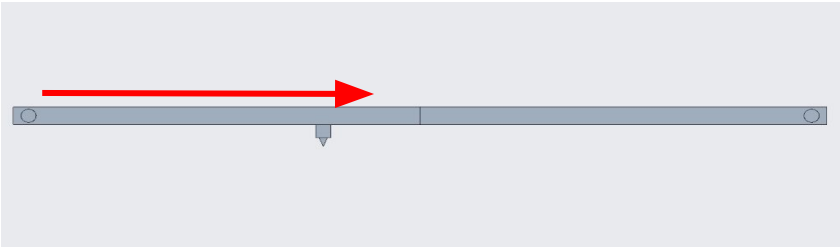
https://jialitxk.en.made-in-china.com/product/TsBxctCynAVM/China-Single-Motor-1-Ton-Double-Hook-Hoist.html

Design Alternatives - Transport Component

Drawbridge

- Located above parent roll
- Starts in a stowed position
- Lowers cutting device onto roll
- Cutter runs across the width of roll
- Returns to the stowed position





Design Alternatives - Transport Component

Hydraulic

- Located below parent roll
- Starts in a stowed position
- Raises cutting device onto roll
- Cutter runs across the width of roll
- Returns to the stowed position

https://www.shutterstock.com/search/hydraulic

Design Selection - Transport Component

Cutter Design Matrix								
	Weight	Space	Cost	Mobility	Stability	Maintainability	Manufacturability	TOTAL
Drawbridge	5	6	2	6	7	5	5	36
Crane	5	8	2	6	5	7	5	38
Hydraulic	3	4	1	5	8	6	5	32
Weights	5	9	2	8	8	7	7	46
How Points Are Assigned	Low weight	Small size overall	Low cost overall	Fast Movement	Device is very stable	Easy to maintain	Easy to manufacture	

Design Selection - Traction Component

Benefits of Traction Belts

- Pre-existing component
- Easier to implement than other options
- A button needs to be installed in order to use.

Design Selection - Transport Component

Benefits of Twin Hook Hoist

- Out of the way of operations
- Easier to implement than other options
- Easier to maintain than other options

https://jialitxk.en.made-in-china.com/product/TsBxctCynAVM/China-Single-Motor-1-Ton-Double-Hook-Hoist.html

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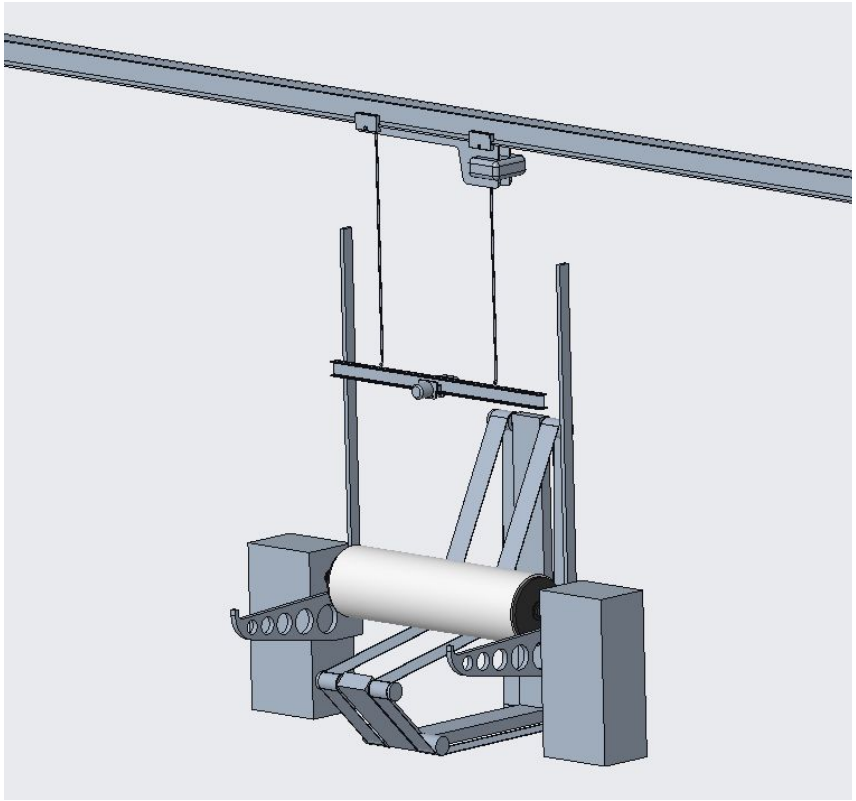
Model of Final Design



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Additional Design Details - 2nd Transport Device

Motorized Trolley

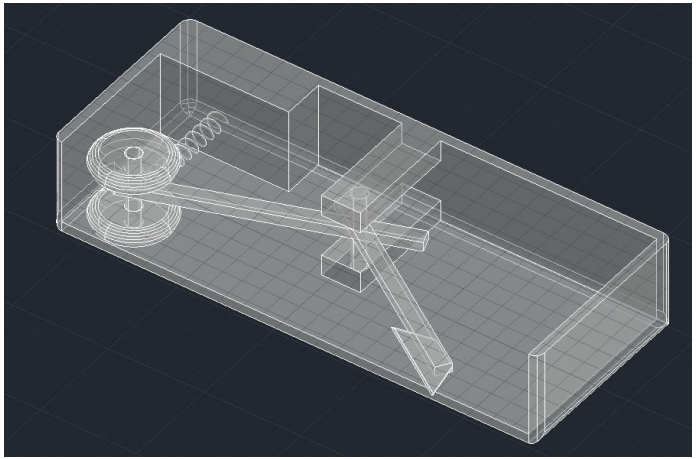
- Mounted on an aluminum I-beam
- I-beam will be lowered by hoist
- Will be used to move cutting device across the face of roll

https://hoistzone.com/shop/black-bear-motorized-trolley/

Additional Design Details - Cutting Device

Rocker Blade with Enclosure

- Mounted onto motorized trolley that will be placed on an I-beam
- I-beam is connected to the twin hook hoist
- When force is placed on the spring, the blade will be exposed for operation



Additional Design Details - Cutting Device (cont.)

Spring:

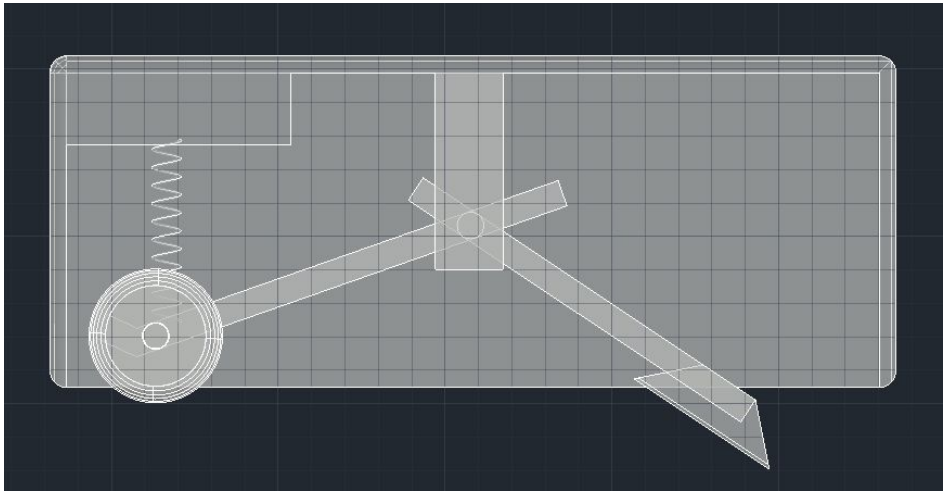
- Makes the blade retract when not in use

Wheels:

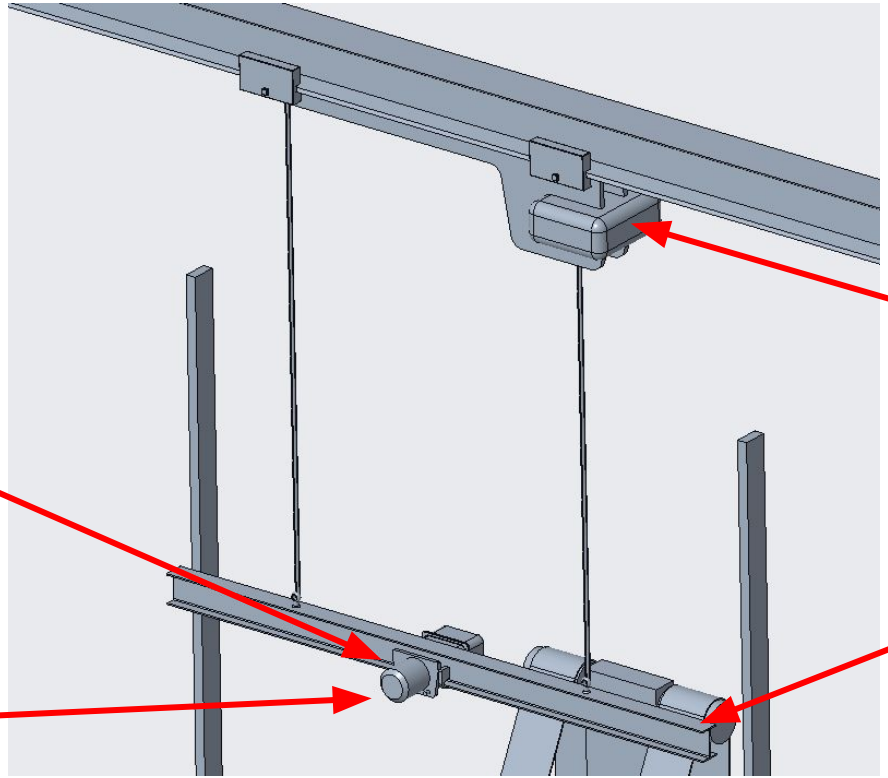
- Rubber to withstand force and repeated use

Blade:

- Carbide utility blade for multiple uses



Model of Design (cont.)



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Tonnage of System

- Twin Hook Hoist - 1,000 lbs to 2,000 lbs
- Aluminum I-beam - 30 lbs
- Motorized Trolley - 100 lbs
- Cutting Device - 40 lbs
- Total - 1,180 lbs to 2,180 lbs (1.17 tons to 2.17 tons)

Estimated Cost

- Twin Hook Hoist - $2,500 - $4,500
- Aluminum I-beam - $80 - $150
- Motorized Trolley - $625 - $1,350
- Cutting Device - $200 - $550
- Total - $3,405, to $6,550

Benefits of Design

- Cost effective compared to other options
- Easy to implement compared to other options
- Speed of process will be improved
- Out of the way of worker or machine
- Retracting blade for safety

New Order of Operations

- Operator receives alert that roll is running low & stops process
- Green belts are slowly jogged to create around 6ft of slack
- Dual Hoist moves across I-beam until centered over roll
- Trolley with cutter attachment is lowered onto the roll

New Order of Operations (cont.)

- Cutting device makes contact with the roll
- Blade extracts from device
- Trolley initiates cut across width of roll
- Hoist lifts trolley back to a stowed position (blade retracts)
- Hoist parks away from existing crane on I-beam

Testing & Validation

Inspection

- Model & Assembly
- Video of existing process

Calculation

- Safety Factor
- Working stress

Analysis

- Finite Element Analysis

Material of I-beam

Material of I-beam: AL6061-T6

This material provides:

- **High yield strength - 40,000 psi.**
- **Low weight - 0.0975 lb/in³**

Motorized trolley with the cutting device attached will be attached to bottom flange

https://bh-usa.com/25-x-8-aluminum-structural-beam/

Safety Factor

Essity has placed a heavy focus on safety at their facility.

Because of this, we set our safety factor to 10.

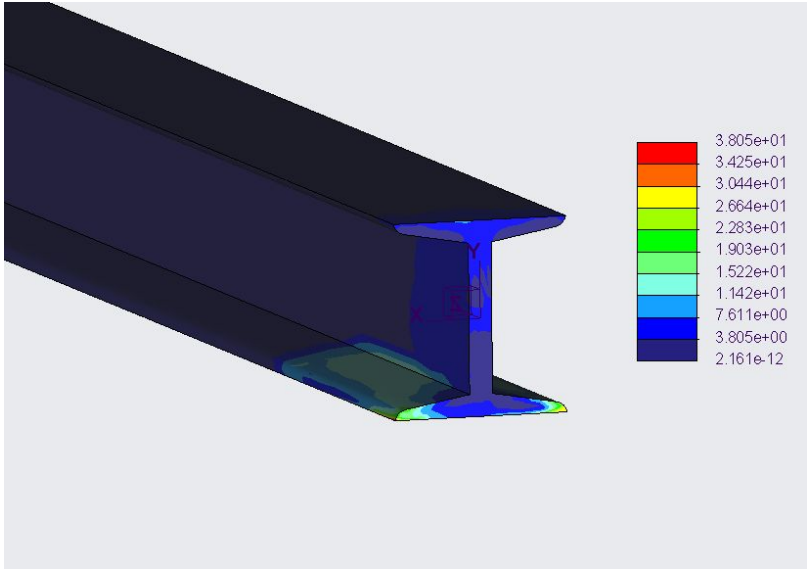
$$Safety\ Factor = \frac{Yield\ Stress}{Working\ Stress}$$

$$10 = \frac{40{,}000 \frac{lbf}{in^2}}{S_w \frac{lbf}{in^2}} \quad \rightarrow \quad S_w = 4{,}000 \frac{lbf}{in^2}$$

Front Load Test

Purpose of this test:

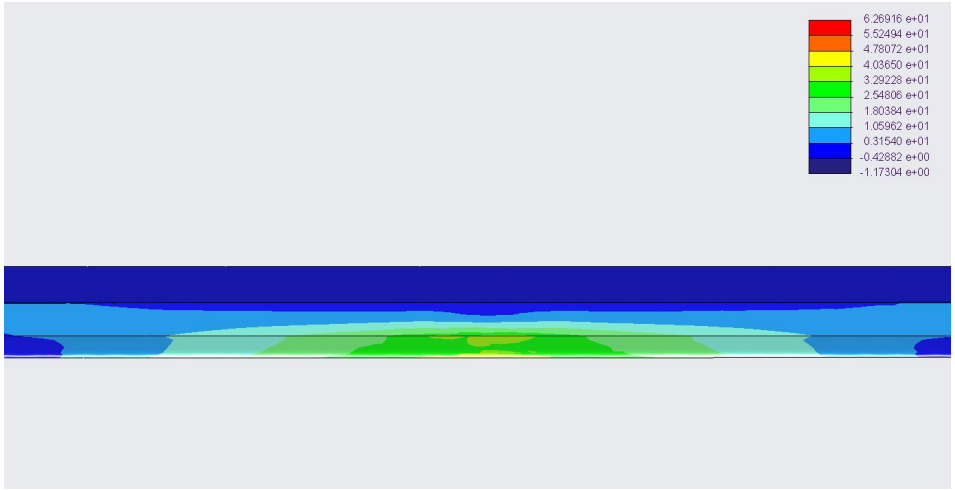
- **This is the point where trolley will be parked or paused.**
- **The forces shown on the beam were found to be within an acceptable range with 50lb load.**
- **Range: 3.8lbs to 26.64lbs**



Middle Load Test

Purpose of this test:

- **Weakest part of beam**
- **The forces shown on the beam were found to be within an acceptable range with 50lb load.**
- **Range: 0.32lbs to 40.36lbs**



Design Objective Validation

Should be automated at the push of button

- **Essity has confirmed it is possible to automate this process with one button.**

Should provide a straight finished cut

- **I-beam is constrained such that the cutting device can deliver a straight cut.**

Should transport cutter to its destination with stability

- **The method of transport for the cutter device ensures stability in transport.**

Design Objective Validation (cont.)

Should be reliable for multiple uses without maintenance

- **Hoist, trolley, and blade are rated for many uses before maintenance.**

Should have a cost-effective design.

- **We implemented cost efficient solutions to minimize cost while ensuring quality and safety.**

Should produce a cut quickly (less than 1 minute).

- **The motorized trolley travels at a rate of 79 feet per minute or 1.316 feet per second.**

Design Constraint Validation

Must be small enough as to not interfere with the rest of Machine #515's operation, personnel and floor space.

- **From video analysis and model inspection, the device not be in the way of operators or Machine #515's components.**

Must be safe to operate in all aspects under the ANSI B11 standard.

- **The rocker blade meets the ANSI B11 standard by tucking itself away after use. The process also places the device on a properly rated I-beam.**

Functional Requirement Validation

Must reduce the process time to under 45 seconds.

- **The original process takes around 1.5 minutes with two operators.**
- **The new process saves an est. 43 seconds on a two person operation.**

Must not obstruct the operators when they are working on the machine.

- **The device is completely out of the way of the machine when stowed**

Functional Requirement Validation (cont.)

Must be at most 7 ft of paper when creating slack.

- **The process of creating slack will not exceed 7 ft by testing at Essity.**

Must keep the paper from tearing apart.

- **By utilizing pre-existing parts, we can ensure that the belts are properly rated for the paper.**

Recommendations

Automation

- Signals to tell the crane to stop lowering onto the roll so that the cutting device is at the correct height
  - Laser signal - Beam is broken, lowering stops
  - Pressure signal - Pressure pad is pressed, lowering stops

Recommendations (cont.)

Safety Guard

- Guard for the internal components located under the enclosure where the wheels and blade protrude

Sway Rail

- Rail extending off of aluminum I-beam that would limit sway when initiating a cut

Questions?

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