Progress Report for

Book Corner Rounder

Winter 2011

Sponsor

Pinball Publishing

Industry Advisor

Austin Whipple



Group Members

Joshua Schmidt

Andrew Dillon

Melissa Anders

Matt Kirtley

Faculty Advisor

Dr. Huafen Hu

## Executive Summary

The intent of this document is to detail the progress and conclusions made by the Book Corner Rounder Capstone Team in designing a production device for Pinball Publishing. The device will round two corners of a pocket notebook called the Scout Book. Current production exceeds the capacity of the corner rounding devices used by Pinball Publishing. The device to be delivered by the Book Corner Rounder Team will meet the needs of the customer (Pinball Publishing) and exceed the output of the current system used. The background information, product design specifications, research performed and design evaluations that were used to make the design selection are outlined in this document. The progress of the detailed design is also included.

Table of Contents

[Executive Summary 1](#_Toc287272712)

[Introduction 3](#_Toc287272713)

[Mission Statement 3](#_Toc287272714)

[Project Plan 4](#_Toc287272715)

[PDS Summary 4](#_Toc287272716)

[External Search 5](#_Toc287272717)

[Internal Search 6](#_Toc287272718)

[Design Evaluation and Selection 7](#_Toc287272719)

[Progress on Detailed Design 9](#_Toc287272720)

[Automation 9](#_Toc287272721)

[Cutting 9](#_Toc287272722)

[Future Design Decisions 10](#_Toc287272723)

[Conclusion and Recommendations 10](#_Toc287272724)

[Appendix A: Gantt chart 11](#_Toc287272725)

[Appendix B: Product Design Specifications 12](#_Toc287272726)

[Appendix C: Existing related products 17](#_Toc287272727)

[Appendix D: Available cutting technologies 18](#_Toc287272728)

[Appendix E: Available power sources 19](#_Toc287272729)

[Appendix F: Decision matrices 20](#_Toc287272730)

## Introduction

Pinball Publishing (a local, offset print shop) approached the School of Mechanical Engineering at Portland State University to design and manufacture a device to be used in the production of pocket notebooks called Scout Books. The Scout Books are distinguished from competitor’s products by two rounded corners. There are no commercially available machines that can round the corners of the notebooks quickly enough to keep up with the current output. In current production two devices are used to round the corners. The preferred device (double corner rounder) is a custom, retrofitted device that rounds two corners, of four notebooks at a time. The double corner rounder requires the operator to properly position the notebooks, and press a pedal that mechanically leverages two dies to cut the two corners. One drawback of the double corner rounder is that when four notebooks are stacked and rounded, the bottom notebook suffers from pinching that damages the book. The second device is a pneumatically powered, commercially available device (single corner rounder) that can round only one corner of the notebooks at a time. The single corner rounder is used only when the double corner rounder can’t keep up with production needs. The current devices require two skilled employees to produce 2,000 notebooks an hour.

Pinball Publishing sold 500,000 Scout Books in the past year, and anticipates sales to double in the next. The Scout Books are produced at 2,000 pieces an hour by a stitching machine. There are plans to produce a second line of product that emulates the Scout Book, but is larger. The stitching machine used can be retrofitted to produce the larger book. There is a need for a device that can meet the production speed of the stitching machine with fewer employees.

Mission Statement  
The Corner Rounder Capstone Group will develop and produce a device that will complete the final step in production for Pinball Publishing’s Scout Book. The device will exceed the output of the equipment currently being used, improve scrap disposal, allow for adjustment of various sizes of books, automate the cutting process, meet safety regulations, and stay within budget. The device will be delivered June 2011.

## Project Plan

At the start of the Capstone project, a Gantt chart was created to layout important milestones and project due dates. This chart, included in Appendix A, has been referenced and updated throughout the project to assess the team’s progress. The team has been on track with completion dates until recently when the feasibility of the team’s concept was questioned. With this evaluation, the internal search and concept analysis completion dates have been extended to allow for a different concept path to be pursued. The team is currently selecting a final design concept, which will be completed by mid-March. The detailed design of the final concept will be completed by the end of March. During this phase the team will also begin selecting materials and components, and compiling a bill of materials.

## PDS Summary

The Product Design Specifications, attached in Appendix B, has a complete list of design requirements that were defined by the customers of this Capstone project. The external customers include Pinball Publishing and their employees, maintenance technicians, and government codes and standards. The internal customers include the Capstone team members, the Capstone class, and the PSU Mechanical Engineering department. From the input and consideration of these customers, the criteria of highest priority were determined to be performance, life in service, cost of production, maintenance, ergonomics, safety, and quality and reliability. An incomplete list of these criteria, shown in Table 1 below, describes the higher priority requirements in detail.

Table 1: High priority criteria and their corresponding requirements.

|  |
| --- |
| **The main performance requirements for the device shall be:** |
| * The device is to handle a capacity of at least 2000 books/hour. |
| * The device is to cut within an accuracy of 1/64”. |
| * The device is to be adjustable to 3.5”x5” and 5”x7” book sizes. |
| * The device is to adjust within an accuracy of 1/64”. |
| * The device is to collect all scraps during operation. |
| * The device is to withstand operation times of at least 10 hours/day. |
| * The device is to be semi-automated. |
|  |
| **The main life in service requirement for the device shall be:** |
| * The device is to have an expected time in service of at least 5 years. |
| **The main cost of production requirement for the device shall be:** |
| * The device is to remain below a $1000 production cost. |
| **The main maintenance requirements for the device shall be:** |
| * The device is to have easily available replacement parts. |
| * The device is to require no specialty tools to repair. |
| * The device is to be easily accessible for servicing. |
| **The main ergonomics requirements for the device shall be:** |
| * The device is to be operated by 1 person. |
| * The device is to be easily worked at all day. |
| **The main safety requirements for the device shall be:** |
| * The device is to have safety guards. |
| * The device is to have an emergency stop. |
| **The main quality and reliability requirement for the device shall be:** |
| * The device is to be reliable 95% of the time. |

## External Search

An external search was conducted to see what products there were in terms of direct competition, as well as existing related products and technologies. This was done by searching a variety of sources, including relevant patents, websites, and catalogs. No direct competition was found. There were also no patents that represented devices not already on the market. Local printing equipment sales offices were called, but couldn’t offer anything similar to what the group was looking for. The most comparable products available are manually operated corner rounders, similar to what is already used in the shop. Appendix C shows a breakdown of a few of the related products on the market, including their advantages and disadvantages.

The most important step in the process is cutting the corner. Therefore an external search for cutting technologies was also carried out. This led to a variety of different options. Appendix D lists the various technologies found in this search, along with their advantages and disadvantages.

Additionally, the team also researched how the device will be powered. The team not only looked at off-the-shelf devices, but also designing and building a new system. This led to research of motors and various types of linear actuators. Appendix E shows the advantages and disadvantages of the systems that were researched.

## Internal Search

The team started the internal search by performing a functional decomposition on the corner rounding process. The scope of the project dictated that the process could only be semi-automated, and that the insertion and removal of the book would have to be done manually. This left the main processes to be aligning, clamping, and cutting of the book, as well as disposal of scraps. These actions were further broken down into possible options. Figure 1 below shows the concept classification chart that illustrates the functional decomposition. The signal flow throughout the process was also broken down and is illustrated in Figure 2.

Figure 1: Concept Classification Chart showing the functional decomposition

Figure 2: Chart showing signal flow throughout process

## Design Evaluation and Selection

Once the scope of the project was accurately defined, the team generated several concepts as a group and individually. Concepts were generated for each of the steps defined in the Functional Decomposition, as shown in Figure 1 of the Internal Search section. Each available concept was discussed, refuted, and defended during the weekly team meetings. Several decision matrices, shown in Appendix F, were created during team meetings to evaluate the feasibility of each concept. The main concepts that were evaluated are shown in Table 2 and are organized by the device process. Each concept has a brief description and the feedback of the group in terms of the advantages and disadvantages.

Table 2-Concept generation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device Process | Concept # | Description | Advantages | Disadvantages |
| **Alignment of Books** | 1 | One side fixed. One side connected to an inset plate. | Only one side needs to move, less moving parts | Gap in table surface, centering of the power source might be a problem |
| 2 | Both sides move, Each side on a plate, Plates are interconnected to minimize gap | Smaller gap in table surface, centering of power source not an issue | More moving parts |
| 3 | Plate adjusts by a threaded rod in middle, Smooth shafts on either side | Keeps plates square | Threaded rod subject to wear, needs maintenance |
| 4 | Three slots with adjustment knobs | Keeps plates square | More things to adjust |
| **Clamp Books** | 1 | Plate connected to actuator bar | No additional moving parts, integrated with cutting motion |  |
| 2 | Springs | Allows to clamp down to different size stacks | Subject to wear |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device Process | Concept # | Description | Advantages | Disadvantages |
| **Cut Corners** | 1 | Linear Actuator | Off the shelf, don’t need to convert motion, maintenance, safety | Cost |
| 2 | Linear actuator, connected through bottom with one rod in the center | Bottom setup easy to enclose/maintain, bottom-heavy | May have problems with centering with adjustment |
| 3 | Linear actuator, connected on the top | Table top design | Top heavy, maintenance, access to dies |
| 4 | Linear actuator, connected through bottom with two rods on either side | Centering not as much of an issue |  |
| 5 | Electric motor with conversion to linear motion (Cam, crank, etc.) | May be cheaper | Maintenance, complexity, Time to fabricate |
| **Dispose of Scraps** | 1 | Brushes connected to actuator bar | No additional moving parts | Subject to wear? |
| 2 | Enclosure | Keeps scraps in | Complicated removal of dies |
| 3 | Deflection devices | Diverts scraps | May not eliminate all scraps on own |

With the use of the decision matrices and general group consensus, some main concepts have been selected for use in the final design. For the power source, a pneumatic actuator has been selected for several reasons including maintenance, reliability, force/speed output, and availability of prefabricated parts. The orientation of the actuator in the bottom position has been selected for adjustability, safety, accessibility, and ease of design. As for the alignment and disposal mechanisms, concept generation and selection is currently in the process of completion.

## Progress on Detailed Design

### Automation

The design team had to decide how much automation was to be incorporated into the final product. According the PDS, performance is a very high priority. For this product, performance includes production numbers. Because of this, the first designs included full automation. Full automation of the process includes material handling and the actual cutting of the corners. After several designs were seriously considered and reviewed against the PDS, it was determined that full automation was not possible. This was due to other high priority items on the PDS such as cost and reliability. Given the time and funds available to the team, a fully automated process was not feasible. Subsequent designs eliminated materials handling from the automated processes leaving only the actual cutting step.

The current design leaves the process of getting the Scout Books, inserting them into the machine, removing them, and packaging them to an operator. The cutting portion of the process is to be automated and triggered when the Scout Book has been properly aligned by the operator.

### Cutting

Two main design decisions involved in the cutting step are how to cut the book and how to power the cut. Several ideas for how to cut the book included using commercially available dies, rotary blades, straight blades, and abrasive cutters. After comparing each concept to the PDS, it was determined using a decision matrix that using commercially available dies was the best decision. Although this decision limits other creative ideas for the rest of the process, the dies are easy to maintain, very reliable, and relatively inexpensive.

The next main step is how to power the cut. After reviewing stepper motors, pneumatic presses, and hydraulic devices it was decided to use a pneumatic linear actuators. This was chosen due to how cost effective it is, how controllable it is, and the fact that it is the simplest way of creating large amounts of linear force. Another consideration, given this decision, includes what air compressor to purchase. The main deciding factor will be how much pressure is needed to provide sufficient cutting force. This is to be determined in future testing. The tests will involve dull dies and sharpened dies to set a baseline force that will cut the corners under all in-service conditions. This testing will also provide insight as to how large of a tank the air compressor will need. By determining the force and PSI required per cut, a tank can be chosen to minimize cycling of the compressor. After considering the information in the decision matrix in appendix F, it was determined to mount the linear actuator underneath the cutting platform.

### Future Design Decisions

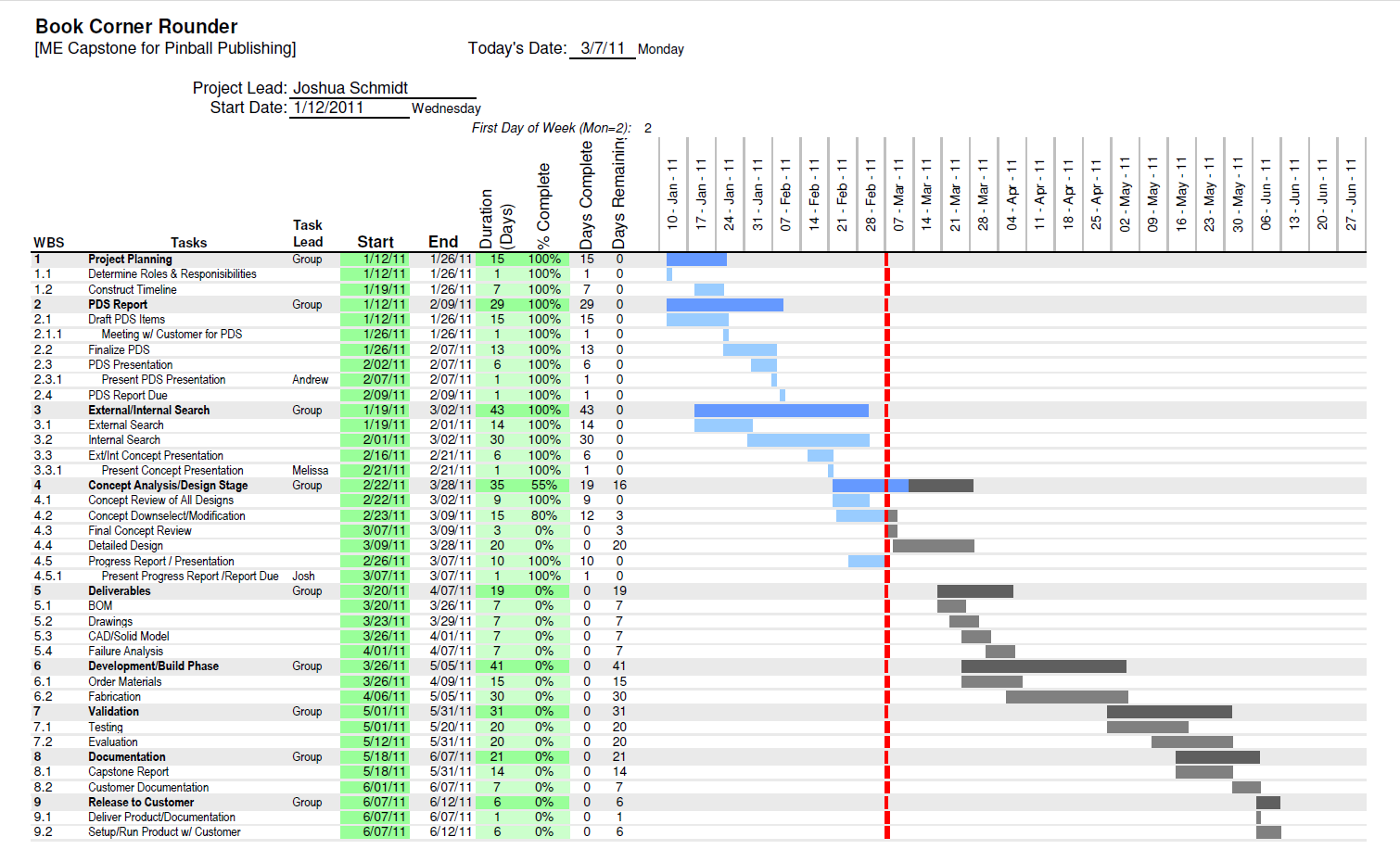
Cutting surface: A cutting surface is needed that is both adjustable and can receive the commercially available dies. Several ideas involving wedges and slotted members are on the table for how to handle this issue.

Safety Equipment: A high priority item on the PDS is safety. It is important to both the design team and the end user that the product have systems in place to reduce or eliminate operator injury. Current system being considered include switches to activate the cutting process that can only be triggered by the books, a whole system enclosure, and kill switch.

## Conclusion and Recommendations

Currently there are very few commercially available book corner rounders. It is the purpose of this team to deliver a device to the customer that meets their needs not met by currently available products. This far, the design has been narrowed down to a semi-automated machine powered by a linear actuator. A PDS report has been completed to fully determine the requirements of the final product and extensive internal and external research has been completed. The design is very user friendly and extremely simple to operate. Given the speed that the machine can produce rounded corners, quality of production will increase over the current system employed by Pinball Publishing. Although the customer originally envisioned a fully automated system, and because cost and deadlines are high priority items, the design team decided to limit the amount of automation. However, the team is still confident in the design’s ability to meet and exceed the customers overall goal of a more reliable, faster alternative to the processes currently in place to cut the corners of their Scout Books.

Appendix A: Gantt chart



## Appendix B: Product Design Specifications

The PDS check sheet, shown in Table 3, lists the page location of each design criteria as well as the priority level. The priority level is based on the importance of the criteria to the project, rated from high to low with N/A indicating that the criteria is not applicable. Table 4 further refines the criteria with the level of importance rated on a three star scale (with one star indicating low priority, two stars indicating medium priority, and three stars indicating high priority). For each criteria; the customer, metric, target, target basis and method of verification has been defined. TBD indicated the item has yet to be determined.

Table 3-PDS check sheet

|  |  |  |
| --- | --- | --- |
| **Criteria** | **Priority** | **Page** |
| Performance | High | 13 |
| Life in Service | High | 13 |
| Cost of Production | High | 13 |
| Size and Shape | High | 14 |
| Maintenance | High | 14 |
| Ergonomics | High | 14 |
| Safety | High | 15 |
| Quality and Reliability | High | 15 |
| Applicable Codes and Standards | High | 15 |
| Company Constraints and Procedures | High | 16 |
| Documentation | High | 16 |
| Legal | High | 16 |
| Timelines | High | 16 |
| Aesthetics | Medium | 15 |
| Testing | Medium | 15 |
| Disposal | Medium | 16 |
| Environment | Low | 13 |
| Weight | Low | 14 |
| Installation | Low | 14 |
| Quantity | N/A | 16 |
| Shelf Life | N/A | 16 |
| Materials | N/A | 16 |
| Manufacturing Facilities | N/A | 16 |
| Shipping | N/A | 16 |
| Packaging | N/A | 16 |

Table 4-PDS criteria and requirements

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Performance** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Capacity | Pinball Publishing | \*\*\* | # of books per hour | >2000 | Customer feedback | Testing |
| Accuracy of corner cutting | Pinball Publishing | \*\*\* | inch | <1/64 | Customer feedback | Testing |
| Corner radius | Pinball Publishing | \*\*\* | inch | 1/4 | Customer feedback | Testing |
| Adjustable to different book sizes | Pinball Publishing | \*\*\* | inch x inch | 3.5x5 / 5x7 | Customer feedback | Testing |
| Accuracy of adjustability | Pinball Publishing | \*\*\* | inch | 1/64 | Customer feedback | Testing |
| Scraps collected | Pinball Publishing | \*\*\* | yes/no | Yes | Customer feedback | Testing |
| Movement during operation (Frame stability) | Pinball Publishing | \*\*\* | yes/no | No | Team | Inspection |
| Operation time | Pinball Publishing | \*\*\* | hours per day | 10 | Customer feedback | Testing |
| Product is semi- automated | Pinball Publishing | \*\* | yes/no | Yes | Customer feedback | Inspection |
|  |  |  |  |  |  |  |
| **Environment** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Temperature range | Pinball Publishing | \* | °F | 40-80 | Customer feedback | Testing |
| Humidity | Pinball Publishing | \* | % | <95 | Team | Testing |
| Noise | User | \* | dB | <90 | Customer feedback | Testing |
|  |  |  |  |  |  |  |
| **Life in Service** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Expected time in service | Pinball Publishing | \*\*\* | years | >5 | Customer feedback | Analysis / Testing |
|  |  |  |  |  |  |  |
| **Cost of Production** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Return on Investment (ROI) | Pinball Publishing | \*\*\* | years | TBD | Customer feedback | Analysis / Expenses |
| Budget (production cost) | Pinball Publishing | \*\*\* | $ | <1000 | Customer feedback | Expense sheet/ BOM |
|  | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Size and Shape** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Portability | User | \* | # of people to move | 1 | Customer feedback | Inspection |
| Space occupied | Pinball Publishing | \*\*\* | feet x feet | <3x3 | Customer feedback | Measurement |
|  |  |  |  |  |  |  |
| **Weight** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Maximum weight | Pinball Publishing | \* | pounds | <400 | Team | Measurement |
|  |  |  |  |  |  |  |
| **Maintenance** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Cost of weekly maintenance | Pinball Publishing | \*\* | $ per week | <10 | Team | Analysis / BOM |
| Replaceable parts easily available | Technician | \*\*\* | yes/no | Yes | Customer feedback | Research / Design |
| Specialty tools required | Technician | \*\*\* | yes/no | No | Customer feedback | Research / Design |
| Serviceability (Easy to access) | Technician | \*\*\* | yes/no | Yes | Customer feedback | Inspection |
| Unjamming time | User | \*\*\* | minutes | <3 | Team | Testing |
|  |  |  |  |  |  |  |
| **Installation** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Manpower to Install | Pinball Publishing | \* | people | ≤2 | Team | Analysis |
| Amount of time to install | Pinball Publishing | \* | days | 1 | Team | Analysis |
|  |  |  |  |  |  |  |
| **Ergonomics** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Number of operators | Pinball Publishing | \*\*\* | people | 1 | Customer feedback | Design |
| Can be worked at all day | User | \*\*\* | yes/no | Yes | Team | Inspection / Testing |
| Working position | User | \*\* | position | Standing | Customer feedback | Design |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |
| **Safety** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Guards | Pinball Publishing | \*\*\* | yes/no | Yes | Customer feedback | Inspection |
| Emergency stop | Pinball Publishing | \*\*\* | yes/no | Yes | Customer feedback | Inspection |
| Jam stop | Pinball Publishing | \*\*\* | yes/no | Yes | Customer feedback | Inspection |
| Required safety warnings and labels | Pinball Publishing | \*\*\* | yes/no | Yes | Team | Inspection |
|  |  |  |  |  |  |  |
| **Aesthetics** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Color, shape, form, finish (looks nice) | Pinball Publishing | \*\* | yes/no | Yes | Customer feedback | Inspection |
|  |  |  |  |  |  |  |
| **Quality and Reliability** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Reliability | Pinball Publishing | \*\*\* | % of time | 95 | Customer / Team | Analysis / Testing |
|  |  |  |  |  |  |  |
| **Applicable Codes and Standards** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Electric wiring standards | Standards | \*\*\* | yes/no | Yes | Regulations | Research / Requirements |
| Requirements mandated by government | Government | \*\*\* | yes/no | Yes | Regulations | Research / Requirements |
| Professional society's codes and standards | Professional Society's | \*\*\* | yes/no | Yes | Regulations | Research / Requirements |
| OSHA safety codes | OSHA | \*\*\* | yes/no | Yes | Regulations | Research / Requirements |
|  |  |  |  |  |  |  |
| **Testing** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Perform industry standard tests | Pinball Publishing | \* | yes/no | Yes | Team | Requirements/ Testing |
| Tests required to verify performance | Pinball Publishing | \*\* | yes/no | Yes | Team | Testing |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Company Constraints and Procedures** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Compatibility with other machines | Pinball Publishing | \*\*\* | yes/no | Yes | Customer feedback | Design / Inspection |
|  |  |  |  |  |  |  |
| **Documentation** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Schematics & coding provided | Technician | \*\*\* | yes/no | Yes | Customer feedback | First Hand |
|  |  |  |  |  |  |  |
| **Legal** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Relevant patents violated | Legal | \*\*\* | yes/no | No | Legal necessities | Research |
|  |  |  |  |  |  |  |
| **Timelines** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Whole design project / milestones included | Capstone | \*\*\* | yes/no | Yes | Course requirements | First Hand |
| Final product to be delivered by June 2011 | Pinball Publishing | \*\*\* | yes/no | Yes | Customer requirements | First Hand |
|  |  |  |  |  |  |  |
| **Disposal** | | | | | | |
| **Requirement** | **Customer** | **Importance** | **Metric** | **Target** | **Target Basis** | **Verification** |
| Recyclable (scrap able) | Pinball Publishing | \*\* | yes/no | Yes | Customer feedback | Inspection |
|  |  |  |  |  |  |  |
| **Not Applicable** | | | | | | |
| **Criteria** | | | **Reason** | | | |
| Quantity | | | One product being produced | | | |
| Shelf Life | | | Product will be used immediately | | | |
| Materials | | | Any suitable materials are permitted | | | |
| Manufacturing Facility | | | Manufacturing will be done by the team | | | |
| Shipping | | | Product will be delivered by Pinball Publishing | | | |
| Packaging | | | Packaging is not required before delivery | | | |

## **Appendix C**: Existing related products

|  |  |  |  |
| --- | --- | --- | --- |
| Product | Picture | Advantages | Disadvantages |
| **Cutter with individual dies** |  | -Accurate  -Can cut any size book (if only one die is used)  -Reliable (few moving parts)  -Uses off-the-shelf dies  -Can cut multiple books at one time  -Can be automated  -Double die versions are also available  -Up to 30 strokes/min | -Same as current system  -$1,400  -Not table top (size)  -Requires foot pedal operation  -Not easily portable |
| **Roller Cutter** |  | -Safe operation  -Can cut any size book  -Portable | -Only cuts one corner at a time  -Takes too long between cuts  -Can’t handle necessary capacity  -Completely manual |
| **Electric tabletop rounder** |  | -Can use cutting knife or die  -Can cut multiple books at a time  -Portable/table top model(55 lbs) | -Only cuts one corner at a time  -Expensive ($2,400)  -Requires foot pedal to operate |
| **Challenge double corner cutter** |  | -Can cut two corners at a time | -Expensive ($8,500)  -Too large  -Not portable  -Requires foot pedal to operate |

## Appendix D: Available cutting technologies

|  |  |  |  |
| --- | --- | --- | --- |
| Product | Picture | Advantages | Disadvantages |
| **Individual dies** |  | -Doesn’t over-cut  -Available in various radii  -Off-the-shelf  -Can be sharpened to prolong life  -Client already uses them | -Restricted substrate path due to construction of die  -Somewhat expensive ($100 each) |
| **Knives** |  | -Available in various radii  -Off-the-shelf | -Possible to over-cut  -Not very accurate |
| **Pre-shaped Die Cutter** |  | -Accurate | -Need new die for every size  -Can only cut one book at a time  -Only meant for single sheets of paper |

## Appendix E: Available power sources

|  |  |  |
| --- | --- | --- |
| Product | Advantages | Disadvantages |
| **Electric linear actuator** | -Inexpensive  -Provides linear motion  -Doesn’t require additional pieces/devices  -Easy to maintain  -Works right off the shelf | -Not fast enough  -Not enough force |
| **Electro-mechanical linear actuator** | -Provides linear motion  -Doesn’t require additional pieces/devices  -Can handle force  -Wide range of speeds  -Easy to maintain  -Works right off the shelf | -Too expensive |
| **Pneumatic linear actuator** | -Provides linear motion  -Fast  -Can handle force  -Inexpensive | -Requires additional compressor and valves  -Requires some maintenance |
| **Motor with cams and linkage** | -Inexpensive  -Wide range of speeds  -Wide range of forces | -Requires most maintenance  -Needs to be designed  -Needs to be built |

## Appendix F: Decision matrices

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| POWER SOURCE | | Linear Actuator | | | Electric Motor w/ |
| Weight | Criteria | Linear-electric motor | Electro-Mechanical | Pneumatic | Cam, crank, linkage, etc. |
| 3 | Force | 1 | 5 | 5 | 4 |
| 3 | Speed | 2 | 4 | 5 | 4 |
| 3 | Cost | 4 | 1 | 3 | 4 |
| 3 | Maintenance | 5 | 5 | 4 | 3 |
| 1 | Off shelf | 5 | 5 | 5 | 3 |
| 2 | Complexity | 5 | 5 | 4 | 2 |
|  | TOTAL | 51 | 60 | 64 | 52 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| MOUNTING POSITION | |  |  |  |
| Weight | Criteria | Top | Bottom | Side |
| 3 | Manufacturing | 4 | 4 | 2 |
| 4 | Maintenance | 3 | 5 | 2 |
| 3 | Life in Service | 5 | 5 | 2 |
| 5 | Safety | 4 | 5 | 3 |
| 2 | Size and Shape | 3 | 5 | 3 |
|  | TOTAL | 13 | 16.4 | 8.2 |