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Puncture and Cut Resistant Glove Testing

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Problem Statement
American Packaging Corporation is a flexible packaging converter; they currently have three operational facilities in Story City, IA; Columbus, WI; and Rochester, NY, with a new facility being built in Chili, NY. Engineering laminations and coatings, rotogravure printing and lamination, and flexographic printing and laminating are some of the techniques that they are capable of. They provide packaging for a wide range of products in food and beverage, personal care, health care, and specialty packaging. A testing procedure is needed to test the performance of puncture and cut resistant gloves in a specific scenario that is commonly seen throughout through their facilities. The problem that American Packaging faces is that the current gloves that they use meet the specifications for cut resistance, but have no rating for puncture resistance. This is because their manufacturers of cut resistant gloves do not provide a rating scale/system for puncture resistance (Safety Gloves and Hand Protection). Employees are getting hurt, and this is causing costs in medical care and lost productivity. Our proposed solution will apply to American Packaging outside of its location in Story City, Iowa, as they are planning to implement one set of gloves to be used across all of their manufacturing facilities in the United States. This proposed solution will potentially reduce the cost and amount of gloves American Packaging has currently been spending. What is not known about the problem is the severity of injuries, also we do not know the lifespan of this project. Especially we don't know if they will use it once or use it continuously.

Disciplines
Bioresource and Agricultural Engineering | Industrial Technology

Authors
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Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Puncture and Cut Resistant Glove Testing

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*course instructors and corresponding authors.

Client: American Packaging Corporation, 103 West Broad Street, Story City, Iowa, 50248, http://www.ampkcorp.com/

- Contact(s): Jim Withers, Corporate Safety Director, JWithers@ampkorp.com, 515-733-3226; Dylan Gaudineer, HSE Manager, DGaudineer@ampkcorp.com, 515-733-1475

1 PROBLEM STATEMENT

Problem Statement

American Packaging Corporation is a flexible packaging converter; they currently have three operational facilities in Story City, IA; Columbus, WI; and Rochester, NY, with a new facility being built in Chili, NY. Engineering laminations and coatings, rotogravure printing and lamination, and flexographic printing and laminating are some of the techniques that they are capable of. They provide packaging for a wide range of products in food and beverage, personal care, health care, and specialty packaging. A testing procedure is needed to test the performance of puncture and cut resistant gloves in a specific scenario that is commonly seen throughout through their facilities. The problem that American Packaging faces is that the current gloves that they use meet the specifications for cut resistance, but have no rating for puncture resistance. This is because their manufacturers of cut resistant gloves do not provide a rating scale/system for puncture resistance (Safety Gloves and Hand Protection). Employees are getting hurt, and this is causing costs in medical care and lost productivity. Our proposed solution will apply to American Packaging outside of its location in Story City, Iowa, as they are planning to implement one set

of gloves to be used across all of their manufacturing facilities in the United States. This proposed solution will potentially reduce the cost and amount of gloves American Packaging has currently been spending. What is not known about the problem is the severity of injuries, also we do not know the lifespan of this project. Especially we don't know if they will use it once or use it continuously.

Business Case Statement

Employees are getting injured while changing out a doctor blade, this is done multiple times a day on each of the four machines, and there are also 20+ blades per machine. This hazard occurs when the operators are replacing the old blade with a new one. The employees typically get injured on the old blade that has been sharpened from the process of applying ink to the anilox (ink transfer) cylinder. It makes strategic sense to solve this problem because American Packaging Corporation is dedicated to employee safety. Employees and management care about controlling hazards associated with sharp objects because these hazards may cause workplace injuries.

2 GOAL STATEMENT

The fundamental improvement that is needed for American Packaging is new protective glove that has ratings in both puncture and cut resistance that meets the standard of handling doctor blades. The data will be measured by puncture resistance, and cut resistance ratings compared to unit cost of the gloves (Safety Gloves and Hand Protection). Also we will test how they perform under work conditions, specifically how they handle cutting and puncture forces from the doctor blades. Specific parameters are that the gloves being tested need to withstand a certain amount of both cutting and puncturing forces from doctor blades, these specific values have yet to be determined. Tangible results include minimizing/preventing risk to employees, potentially reduce costs spent purchasing PPE, and test and gather data from purchased gloves when used on a doctor blade in a controlled environment. Other deliverables that we expect results for, that would be difficult to measure, would include employee and public relations, as well as company image. Create a suggestion based off of successfully tested gloves that meet required rating specifications while factoring in and comparing prices of said gloves.

- **Main Objective(s) and Specific Objectives**
  The main objective is to create a test stand that will be able to replicate a specified force and be able to test gloves in multiple grip positions. Also to collect and analyze the data so we can make a suggestions on what is the best glove according to our client criteria.
- **Specific objectives include**:(sub-points in the appendix)
  - (1) Create a test stand
  - (2) Collect visual data
  - (3) Create Standard Operating Procedure (SOP)
  - (4) Compile and summarize findings/data
  - (5) Make glove suggestion focused on employee safety
- **Rationale**
  - Reducing injuries to employee hands while operating machinery with doctor blades.
  - Potentially reducing amount of money spent on gloves.

3 PROJECT PLAN/OUTLINE

A. Methods/Approach (In Appendixes)

B. Results/Deliverables

- Our main deliverables are to have a functional testing rig, and to also have several SOPs of how to operate the testing rig, assemble to rig, and how to make the ballistic gel.
- Our project was not completed as planned, we had to cut down our scope and our project deliverables. This was due to time constraints and issues getting the materials ordered for the testing rig.
- Our recommendations are to follow our SOPS to carry out the testing using our rig and methods.
- The follow up steps would be for the client to do continuous testing to see if new and better gloves get released to the public. To revise our methods and SOPs to more accurately reflect their procedures.

C. Timeline ***(can be combined with Deliverables above)***

- Research was completed on 1/19/2018
- Design of testing rig was completed on 2/23/2018
- SOPs will be completed 4/13/2018
- The final report rough draft was finished by 4/5/2018
- The oral presentation and final report will be given on capstone day at 1pm 4/20/2018
- The final draft will be complete by 4/27/2018

4 BROADER OPPORTUNITY STATEMENT

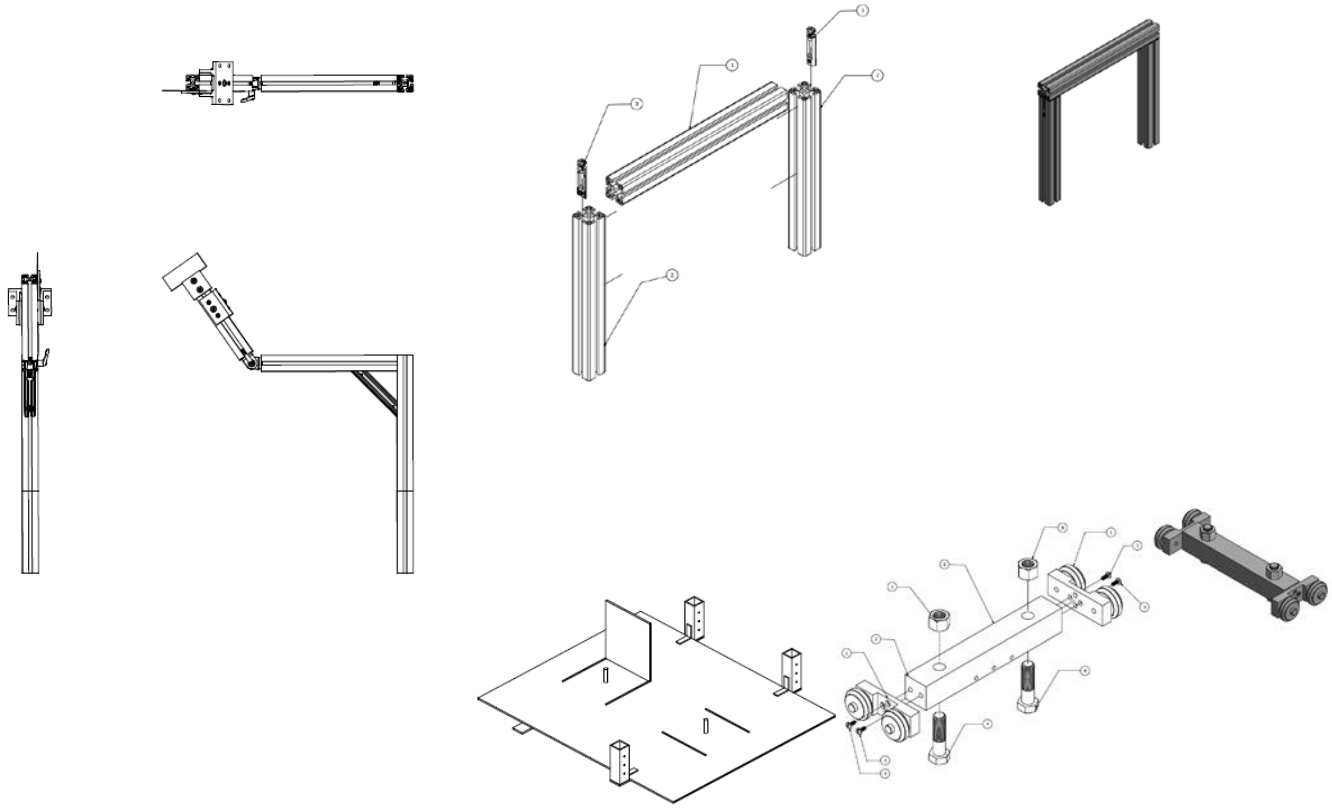
Our project is a little bit specialized in the specific machine and process we will be examining. However, the general public should be able to understand the basic concepts, they can understand that a sharp blade is puncturing a cut resistant glove and we need to find a glove that will reduce this problem; while still maintaining a decent cost and cut protection. This project might not appeal to everyone since the use of cut resistant gloves is, typically, only an industry situation, but those who have similar scenarios with the use of PPE will find our project very interesting. The “big challenges” we are facing and hoping to overcome all have to do with improvement whether it is the improvement of employee safety, improving health, or even improving the quality of life. There are many people who will experience similar types of problems, such as any industry that deals with work environments with cutting/puncture potential.

5 PROJECT SCOPE

At the start of this project we were very unclear what exactly would be required of us, after meeting face to face with the client we discovered our scope was fairly simple. We need to create a test rig and participate in an experiment to determine the best overall glove that will protect the employees as they change the doctor blades. As any project progresses things will have to change it is only natural. Our client is very easy going on how we accomplish the task as long as we keep him informed and the

direction we take the project still matches with what he is expecting. During the course of our project we ran into time constraints which compelled us to change the scope and deliverables. We still created a testing rig that would replicate the hazards faced by American Packaging, however we did not implement our physical testing. We will produce SOPS that describe everything associated with the rig and the experiment we had planned to do, so that in the future American Packaging can conduct the physical testing. Our project only focused on the hazard created by the continuous changing of the doctor blades. This is the hazard we focused on simply because that is where American Packaging has seen issues in the past. One alternative solution would be automation or incorporating some sort of guard for the blade before an employee changes it. These options were not considered because at this time our client does not wish to change their system but rather find a way to make the current system safer.

6 GRAPHICAL ABSTRACT



(McMaster-Carr.)

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8 APPENDIXES

Specific objectives include:

(1) Create a test stand
- Replicate work environment
- Replicate human hand (*Mythbusters)*
  - Create through the use of ballistic gel (GELITA®)
- Replicate specific force(s) every time
- Test cut and puncture resistance (Vrshek)

(2) Collect visual data
- Visually assess if glove passed or failed
  - Specific force used
  - Glove type used
- Collect information on glove prices
  - Compare between gloves that passed test

(3) Create Standard Operating Procedure (SOP)
- Understandable to everyone
  - Simple vocabulary
  - Use of visual aids to enhance understanding
  - Outline safety requirements, i.e. PPE, while testing
- Formatted for use in training new employees
  - Illustrates potential risk while operating with doctor blades

(4) Compile and summarize findings/data
- Using charts, graphs, and trend lines
- Pictures of gloves both before and after testing
- Create a "Top 5" list of the best performing gloves with cost

(5) Make glove suggestion focused on employee safety
Based, primarily, on data collected
Factoring in price of gloves (secondary factor)

Purchase Order #:	33487	**Chg/Rel #:**	HC000

Supplier:	McMaster Carr 600 COUNTY LINE ROAD ELMHURST, IL 60126-4355	**Phone #:** **Fax #:** **ShipVia #:** **Terms #:**	(630) 833-0300 NET 30

Ship To:	American Packaging Corp. 103 W. Broad Street Story City, IA 50248	**Bill To:**	American Packaging Corp. 103 W. Broad Street Story City, IA 50248

Date Ordered:	03/29/2018	**Sub Total:**	328.95
Date Required:	03/29/2018	**TAX1:**	23.03
Approved By:	JOHNNA MOELLER	**TAX2:**	.00
		Total:	351.98

Part#	Description	Quantity	Units	Unit Price
47065T102	1' LONG HOLLOW T-SLOT	4.0000	EA	6.9800
47065T221	LOCKING PIVOT FOR 1" HIGH SINGLE RAIL	1.0000	EA	18.9800
47065T186	DIAGONAL BRACE 6" LONG	1.0000	EA	14.3600
5537T294	STRAIGHT CONNECTOR FOR 1 1/2" AND 40mm RAIL	4.0000	EA	6.3000
5537T316	L SHAPED CONNECTOR FOR 1 1/2" , 30mm RAIL	1.0000	EA	3.5600
47065T233	DROP IN FASTENER WITH STUD	2.0000	EA	1.5200
47065T102	T-SLOTTED FRAMING 2'	2.0000	EA	13.5200
47065T852	SQUARE MOUNTING PLATE	1.0000	EA	11.3200
47065T147	DUAL END FEED FASTENER	1.0000	EA	4.2900
47065T962	BEARING FOR 1 1/2" WIDTH RAIL	1.0000	EA	58.0000
47065T142	END FEED FASTENER FOR 1" HIGH SINGLE RAIL	3.0000	EA	2.3000
47065T974	TRACK ROLLER CARRIAGE	2.0000	EA	64.1700

Purchase Order #:	33505	**Chg/Rel #:**	HC000

Supplier:	McMaster Carr 600 COUNTY LINE ROAD ELMHURST, IL 60126-4355	**Phone #:** **Fax #:** **ShipVia #:** **Terms #:**	(630) 833-0300 NET 30

Ship To:	American Packaging Corp. 103 W. Broad Street Story City, IA 50248	**Bill To:**	American Packaging Corp. 103 W. Broad Street Story City, IA 50248

Date Ordered:	03/29/2018	**Sub Total:**	105.32
Date Required:	04/02/2018	**TAX1:**	7.37
Approved By:	JOHNNA MOELLER	**TAX2:**	.00
		Total:	112.69

Part#	Description	Quantity	Units	Unit Price
9143K24	1' LOW CARBON STEEL BAR	1.0000	EA	37.1000
9124A362	GRADE 5 STEEL HEX HEAD SCREW	1.0000	EA	10.7400
9017K494	1' ANGLE 18" WALL THICKNESS 2 X 2	1.0000	EA	5.6000
8910K555	2' low carbon steel bar	1.0000	EA	14.2300
8920K115	3' LOW CARBON STEEL ROD	1.0000	EA	2.5500
9143K724	1' LOW CARBON STEEL BAR	1.0000	EA	35.1000

- **Methods/Approach**
- **Reference Material(s):**

- We have researched four main topics including already existing standards (Vrshek), already existing test stands (Puncture Resistance Testers), human hand replication (GELITA®), and non-glove material cut resistance. As we continue our project we plan to look into more of the existing standards, contacting competitors of American Packaging Company to see if they have encountered similar problems, and also the glove manufactures and supplies to see what kind of data and tests they have already run on the gloves.
- **Data collection**:
- Our data will take the form of results generated by testing. We will most likely use visual inspection to determine whether or not the glove was cut or punctured by the test. We are doing measurements of cuts including possible depth and length of laceration within the ballistic gel.
- **Skills**:
- The skills we will need to utilize include understanding force relationships and equations, a familiarity with the process American Packaging is having issued with, and learning to consistently judge the effectiveness of the glove at withstanding our test. Some of the relevant courses that will help us with this project are Physics, Statics, the two safety courses TSM 270 and TSM 370.
- **Solutions**:
- The solution was developed by compiling all of our research to design a testing rig that will successfully replicate the specified hazards. We designed a pendulum, guillotine, and base plate to make up our testing rig design.
- The solution will be measured by visually analyzing the gloves for failure, and also by analyzing the applied force to the glove. The solution will also be measured by how accurately it replicated the forces needed. We will use OSHA and ASTM standards to evaluate our preliminary options (Vrshek). We modeled our design in AutoDesk Inventor, and evaluated the feasibility of the design with our client.
- We researched the type of safety hazards that exist in the American Packaging Corporation and used those as a metric to compare the effectiveness of our design.
- We evaluated our design to be better because it was more reliable, less complex, and more cost effective.
- Yes this will meet client expectations, this is because we worked closely with our client initially so we understood what they expected of us. Client feedback was incorporated, however most of the design phase was completed independently and altered on client's request.
- **Organization:**
- We reached out to the client every week for both semesters during our team meeting time, if needed we did send more client updates. As a team we met during out weekly time, but we also worked together in between classes, at night, and collaborate on google drive.
- We assigned job for each member to do per week, usually independent research. We also split our team into two groups of two to collaborate on bigger portions of the project as needed.
- The major milestones of our project were research, initial design, final design, and fabrication.
- In this project we encountered some time setbacks, and also communication setbacks. The way we responded to these was to reach out to both our clients more frequently, and to continue work on a more independent level. We also attempted to do as much work on the project with the information we had at our disposal. As time constraints got tighter we were forced to cut

down our scope, we removed the testing portion of our scope and instead focused on fabrication of a functional testing rig.

Purchase Order #:	33520	**Chg/Rel #:**	HC000

Supplier:	Central Iowa Building	**Phone #:** **Fax #:** **ShipVia #:** **Terms #:**	(515) 832-4465 VENDELIV NET 30

Ship To:	American Packaging Corp. 103 W. Broad Street Story City, IA 50248	**Bill To:**	American Packaging Corp. 103 W. Broad Street Story City, IA 50248

Date Ordered:	04/02/2018	**Sub Total:**	94.95
Date Required:	04/03/2018	**TAX1:**	6.65
Approved By:	JOHNNA MOELLER	**TAX2:**	.00
		Total:	101.60

Part#	Description	Quantity	Units	Unit Price
PLATE	1/4" X 2.5' X 3' PLATE	1.0000	EA	94.9500

SOPs (*Note that these procedures are subject to change*)

Ballistic Gel Procedure

Materials Needed:

- Surgical Glove(s)
- 10% Mixture ballistic gel and water
- Hand Whisk
- Pot
- Refrigerator

Steps:

1. Heat water to a boil.
2. Pour ballistic gel & gallon of water into pot (ratio is 9 parts hot water to one part powder).
3. Stir thoroughly with whisk as you pour in the powder.
4. Pour mixture into gloves up to wrist level.
5. Tie off or duct tape the end of each glove for a tight seal.

6. Place the gloves flat in the refrigerator
7. Let gel set overnight – keep refrigerated longer if necessary.
8. Inspect gloves in the morning to see if gel has set.
9. Keep gel in refrigeration until ready to test (GELITA®), (*Mythbusters*.)

Assembly of the Testing Rig

Materials Needed:

- Baseplate
- Pendulum components (See bill of materials) ("McMaster-Carr.")
- Guillotine components (See bill of materials) ("McMaster-Carr.")

Steps for base (See drawings/assemblies for reference):

1. Screw the 3 pieces of T-Slotted framing with tapped holes in the ends into the baseplate
2. Ensure they are tightened so they don't shift in testing
3. Screw in fist pins if desired

Assembly for the Guillotine (See drawings/assemblies for reference):

1. Install track roller carriage into both sides of the runner, using screws
2. Install 2 bolts vertically into the runner
3. Install 3 bolts horizontally into the runner that are used to attach doctor blade
4. Ensure vertical T-slotted framing (from base-plate instructions) are square to one another
5. Slide assembled runner into slots on the vertical T-slotted framing (from base-plate instructions)
6. Using 2 drop in fasteners with studs to secure the horizontal t-slotted framing to the two vertical t-slotted framing(from base-plate instructions)

Assembly for the Pendulum (See drawings/assemblies for reference):

1. Install the diagonal brace on the horizontal piece t-slotted framing using 1 end feed fastener
2. Slide the horizontal t-slotted framing and diagonal brace on the vertical t-slotted framing using 1 end feed fasteners on the bottom portion and a L shaped connector for the top portion
3. Attach locking pivot to the tapped end of the horizontal t-slotted framing using screws
4. Attach the short piece of t-slotted framing onto the other end of the locking pivot using the dual end feed fastener
5. Slide the bearing on the short t-slotted framing and secure using 2 bolts
6. Attach the square mounting plate using screws/bolts

Testing Procedures for Pendulum

Steps:

1. Attach doctor blade to the square mounting plate
2. Place ballistic hand in desired testing glove
3. Place ballistic hand in testing position
4. Make sure the angle of the blade is set for optimized cut
5. Add additional weight if desired
6. Lift arm and lock in place
7. Stand on side with the pendulum lock
8. Check the testing area to make sure it is clear of safety hazards
9. Release lever so the arm falls, performing the test
10. Remove ballistic hand
11. Analyze for depth of cut/glove failure
12. Document results

13. Change ballistic hand/glove

Testing Procedures for Guillotine

1. Attach doctor blade to runner
2. Place ballistic hand in desired testing glove
3. Have one operator raise the runner to desired height
4. Have the second operator place ballistic hand in testing position
5. Check the testing area to make sure it is clear of safety hazards
6. Drop runner to perform the test
7. Remove ballistic hand
8. Analyze for depth of cut/glove failure
9. Document results
10. Change ballistic hand/glove