UNIVERSITY OF MANITOBA

Final Design Report

Variable Width Slitter Spacer Design

MECH 4860
Sponsoring Company: Winpak Ltd
Instructor: Dr. Paul E. Labossiere
Project Advisor: Vern Campbell
Submission Date: December 1, 2014

Prepared By: Team 22
Members:

Dominic Casar ______________________

Martin Klimenko ______________________

Michael Olynyk ______________________

Peter Wong ______________________

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LETTER OF TRANSMITTAL

Paul Labossiere, Professional Engineer, Senior Instructor
University of Manitoba
Engineering Information and Technology Complex, E1 546
Winnipeg, Manitoba

Dear Dr. Labossiere,

The following attached report entitled Variable Width Slitter Spacer Design was requested by the company Winpak Limited. This project was completed by a team of undergraduate University of Manitoba engineering students as a requirement of the course MECH 4860.

The purpose of this project was to develop a device to measure the various required spacing distances between the slitting blades currently being utilized as part of Winpaks' plastic slitting operations. The developed device must also be able to lock at any specific measurement as well as ensure proper centerline spacing of the blades.

The following report describes in detail the needs and requirements of the final design as well as the constraints and limitations placed upon its development. The final design and its respective schematic drawings will be presented by clarifying all of its features and detailing how the various components aid in the fulfillment of the needs of the client. The proper operational procedures for the design as well as the cost of production and the corresponding bill of materials will also be included.

The team hopes that both the final design and report for the variable width slitter spacer are to your complete satisfaction. We are pleased to respond to any questions requiring clarifications or concerns.

Yours sincerely,

EXECUTIVE SUMMARY

The project presented to Team 22 consists of designing a Variable Width Slitter Spacer for Winpak Ltd. The device would be used in Winpak's slitting department for their slitter-rewinder machines. These machines are used to cut a large roll of plastic packaging material into multiple rolls of the desired width. The project is to design a device to space the slitting blades of the machine. The current process uses a tape measure and is simple but inconsistent, producing wasted material if the spacing is not accurately applied. The current setup time prior to any design implementations yielded an average of 40 minutes. By implementing the variable width spacer into the setup process, the average setup time is decreased.

Our team has designed a device that will improve the setup times and reduce waste material. By only spacing the blades once, both the time and material involved are reduced, thereby increasing the efficiency of the setup process and optimizing waste reduction through accuracy and precision. The material used in the design consists of 6061-T6 aluminum that is lightweight and strong, fixed with nylon threaded locking nuts yielding a total material weight of 980 grams (2.16lbs). The total material cost for the device is $38.50.

The design itself utilizes a measuring block with incremental measurement indicators serving as a base for the design. The fixed end stabilizer bar is used for keeping the slitter assembly fixed from moving around when applied. In contrast, the moving jaw end can be slid down the measuring block to the preferred distance and locked via a locking screw/clamp located at the base of the part. Once the optimal distance is set, the design can be applied to the slitter assembly and the machine can operate once the slitter blades are moved into place. Once the blades are set, the spacer is removed and finally the machine can begin its operating procedure.

1 INTRODUCTION

The project presented to Group 22 consists of designing a Variable Width Slitter Spacer for Winpak Ltd, a large international packaging company. Winpak produces and distributes high quality plastic packaging materials for the food and beverage industry, as well as the medical industry. We as a team are focusing our project on a design for the Slitting Department in their Winnipeg, Manitoba location.

The majority of the products that Winpak produces are plastic and medical packaging materials. Our team has been commissioned to produce a design to improve setup times in the Slitting Department of the Winnipeg plant. The main objective is to reduce the downtime and waste involved in the current setup process.

The project schedule can be seen in Appendix A. It contents the work breakdown structure that detail the tasks in the project. As well Gantt chart outline the dates and milestones are in Appendix A.

1.1 PROBLEM BACKGROUND

The Slitting Department of Winpak Ltd. is responsible for cutting very large mill rolls (up to 1500 kg) of plastic film into smaller rolls using large slitter-rewinder machines. Mill rolls are cut into the various widths at a specified tolerance, to ensure that the final rolls are what the client orders. Since the finished rolls are often used on high-speed machines such as the ones they were produced on, small deviations from a standard roll can cause major problems for the customer or Winpak when used later on. After being cut, the film then gets wound back up onto cardboard or plastic cores that match the width of the cut rolls. Figure 1 shows the machine, along with the finished cut rolls held by the rewinder arms.

Figure 1: Slitter rewinder machine. Note small rolls of packaging film held by the machine arms [1]

These rolls are then shipped out to the customer after being boxed or wrapped in plastic, depending on the customer's requests. In most cases, the Slitting Department is the final destination for processing rolls before they are sent to the customer. It is vital that the final roll meets each client's precise specifications.

Multiple rolls of the same size are required to be cut simultaneously for most jobs. Therefore, a method to space the blades reliably at the same width would minimize the physical and time waste involved in the current setup process. A close up of the slitting blades is shown in Figure 2.

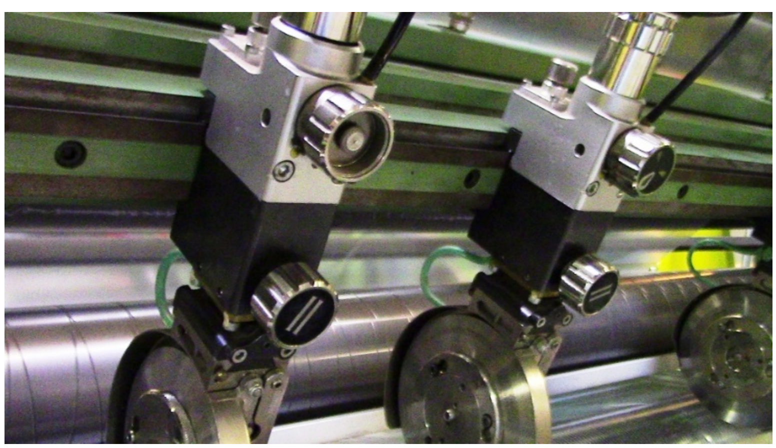

Figure 2: Slitting blades fixed on slitter-rewinder machine [2]

There are variations in the setup due to individual operator preferences, but the general process remains the same. The current setup involves using a measuring tape to set the blade spacing. Once the spacing is set, the machine is initialized to start the slitting operation. After an initial portion of packaging film is cut to the new blade positions, the machine is stopped to determine if the width of the cut material is within tolerance. If the measured values are insufficient, the packaging material is cut off and the slitting blades are adjusted. This operation is repeated until the width of the cut material is within tolerance. When the roll spacing is adequate, excess material is again cut off, discarded and cores are loaded into the machine arms with the material taped to the core. When complete, the machine is started at a low speed, until a small amount of film is wrapped around each roll. The material is then measured to ensure the final blade spacing is correct. The machine can then be run to complete the job.

In a typical run, multiple rolls are being cut to the same width. However, each operator is required to measure and set the spacing for each and every blade. This consumes a large amount of time especially when considering that up to seven rolls can be produced on a single machine simultaneously. Material is also wasted each time the blades need to be adjusted. The expense is even higher with printed material, highlighting the importance in reducing waste.

Variation in skill level and experience of each operator make the current process inconsistent, especially if the spacing is not initially set up with precision. Material for clear or plain films is compacted into bales and sold to a recycler in China at a fraction of the price it costs to make the film. Printed films need to be discarded due to their ink content. Our team has been commissioned to find solutions to this inconsistent process and improve the efficiency.

1.2 PROBLEM STATEMENT

The design team has been tasked with designing a Variable Width Slitter Spacer for the Slitting Department for Winpak's Winnipeg plant. The current setup process for the slitter-rewinder machines is simple, but requires excessive time and material to complete the process. Winpak Ltd, has requested that we as a team design a tool or device that will aid the operator in setting multiple widths of the same size across the machine in a more efficient manner. This tool will be used to improve the current setup process by reducing two important expenses: time and material.

The current method requires an average of 40 minutes to complete, with a varying amount of waste material. The quantity of waste depends on the specific job as well as the amount of times the blades are re-spaced, the total width of the mill roll and the thickness/gauge of the material itself. The ideal case involves a single spacing adjustment, where there is minimal waste.

Each time the blades are re-spaced, an increased quantity of material needs to be cut off and disposed. Our Variable Width Slitter Spacer must be able to reliably space the slitter blades correctly the first time they are set. This will reduce the time required to finish a setup for a new job by enabling the operator to quickly set the tool and use it for multiple blade spacing distances across the machine more quickly and efficiently than using a tape measure. The expenses of time and material are substantially reduced by spacing the blades only a single time. The net effect is an increase in efficiency and reduction of expense in the setup process.

1.3 Client Needs

The customer desires that this spacer be able to work on the majority of their machines, and able to encompass as large of a core range as possible. This core range is directly related to the range of extension of this spacer, and will be a major influence to the design. Further needs identified are a high reliability, high tolerance (at specific values), low cost of production, little to no training involved, and no contamination of the produced packaging rolls.

The first specification of the variable width spacer design must fulfill is to be able to measure the different slitting blade spacing lengths which are currently undertaken by Winpak. A measuring range of 200mm up to at least 635mm would cover 95% of all slitting operations undertaken by Winpak [3]. However, the minimum allowable percentage of slitting operations that must be covered by a single design has been set at 90%. The next specification which must be fulfilled is that the device is accurate and precise in any of its measurements, to within an accuracy of +0/-1 mm as set by the client.

The device will also have to be quick to setup and later take down after ensuring the proper arrangement of the slitting blades. Not only will this help reduce setup time, another major concern of the client, it will also be another incentive for workers to utilize the new tool in place of the current one. Another requirement that must be fulfilled by the new device is that it must be able to be operated by a single worker, due to the current slitter blade spacing operations requiring a single worker to complete. The target measurements which correspond to these technical specifications are that the final tool design must have a total weight under 5 pounds, require less than 20 ft/lbs of force to detach from the main slitter machine after completing a slitter spacing operation, and be able to be taken down within a 30 second time span.

A final requirement of the final design is the overall durability of the tool. The tool must be able to undergo at least 10,000 measurement operation cycles without failing. This target value is to ensure that the tool retains its needed level of measurement accuracy throughout its operational life. A summary of the technical specifications for this project is shown in TABLE I.

TABLE I: SUMMARY OF TECHNICAL SPECIFICATIONS AND THEIR RESPECTIVE TARGET VALUES

Technical Specification	Target Value
Cycles to Failure	Minimum 10,000
Variable Measuring Range	Minimum 90% of All Slitting Operations
Accuracy of Measurements	Measurements Accurate +0/-1mm
Force Required to Remove	Less than 20 ft/lbs
Surface Finish	100% of Tool Has Smooth Finish
Takedown Times	30 Seconds
Weight	Under 5 Pounds

2 Details of the Design

The goal of the slitter spacer design is to compose the apparatus with as little moving pieces as possible, utilizing a smooth, friction free surface allowing for easy adjustability while maintaining precision and accuracy. Through taking a similar design such as the Vernier caliper, and adjusting it accordingly in order to fit the customer requirements as shown below, the final slitter spacer assembly can be constructed based on the following requirements:

Customer Requirements:

1. Applicable to all Slitting Machines
2. Long component life
3. Variable adjustability range
4. Easily removable
5. Resistance to corrosion of chemicals
6. Easy Setup
7. Durable
8. Operate Safely
9. One Person Operation

The team was able to develop a number of possible designs to meet the customer requirements, which can be seen in Appendix B. Through a comparative analysis, the final design was chosen.

2.1 DESIGN COMPONENTS

First the design and its parts were carefully selected with precision and integrity. The following schematics shown in Figure 3 and Figure 4 contain a rendered version of the spacer design with its intended parts and pieces.

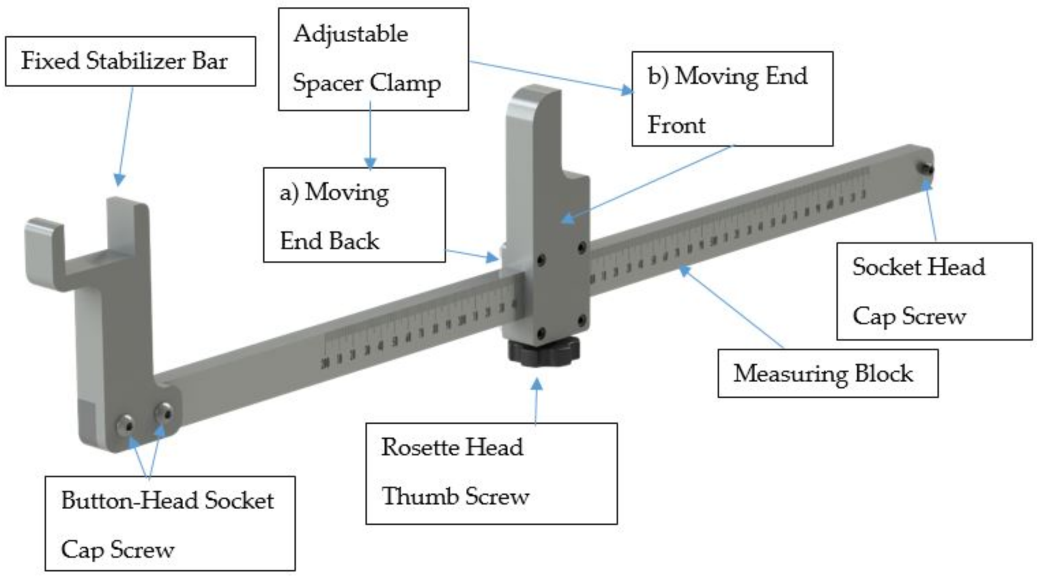

Figure 3: Variable Width Slitter Spacer part assembly

Through a close up of the adjustable spacer clamp, it can be shown that it is constructed internally with two separate material compositions for added support and tightness onto the measuring block.

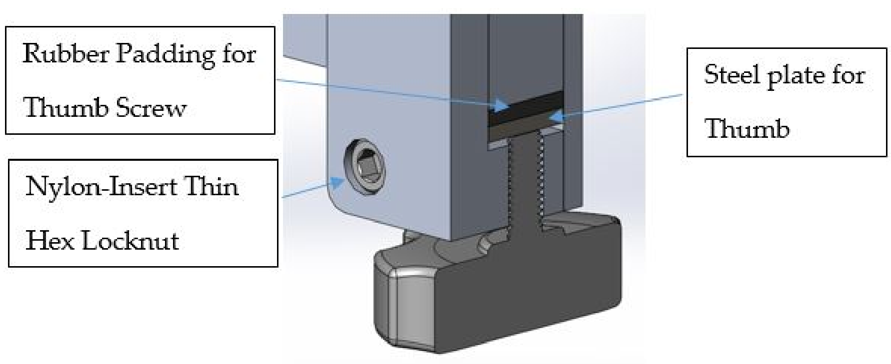

Figure 4: Adjustment knob for internal measuring jaw

Each part is carefully selected to meet the customer requirements. The variable width spacer assembly is applicable to all slitting machines using a variable width measuring block applicable to a variation to packaging films. The fixed end of the assembly uses a fork shape stability bar that is CNC machined to ensure precision fitting to the female end of the slitter blade assembly, the part can be clarified below in Figure 5 with the required dimensions. The dimensions of the slitter blade assembly can be seen in appendix E.

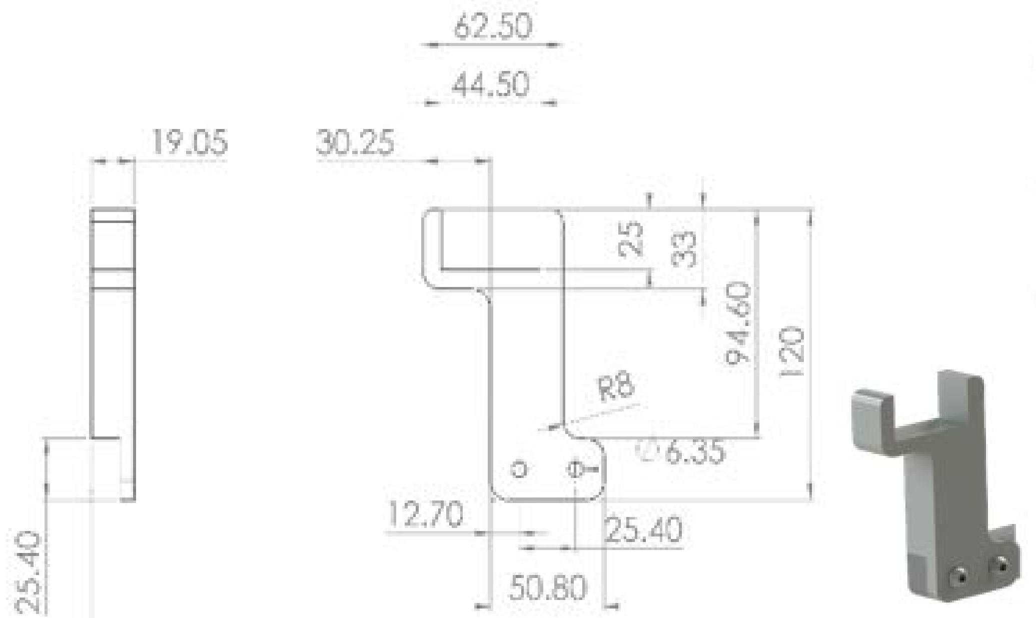

Figure 5: Fixed End Stabilizer Bar Composition & Dimensions

The long component life of the assembly is obtained through using the material of T6-6061 Aluminum. Common applications of this material are used for aircraft fitting and hydraulic pistons yielding excellent joining characteristics. Combined with the materials high strength and good workability, T6-6061 Aluminum also contains a high resistance to corrosion and is widely available for purchase if it were to be damaged or broken.

The following material characteristics for T6-6061 Al are specified at room temperature and shown in TABLE II.

TABLE II: AL T6-6061 PROPERTY CHARACTERISTICS

Physical Properties	Metric
Density	2.70 g/cc
Ultimate Tensile Strength	310 MPa
Yield Tensile Strength	276 MPa
Percentage Elongation at Break	17%
Modulas of Elasticity	68.8 GPa
Notched Tensile Strength	324 MPa
Ultimate Bearing Strength	607 MPa
Bearing Yield Strength	386 MPa
Fatigue Strength	96.5 MPa
Poisons ratio	0.33
Machinability	50 %
Shear Modulus	26.0 GPa
Shear Strength	207 MPa

The assemblies measuring rail in which the sliding measuring jaw moves parallel down contains precise measurement notches from an initial range of 200mm ranging to 635mm. The values on the measuring block are precisely placed in order to compensate for the offsets found in the slitter blade assembly. By constructing the scale exactly 155.50mm from the end of the block. The stabilizer bar protrudes just enough from the surface to make the spacer assembly spaced exactly 200mm when the moving end is zeroed on the blocks scale. Figure 6 shows the dimensions and details of the measuring block with scaling.

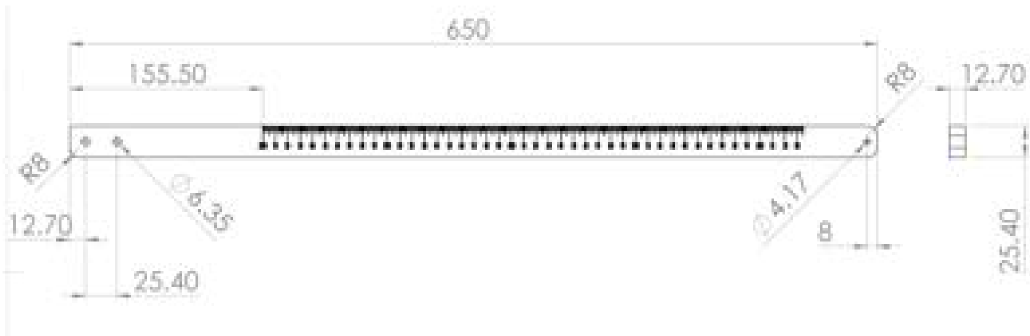

Figure 6: Measuring Block Assembly

By sliding the moving end of the spacer jaw down the measuring block. Specified spacing measurements can be met by tightening the rosette head thumb screw contained on the part. The following moving spacer jaw shown in Figure 7 is able to slide down the measuring block with minimal friction providing a smooth accurate adjustment as shown below.

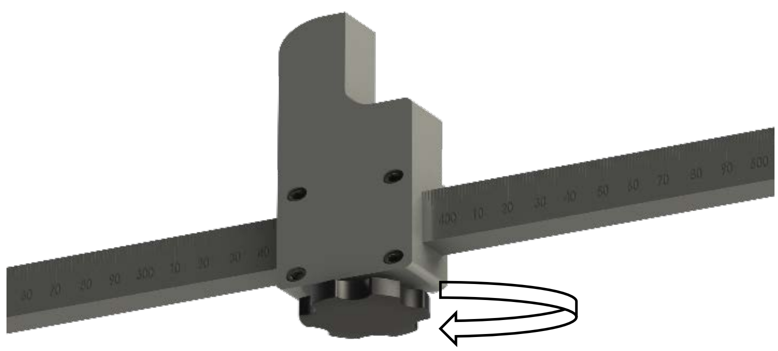

Figure 7: Moving spacer jaw assembly with locking screw

By turning the locking screw clockwise, the moving spacer jaw assembly tightens onto the measuring block using a series of rubber and steel interfaces located internally on the assembly. By doing so, the locking screw is able to safely tighten the assembly onto the measuring block without damaging the outer surface of the block.

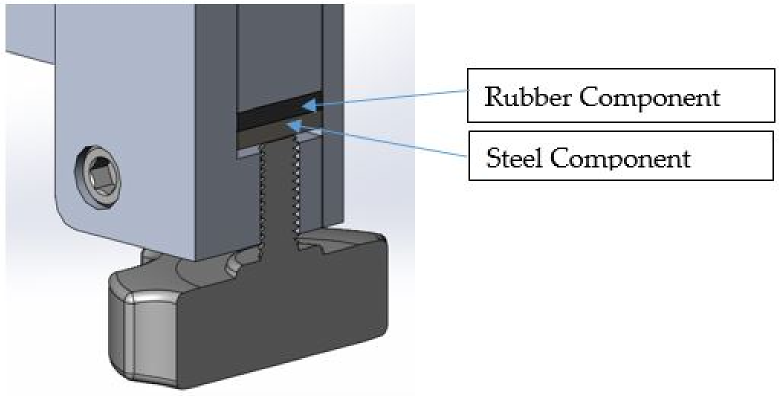

Figure 8: Moving spacer jaw close-up with internal locking components

The rubber component provides a soft surface to impact the measuring block assembly where the locking screw, when rotated clockwise to tighten, pushed the steel plate into the rubber plate which in return applies pressure to the measuring block holding the jaw in place and ready for application. It can be shown in Figure 8 that there are two plates on both sides of the locking screw, both constructed of T6-6061 aluminum and are held together by four socket head cap screws and four nylon insert thin hex locknuts. The nylon locknuts provide excellent resistance to oils, and solvents preventing corrosion and used for medium to low stress application. As well as being excellent for machining, aluminum has strong composition which provides resistance to abrasion. Considering that the Variable Width Slitter Assembly is a delicate measuring instrument, it must be torqued to specs. Considering that the socket head screws require an initial 2 lb ft. of torque to turn, the nylon locking nuts must be torqued to 10.5 lb ft based on the materials physical characteristics.

The measuring jaw assembly shown in Figure 9 and Figure 10 yield proper allocation of the locking nuts and locking screws, followed with their appropriate dimensions. Both front and back plate views are displayed below.

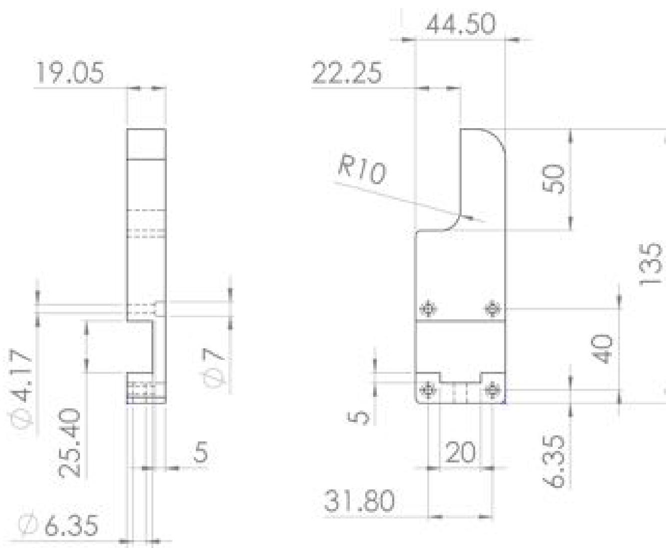

Figure 9: Front side view of measuring jaw assembly

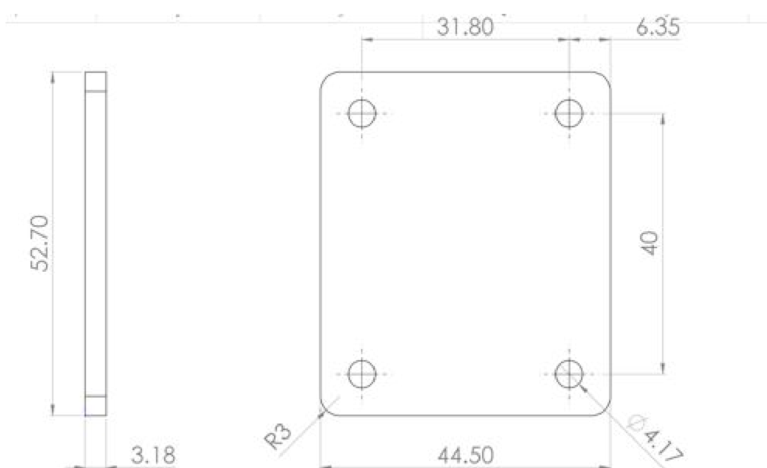

Figure 10: Back plate view of measuring jaw assembly

All detailed engineering drawings for each specified component is shown in the Appendix C.

Through identifying all the major parts of the design, a parts list is constructed for the specified material and sizing shown in TABLE III.

TABLE III: PARTS LIST AND DIMENSIONS

Part	Material	Size
Fixed end	6061 T6 Aluminum	120mm x 81mm x 19mm
Moving end front	6061 T6 Aluminum	44.5mm x 135mm x 19mm
Moving end back	6061 T6 Aluminum	44.5mm x 50.8mm x 3.2mm
Measuring block	6061 T6 Aluminum	12.7 mm x 25.4 mm x 650 mm
Rosette Head Thumb Screws	Plastic head	¼ in-28 thread, ½ in length
Rubber for clamp	Rubber	20mm x 12.7mm x 2mm
Steel for clamp	Steel sheet metal	20mm x 12.7mm x 2mm
Button-Head Socket Cap Screws	Alloy Steel	¼ in -28 thread, 1in length
Socket Head Cap Screws	Alloy Steel	8-32 thread, 7/8 in length
Socket Head Cap Screws	Alloy Steel	8-32 thread, 3/4 in length
Nylon-Insert Thin Hex Locknuts	Grade 2 Steel	¼ in-28 thread
Nylon-Insert Thin Hex Locknuts	Grade 2 Steel	8-32 thread

By providing unique characteristics, specific to Winpak slitter assemblies. The Variable Width Slitter Spacer is an innovative engineering design, offering a simple assembly which can be operated by a single person with minimal setup time. Through proper material selection and precision ensured computer numerical controlled machining. The variable width slitter spacer will help reduce setup time and decrease waste by ensuring accuracy to a tolerance of +/-0.01mm. Thereby providing a design which in due will benefit the slitter machine operators and technicians.

2.2 DESIGN FEATURES

As can be seen in the following figure 11, the variable width slitter spacer will almost be entirely constructed out of aluminum. Aluminum was selected due to a number of its properties being ideal for the purposes of this project. The low density of aluminum means that the final tool will not be excessively heavy, making the future utilization easier for workers on the production floor, while retaining adequate levels of strength and rigidity, ensuring that the tool will tolerate years of use without any significant losses in accuracy due to tool wear and deformation. Another benefit in the selection of aluminum for the primary material of the spacer is that due to the low porosity of Aluminum, it will not retain any contaminants during its lifecycle and well as making any required cleaning easy to accomplish. This is a high priority for the client Winpak as they deal extensively with food and medical packaging where cleanliness is of the utmost concern as contaminated packaging will ruin any products which it is used for.

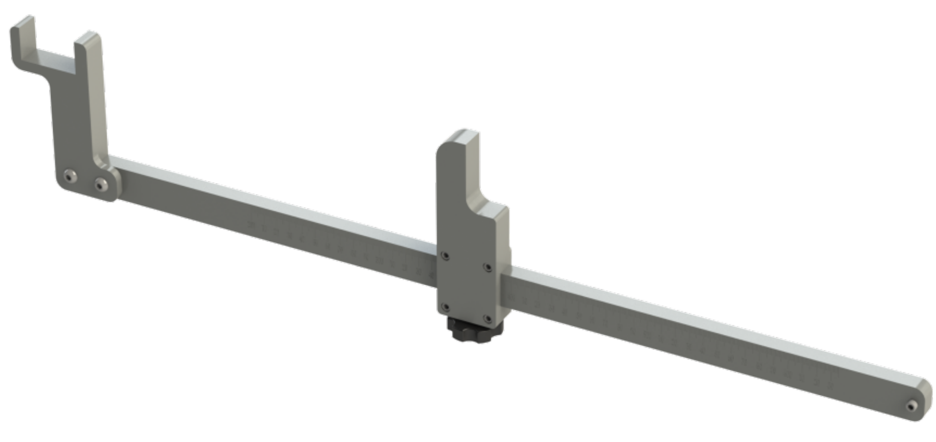

Figure 11: Isometric view of variable width slitter spacer

The next important feature of the variable width slitter spacer is the engraved set of markings on the side of the measuring block assembly, as can be seen in the following Figure 12. These markings will serve as a built in ruler, allowing for accurate measurement of any required blade spacing within the range of 200 to 635 millimeters. This range will cover 95% of the slitting operations undertaken by Winpak, ensuring that the new tool will see significant use and be worth the investment of design and production. By incorporating the measurement system into the tool itself, the chance of any possible inaccurate measurements is reduced as well as increasing the ease with which the tool can be cleaned.

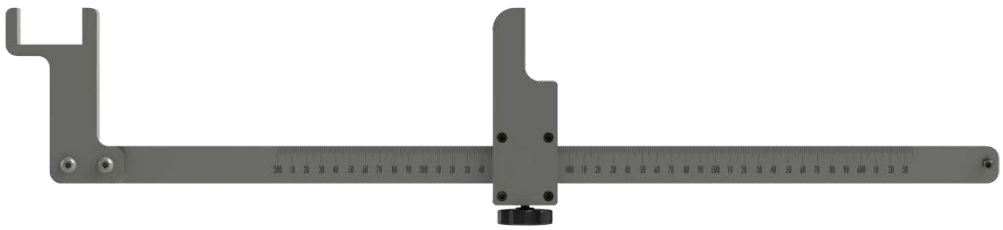

Figure 12: Side view of Variable Width Slitter Spacer with measurement markings

The locking mechanism utilized by the variable width slitter spacer is a simple screw lock controlled by a large knob as depicted in the following Figure 13 utilizes friction to hold the spacer at a set width while the slitting blades are being positioned. The end of the screw lock that comes into contact with the measuring block assembly is a small metal plate layered with a rubberized material to distribute stresses applied to the block shown in Figure 8. This not only prevents gouging which would reduce measurement accuracy but also increases the friction between the lock and the main section, making the locking mechanism more effective. The large knob decreases the amount of force required to lock and unlock the device, increasing the ease of use of the spacer.

Figure 13: Close up view of locking mechanism knob

Another feature of the variable width slitter spacer is the fixed end stabilizer bar, featured in Figure 14. This part of the design slides onto a male slitter blade holder. This helps the user to hold the spacer steady while they are adjusting the male slitter blade positions, both making the operation easier and more accurate. This is due to lessening the level of effort required to hold the spacer steady, which will in turn reduce that amount of fatigue experienced by the end user. Therefore, more attention is available to properly set the blades, reducing the overall operation setup times as well.

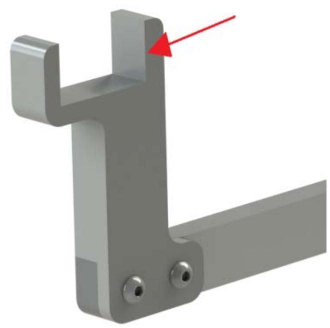

Figure 14: Close up view of fixed end stabilizer bar

The final feature of the variable width slitter spacer of note is the moving spacer jaw assembly. As can be seen in the following Figure 15, the assembly has two primary faces. The red face with the extended red outline is the measuring face. From the edge of this face, all spacing measurements are taken. It should also be noted that this face lines up with the blade of the male slitter blade assembly which means that any measurements taken are the exact distance between the two blades being adjusted. The green face will come into contact with the blade holder of the male slitter blade assembly. The linear distance between the green and red faces is the distance between the inner edge of the blade holder assembly and the actual blade. By incorporating this offset into the tool, inaccurate measurements are much less likely to occur as no mental math adjustments must be made during the use of the tool. This also removes the need for measuring spacing between blades by actually measuring the distance between the blades directly. By measuring physical dimensions at the blade by hand, yields greater potential risk for injury and product contamination. Thereby eliminating any human contact with the blades produces less human risk and contamination hazards.

Figure 15: Close up view of moving spacer jaw assembly of Variable Width Slitter Spacer

The entailed design features help to satisfy the clients' needs and resolve the problem statement.

2.3 OPERATION (HOW IT WORKS)

The Variable Width Slitter Spacer design is a precision instrument which can be used to measure spacing distances extremely accurately. The primary concern of the design was to keep it as simplistic as possible while at the same time providing both accuracy and precision in measurements. Unlike the common Vernier Caliper, the slitter spacer is specific to Winpak's slitting machines and slitter blade tolerances providing a 200 mm to 635 mm measuring range for the specified packaging film size.

The variable width slitter spacer is constructed so that it is spaced using a metric scale in precise millimeter measurements. The total measured range located on the measurement rail contains 435 mm in variable width adjustment.

The following steps should be followed in order to preform basic measurements for the Winpak Slitter Assembly:

Step 1: Clean both fixed end Stabilizer arm and moving block faces before usage

Step 2: Remove any debris or foreign substances on both slitter blade assembly's used for measuring

Step 3: Slitter Spacer should be frequently checked in order to ensure that is properly zero set prior to operation

Step 4: Slide Stabilizer Fork on the Slitter Blade assembly so that it sits firmly with a constant applied pressure in order to maintain accuracy

Step 5: Loosen the heat thumb locking screw in order to get smooth sliding, rotate the adjusting screw to make the fine adjustment close to the measuring block before sliding.(Note: Clockwise to tighten and counter clockwise to loosen)

Step 6: Read the indicated measured markings on the measuring block

Step 7: Always apply constant force on the head thumb screw wheel during measurement and zero setting. Proper Measuring Techniques should be followed to ensure stable and accurate results:

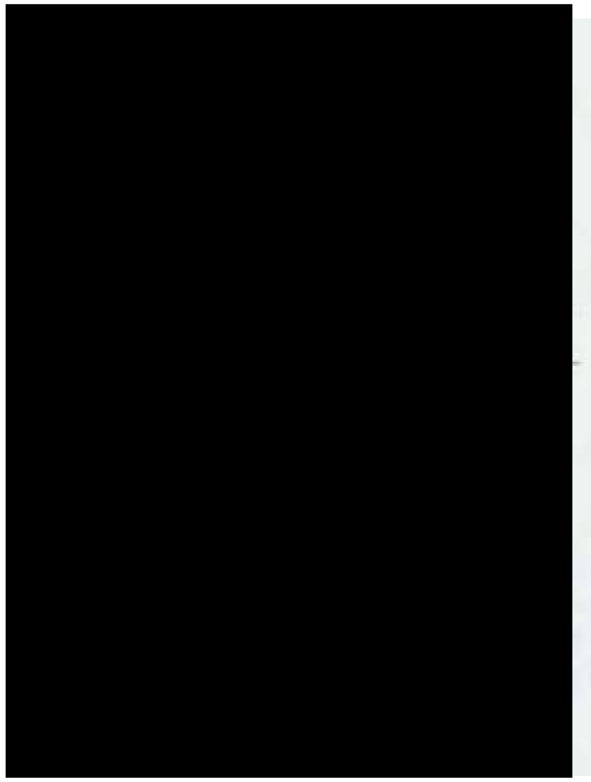

Figure 16: Proper measurement techniques

Step 8: Tighten head screw for selected specified reading

Step 9: Slide the secondary slitter blade assembly until it contacts the moving spacer jaw. Once in contact, tighten slitter blade assembly

Step 10: Remove variable width slitter spacer assembly and run the machine

Step 11: Measuring faces should be carefully protected from being scratched or damaged at all times

2.4 OVERALL COST & BILL OF MATERIALS

TABLE IV show the parts and cost of the design. The costs are based on the material and size of the product. The cost are from online stores McMaster-Carr [4]and Online Metals [5]. The total cost of the design yielded a minimal cost of $38.50.

TABLE IV: COST OF MATERIAL [4, 5]

Part	Material	Size	Cost
Fixed end	6061 T6 Al	120mm x 81mm x 19mm	$10.07
Moving end front	6061 T6 Al	44.5mm x 135mm x 19mm	$6.16
Moving end back	6061 T6 Al	44.5mm x 50.8mm x 3.2mm	0.54
Measuring block	6061 T6 Al	12.7 mm x 25.4 mm x 650 mm	$8.58
Rosette Head Thumb Screws	Plastic head	¼ in-28 thread, ½ in length	$11.62
Rubber for clamp	Rubber	20mm x 12.7mm x 2mm	$0.08
Steel for clamp	Steel sheet metal	20mm x 12.7mm x 2mm	$0.22
Button-Head Socket Cap Screws	Alloy Steel	¼ in -28 thread, 1in length	2 x $0.19 = $0.38
Socket Head Cap Screws	Alloy Steel	8-32 thread, 7/8 in length	4 x $0.11 = $0.44
Socket Head Cap Screws	Alloy Steel	8-32 thread, 3/4 in length	$0.13
Nylon-Insert Thin Hex Locknuts	Grade 2 Steel	¼ in-28 thread	2 x $0.04 = $0.08
Nylon-Insert Thin Hex Locknuts	Grade 2 Steel	8-32 thread	5 x $0.04 = $0.20
		Total:	$38.50

3 CONCLUSION

The ultimate objective of this design project was to develop a Variable Width Slitter Spacer that the client, Winpak Ltd., can implement into its current slitting operations. The developed design needs to be able reduce the amount of material wasted as well as shortening the setup times being taken by the current slitter blade spacing operations. Also, the new tool needed to conform to the codes and standards currently being followed by Winpak, which are detailed in Appendix D. The recommended final design for the Variable Width Slitter Spacer was selected from the numerous designs generated throughout the course of the project. The final selected design was able to fulfill all the needs and requirements of the Winpak Limited while still conforming to the constraints and limitations emplaced upon it by the careful and deliberant selection of its various features.

The 1 millimeter engraved measurement markings fulfill the need for measurements accurate to 1 millimeter and reduces the number of opportunities of incorrect measurements which can occur when using another measurement device, such as a tape measure. It also simultaneously adheres to the requirement that the tool must be easy to clean and not drip any contaminants in the completion of its required tasks. The range of these markings, spanning possible widths of 200 millimeters to 635 millimeters, allows the tool to be utilized for 95 % of all the slitting operations currently being performed by Winpak which makes the future production of the device both efficient and economical. The relatively low cost of the tool, $38.50 for all the required physical components, further reinforces the efficient and economical nature of the selected Variable Width Slitter Spacer design.

Another important feature of the Variable Width Slitter Spacer is its' primarily smooth finish T6-6061 aluminum construction. Not only does this allow for easy cleaning of the tool as the aluminum will be extremely strain resistant and quick to wipe down of any contaminants. Furthermore, the overall low weight, estimated to be approximately 980 grams or 2.16 pounds, will make proper handling of the tool much easier on the workers which will help ensure accurate measurements of the required spacing distances between slitting blades. The relatively high strength of the material will also aid in the accuracy of the tool, as the aluminum will resist any small deformations which could impair its accuracy and resist the wear and tear experienced during its life cycle, allowing the spacer to be used for an extended period of time without the need of replacement.

The integrated screw lock fulfills the need that the spacer can be set at a certain spacing distance with the large control knob making the locking and unlocking of the tool easier of the worker to accomplish. The addition of a rubber pad between the screw lock and the measuring block assembly not only increases the friction between the two parts, making the locking action of the spacer much more secure, prevent any gouging from occurring to either part which would decrease the overall accuracy of the spacer. A gouge could cause the tool to "prefer" a certain measurement within a certain range and create improper measurements during an operation.

The fixed end stabilizer bar aids in the fulfillment of the two needs of measurement accuracy and ease of operation. By sliding the fixed bar onto one of the male slitter blades to be positioned, all spacing distances are ensured to be based on the actual distance between the blades of the male slitters being positioned rather than the perceived distance between the two. Additionally, the act of sliding the fixed end stabilizer bar onto a male slitter blade decreases the amount of strength required to hold the spacer steady during operation which in turn increases the ease with which the tool can be used as well as the accuracy of any measurements taken with it.

The final important feature of the Variable Width Slitter Spacer is the moving spacer jaw. In addition to the ability to lock its position, and by extension the spacing distance of the spacing tool, the moving spacer jaw includes a built in offset. This built in offset allows the spacing distance between blades to be set while only coming into contact with the male slitter blade holder, reducing the chance of a worker cutting themselves on the sharp blades and subsequent contamination of the machine and packing material considerably.

The final design selected fulfills all the needs and requirements set out by Winpak Ltd. as well as conforming to all the relevant constraints and limitations emplaced upon it. The final design will help both reduce the time and material wasted as part of the current plastic slitting operations, as was the primary objective of the project, as well as being more user friendly than the current tooling being utilized, a tape measure. The final production and implementation of the new Variable Width Slitter Spacer design now lies with the client Winpak Ltd.

4 REFERENCES

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[2] C. Sheppard, Artist, *Photos of Male Slitter Blade.* [Art]. Winpak, 2014.

[3] Winpak, *Core Usage - Workbook,* Winnipeg: Winpak, 2014.

[4] McMaster-Carr, [Online]. Available: http://www.mcmaster.com/. [Accessed 30 November 2014].

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Appendices

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APPENDIX A: PROJECT SCHEDULE

A project schedule was developed to ensure the project remains on track. The project schedule consist of a work breakdown structure and Gantt chart. The work breakdown structure was created to identify the major tasks and deliverables in the project. The work breakdown structure is shown in TABLE A I. The project is divided into four phases. The phases are project management, project definition, concept generation, and final report. The work breakdown structure allows the team to divide the major deliverables, reports and presentations, into smaller more manageable tasks.

TABLE A I: WORK BREAKDOWN STRUCTURE

Project Work Breakdown Structure	
1. Project Management	3. Concept Generation
1.1. Planning	3.1. Brainstorming
1.1.1. Meeting	3.2. Concept screening
1.1.2. Minutes	3.3. Develop concept criteria and weight
1.1.3. Schedule	3.4. Develop house of qualities
2. Project Definition	3.5. Evaluate concepts
2.1. Problem background and statement	3.6. Compile concept report
2.2. Project objective	3.7. Concept report submission
2.3. Target specification	4. Final Report
2.4. Constrains and limitation	4.1. Select final design
2.5. Project schedule	4.2. Refine design
2.6. Client approval	4.3. CAD model of design
2.7. Report Summary	4.4. Compile draft report
2.8. Project definition report submission	4.5. Edit report for final submission
2.9. Oral presentation	4.6. Create a poster
	4.7. Final report submission
	4.8. Oral presentation

A Gantt chart was created to monitor the progress of the project. The activities were based on the tasks outlined in the work breakdown structure and deliverable due dates. After compiling all of the tasks and deliverable due dates, the duration and interdependences were determined and compiled into a the Gantt chart shown in Figure A 1 and Figure A 2.

ID	Task Name	Duratio	Start	Finish	Predecessors
1	**Project Management**	**4 days**	**Wed 9/17/14**	**Sat 9/20/14**	
2	Planning	4 days	Wed 9/17/14	Sat 9/20/14	
3	Create Schedule	4 days	Wed 9/17/14	Sat 9/20/14	
4	**Project Definition**	**13 days**	**Wed 9/17/14**	**Mon 9/29/14**	
5	Project Design	5 days	Wed 9/17/14	Sun 9/21/14	
6	Engineering Drawings	5 days	Wed 9/17/14	Sun 9/21/14	
7	Description of proposed modifications	2 days	Mon 9/22/14	Tue 9/23/14	5,6
8	Target Specifications and Baseline	2 days	Mon 9/22/14	Tue 9/23/14	5,6
9	Compile Project Definition Report	1 day	Wed 9/24/14	Wed 9/24/14	7,8
10	Edit and Format Report	1 day	Thu 9/25/14	Thu 9/25/14	9
11	Pre-approval by Client	1 day	Fri 9/26/14	Fri 9/26/14	10
12	Submit Report	0 days	Sat 9/27/14	Sat 9/27/14	11
13	Oral Presentation Draft	2 days	Fri 9/26/14	Sat 9/27/14	10
14	Practice and edit oral presentation	2 days	Sun 9/28/14	Mon 9/29/14	13
15	**Concept Generation**	**24 days**	**Tue 9/30/14**	**Fri 10/24/14**	**11**
16	Individual Brainstorm	6 days	Tue 9/30/14	Sun 10/5/14	
17	Team Brainstorming	3 days	Mon 10/6/14	Wed 10/8/14	16
18	Screen Ideas	1 day	Thu 10/9/14	Thu 10/9/14	17

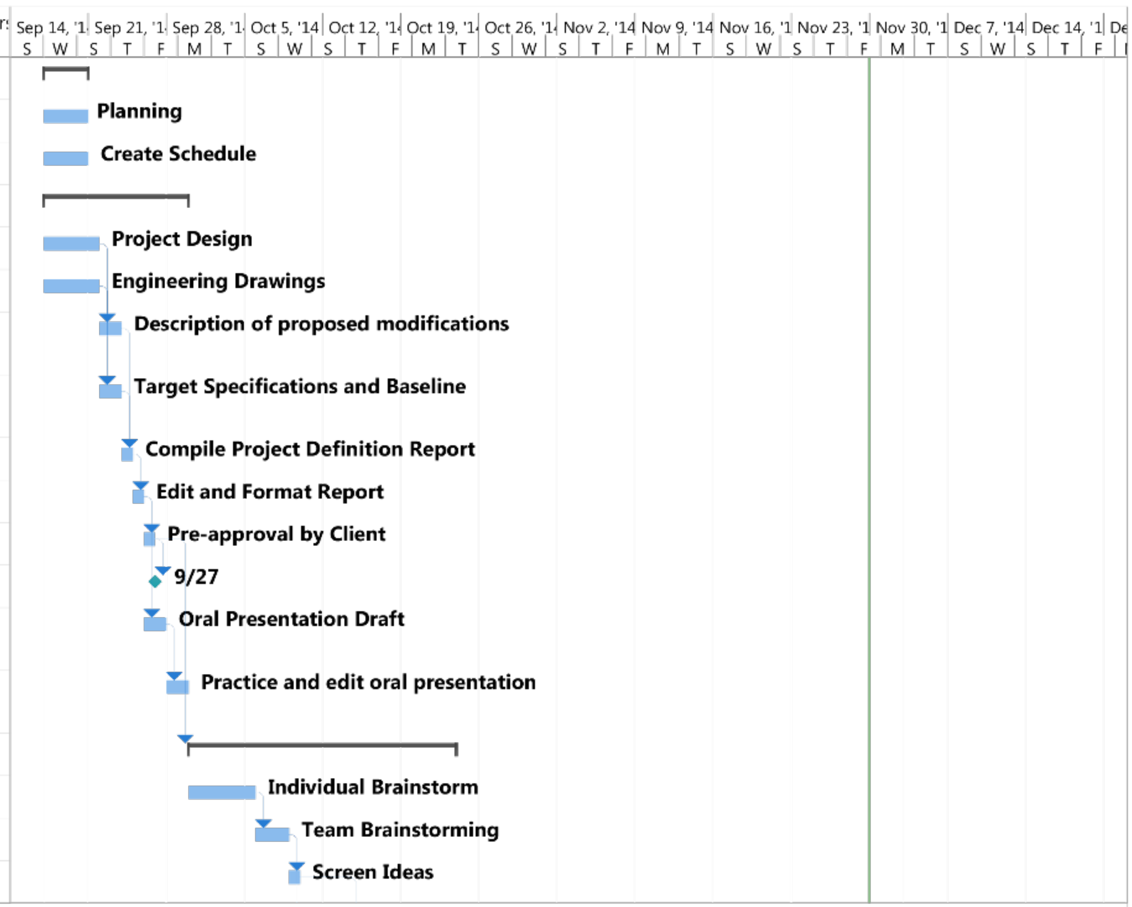

Figure A 1: Gantt chart part 1

ID	Task Name	Duration	Start	Finish	Predecessors
19	Develop Concept Criteria and weight	3 days	Thu 10/9/14	Sat 10/11/14	17
20	Develop House of Quality	3 days	Sun 10/12/14	Tue 10/14/14	19
21	Evaluate Concepts	4 days	Wed 10/15/14	Sat 10/18/14	20,18
22	Compile Concept Design Report	3 days	Sun 10/19/14	Tue 10/21/14	21
23	Edit and Format Report	2 days	Wed 10/22/14	Thu 10/23/14	22
24	Submit Concept Report	0 days	Fri 10/24/14	Fri 10/24/14	23
25	**Final Report**	**30 days**	**Sun 11/2/14**	**Tue 12/2/14**	**24**
26	Select Final Design	6 days	Sun 11/2/14	Fri 11/7/14	
27	Refinement to Design	7 days	Tue 11/11/14	Mon 11/17/14	26
28	CAD Model of Design	2 days	Tue 11/18/14	Wed 11/19/14	27
29	Compile Draft Report	16 days	Sat 11/8/14	Sun 11/23/14	26
30	Submit Draft Report	1 day	Mon 11/24/14	Mon 11/24/14	29
31	Eval other draft Report	2 days	Tue 11/25/14	Wed 11/26/14	30
32	Edit Final Report	4 days	Thu 11/27/14	Sun 11/30/14	31
33	Poster	8 days	Thu 11/20/14	Thu 11/27/14	28
34	Practice Presentation	5 days	Thu 11/27/14	Mon 12/1/14	31
35	Submit Final Report	0 days	Mon 12/1/14	Mon 12/1/14	32
36	Oral Presentation	0 days	Tue 12/2/14	Tue 12/2/14	34,33

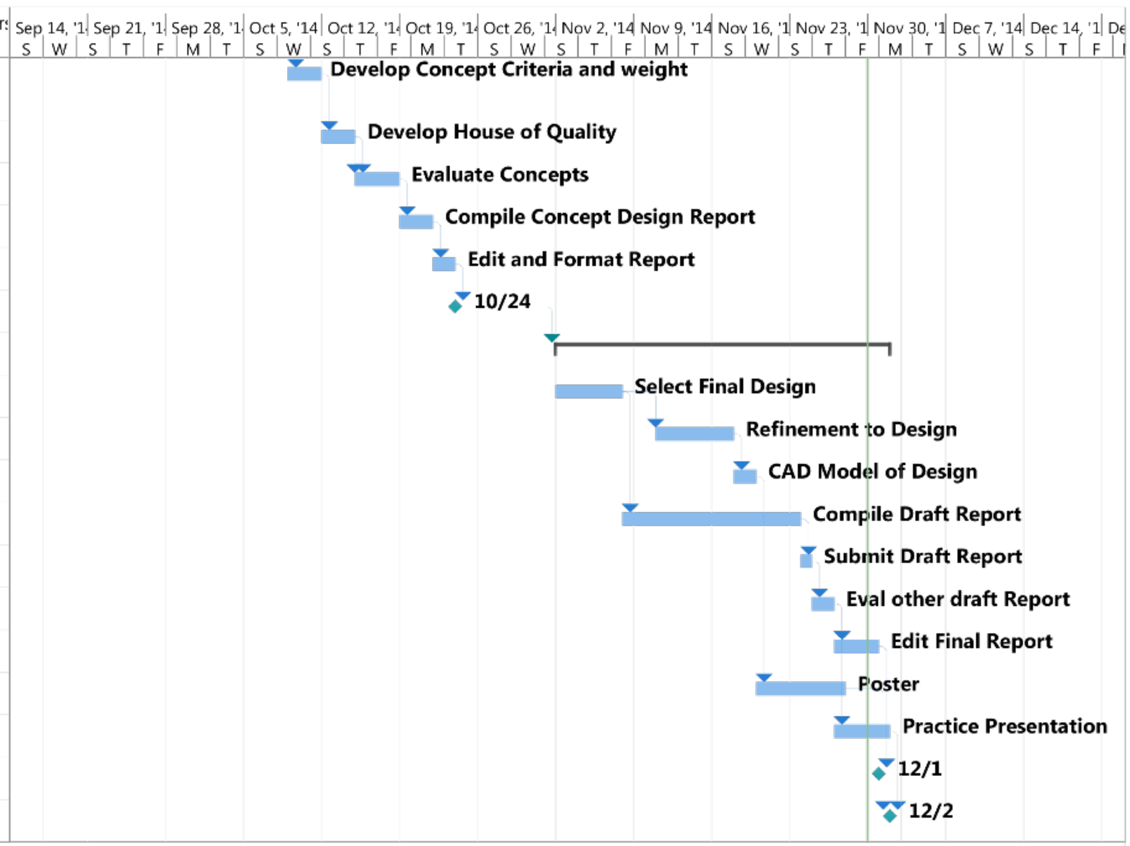

Figure A 2: Gantt chart part 2

APPENDIX B: ELIMINATED CONCEPTS

These are a list of the concepts eliminated by the team. Some of the top concepts that were consider are detail in this appendix.

TELESCOPING TUBE SPACER

Our third concept is simply a telescoping pole, with a number of internal tubes, capped off by butt plates. The design is shown in Figure A 3.

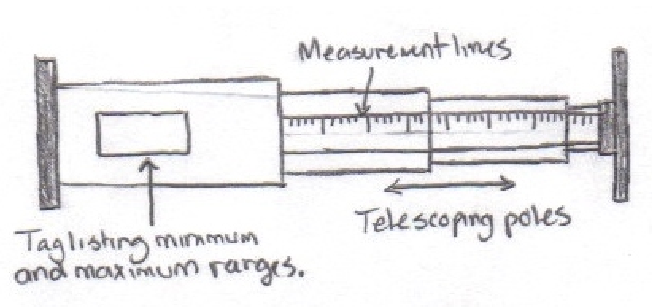

Figure A 3: Telescoping tube spacer sketch

This telescoping pole can extend a great deal beyond its own original length (when collapsed). This is important for us, due to the large range of values required for the core sizes. It allows us to have both a compact and extendible design to space the blades with. In terms of availability, this design would be very easy to produce or have pre-made for us due to the availability of these types of tools. Pool skimmers, painter's sticks and golf ball retrievers use this exact same technology, and they have been well established and designed. The measurements are marked on each section, giving a measurement of the blade spacing, rather than the spacing between the ends of the device. So if the blades are required to be spaced at 420 mm, then the operator would set the reading on the tool to '420' and then set up the blades. While a locking device was not included within this design, there are many designs currently on the market we can use for it, the most popular being the screw ring that binds down the outer old onto the inner one using friction. We could use this ring, or simply use pure friction to hold this device together, albeit that could cause a lot of unneeded wear on the part. This design is a simple and cheap way to space the blades.

INDIVIDUAL SPACERS

Our fifth design comprises of a set of spacer units, set to various lengths. This can be seen in Figure A 4.

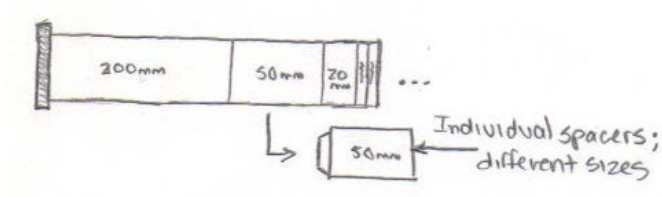

Figure A 4: Individual spacers sketch

This is an example of a possible state that this slitter spacer would be set up in. Using the base spacer (marked 200 mm here), other sections can be added on and the keyed ends (seen on the separated spacer) keep the spacers concentric and spaced properly. To attach the spacers, a magnet is embedded within the end of the tapered part, and there is a steel insert within the base on the opposite side. With each section set up this way they can connect together magnetically, forming a simple method of creating a uniform spacer. These spacers would be made of a lightweight and inexpensive material to ensure that the magnets will hold together firmly under the weight of each section added. This material however, would need to be very stiff, and strong enough to withstand the battering of operators impacting the spacer with the blade unit. We imagine a worst case scenario for this strength limit, where the operator uses the full force of his arm to slide the blade into the tool. The major limiting factor of this design however, is the fact that there would need to be a stockpile of these made for various sizes for Winpak. This may cost more depending on the material and manufacturing costs, plus it may be more tedious for the operators to use by having to search around for a specific spacer, or try and find which other employee took his or her set of spacers etc. There will need to be further analysis done for the costs on this concept, to determine its validity.

FIXED THREADED ROD

This next design is a further adaptation of the previous one, and makes an improvement in the accuracy of the measurements, as seen in Figure A 5.

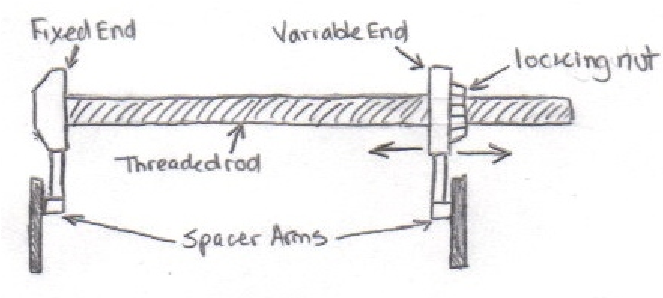

Figure A 5: Fixed threaded rod sketch

By simply fixing one arm and ring to the end of the rod, we are able to more accurately adjust the slitter spacer between settings. Before, when both of the arms could move there was room for error or more slippage than if one end was totally fixed. Here, the left end is totally fixed (possibly welded) to the threaded rod. With the spacer arm on the left fixed, only the right hand side can move and adjust. Using all the same methods as done in the previous adaptation of this concept, the pitch of the thread should be fixed to one millimeter per rotation. This will allow a simpler 'guessing' of the set value and enable the operator to reach the final result faster. There will also be a locking nut included on the variable end of the spacer. By aiding in locking the arm in place, stress is taken off the threads and put onto the locking but, which can distribute force along the rod better (by design). This concept can easily help space the blades, remain in place, and takes very few resources to produce.

APPENDIX C: ENGINEERING DRAWINGS

Engineering drawings for the component in the design are shown here.

Figure A 6: Engineering drawing for measuring block

Figure A 7: Engineering drawing for fixed end

Figure A 8: Engineering drawing for moving end front

Figure A 9: Engineering drawing for moving end back plate

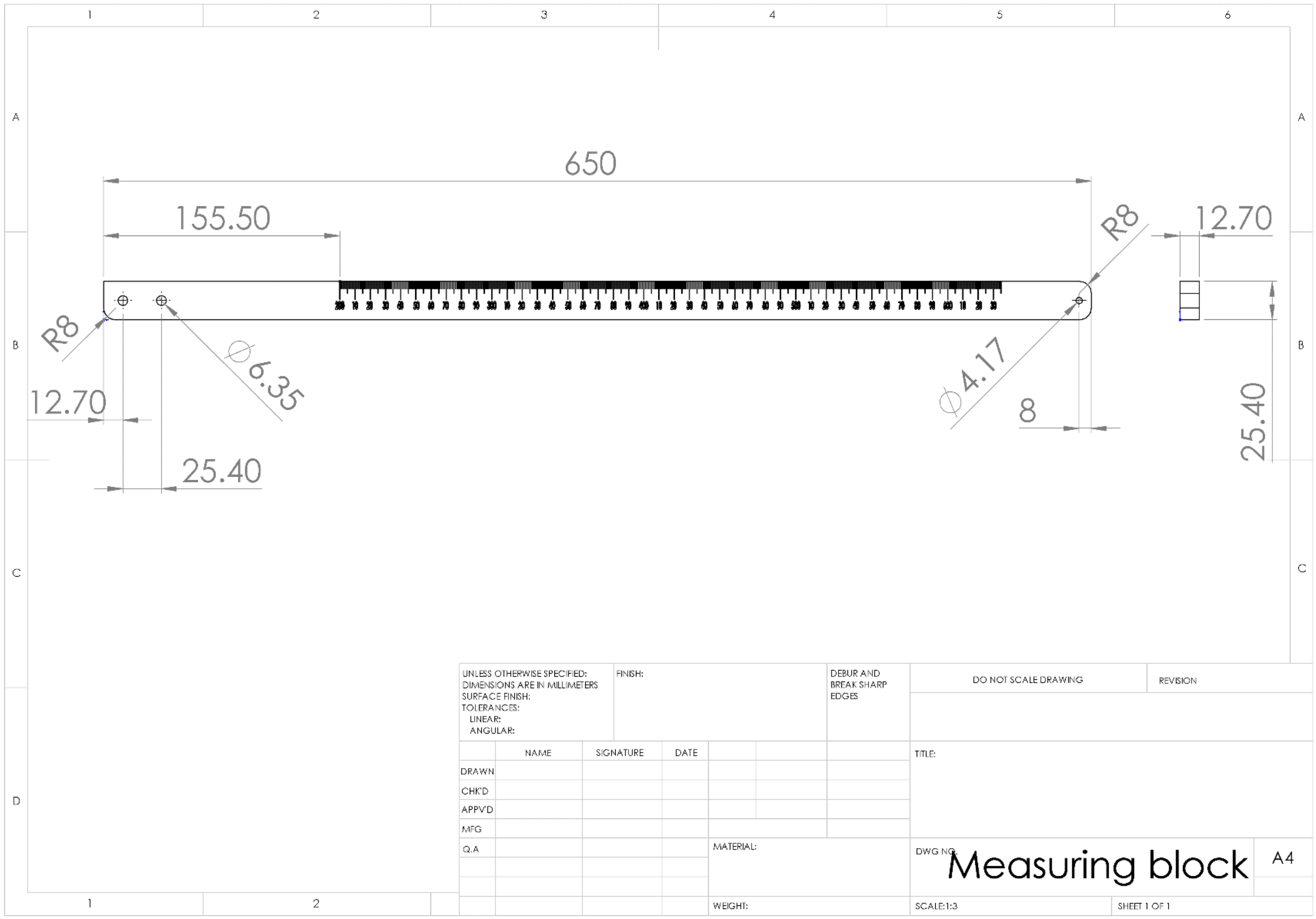

Figure A 6: Engineering drawing for measuring block

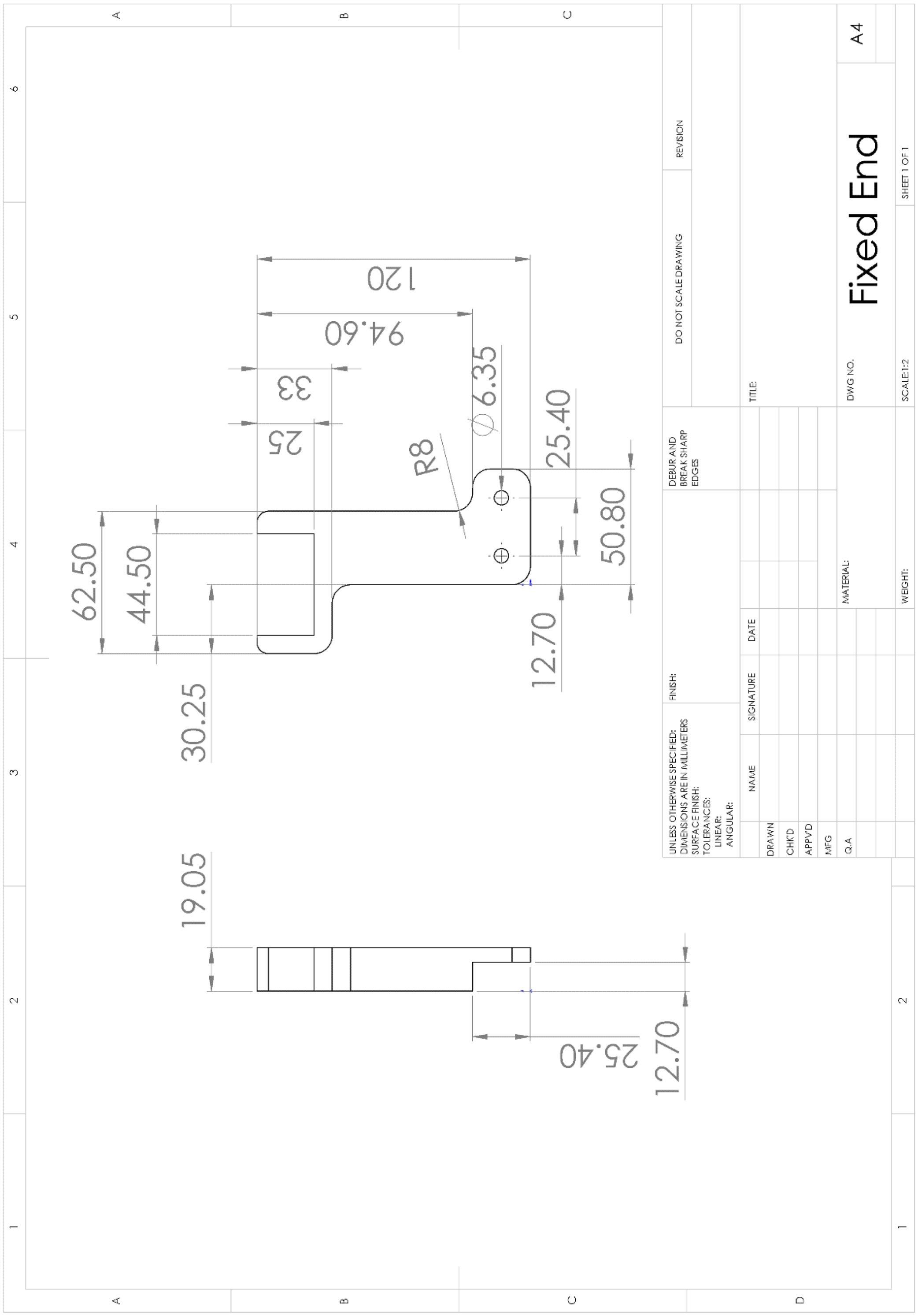

Figure A 7: Engineering drawing for fixed end

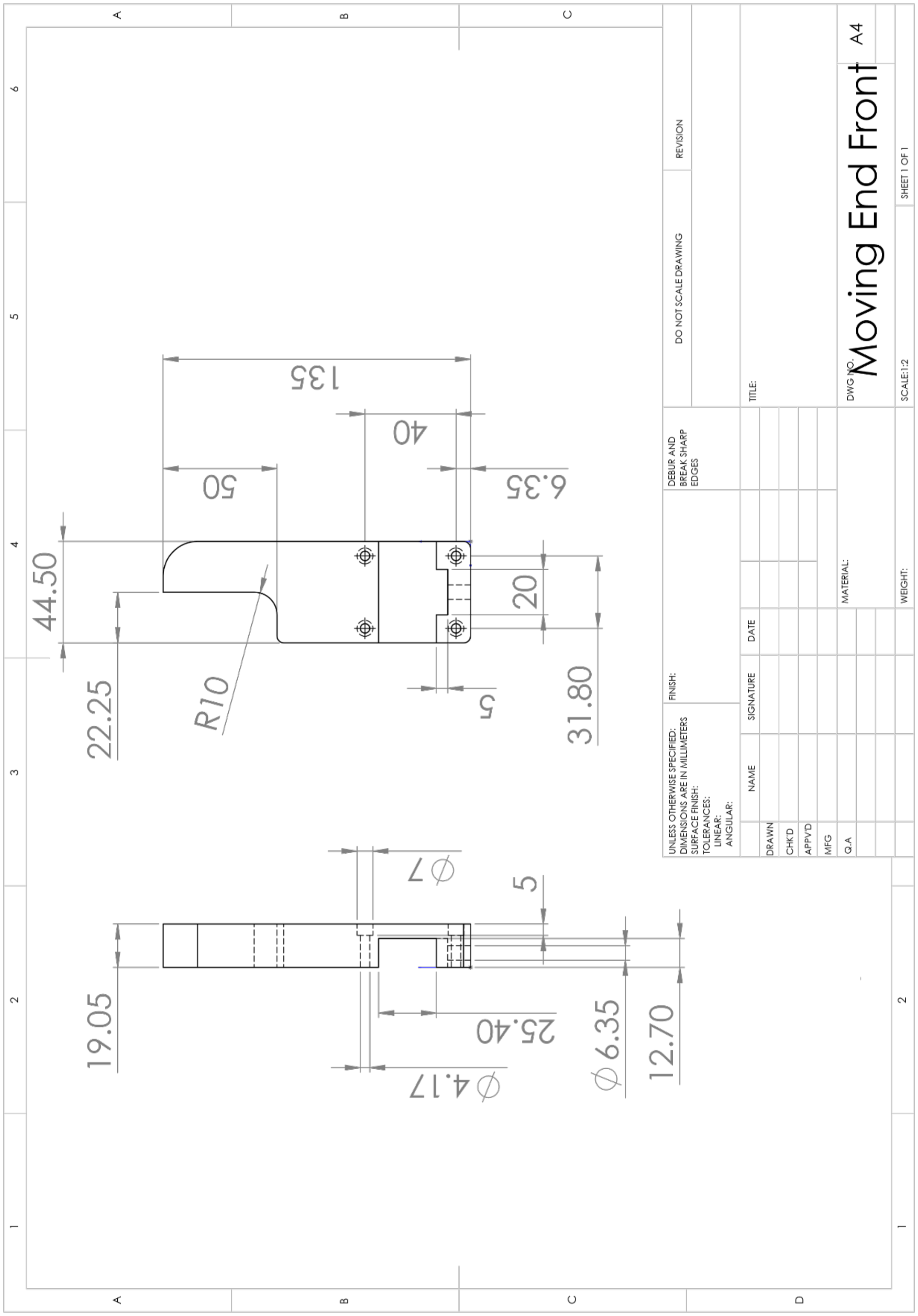

Figure A 8: Engineering drawing for moving end front

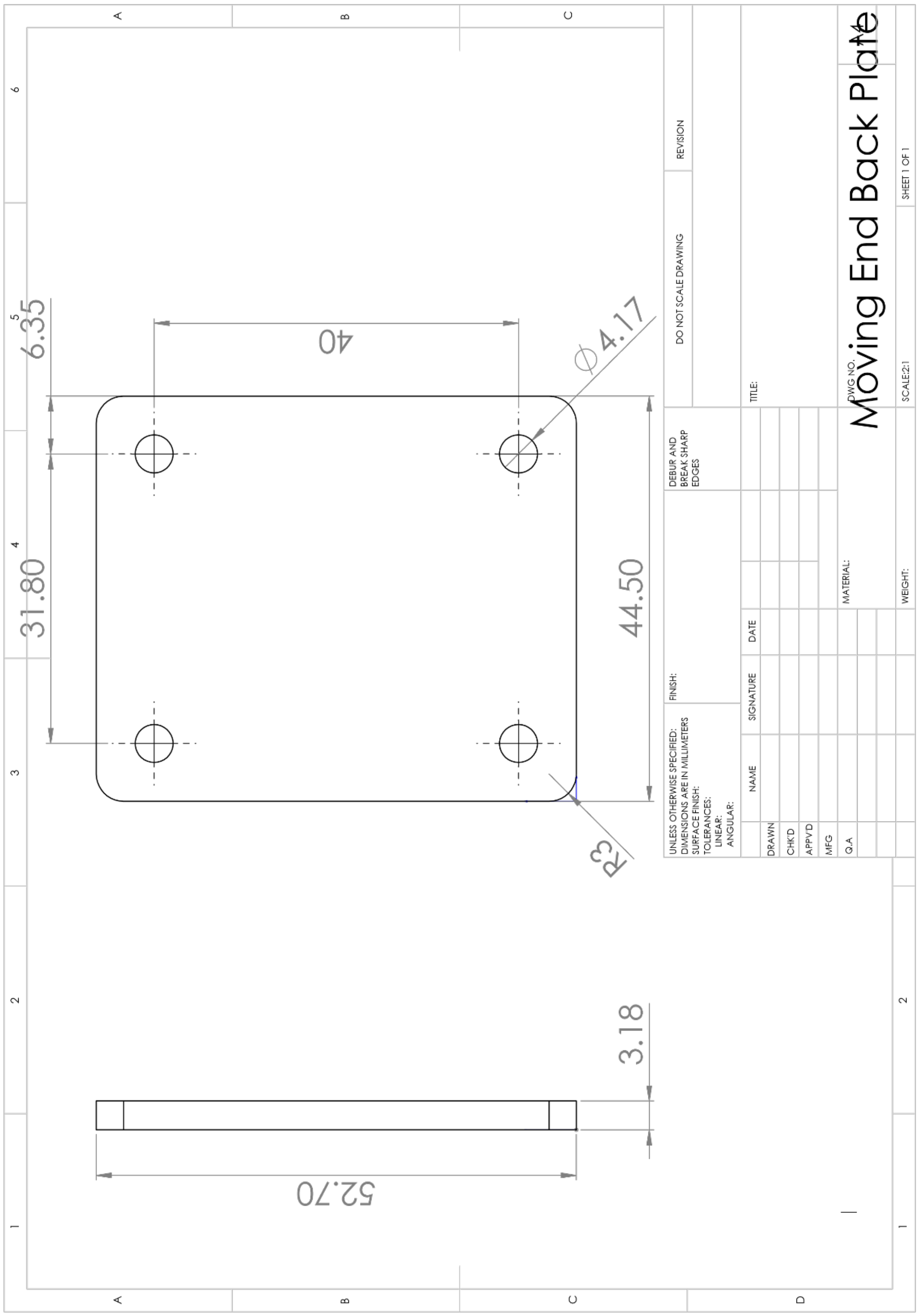

Figure A 9: Engineering drawing for moving end back plate

APPENDIX D: RELEVANT CODES AND STANDARDS

Our final design for the spacing tool conforms to a number of codes and standards. Since Winpak deals with mainly food and medical supply packaging, the relevant codes and standards concerning the cleanliness of all operations within the factory are extremely stringent and vital. Any shortcomings with respect to these requirements will not only affect the client, Winpak, but will affect their numerous customers, which include various food processing companies, and ultimately the general consumer.

The design must adheres to the codes and standards of the Safe Quality Food Program as regulated by the Safe Quality Food (SQF) Institute. The relevant codes and standards to the design of a spacing tool are listed under Sections 13.2.1, 13.2.7.2, and 13.2.10.1 of the cord and standard [1]. These relevant statements are shown in TABLE A II.

TABLE A II: RELEVANT CODES AND STANDARDS [1]

[redacted]

APPENDIX E: MALE SLITTER BLADE ASSEMBLY

The current male slitter blade assembly utilized by Winpak for their plastic film splitting operations is composed of two major components, a circular cutting blade and a holder for the previously mentioned cutting blade. The complete slitting blade assembly is depicted attached to a slitter rewinder machine shown in the Figure A 10.

Figure A 10: Male slitter blade assembly [2]

The male blade holder assembly is held onto the slitter rewinder machine by a built-in clamp, which can be seen in Figure A 11, being controlled by a knob on the top on the device.

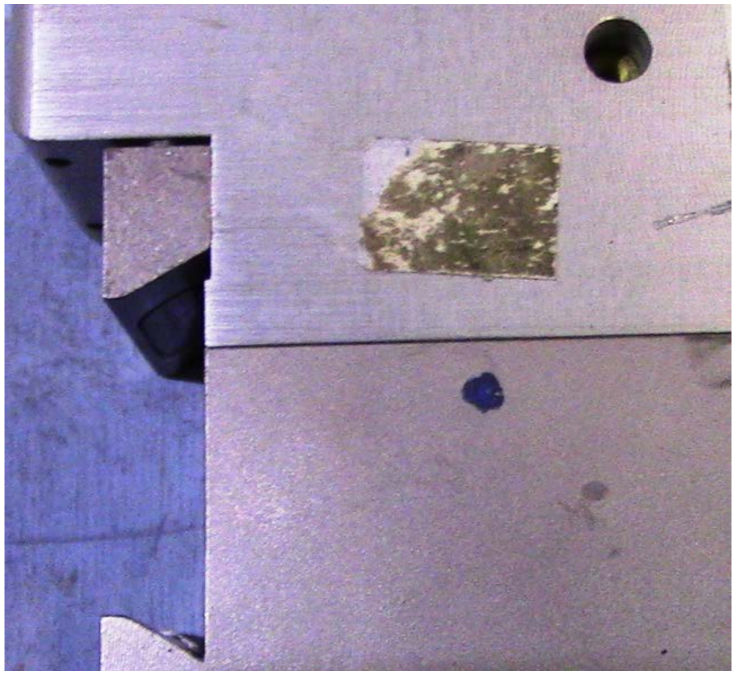

Figure A 11: Close-up of male slitter blade assembly built-in clamp [2]

The height blade portion of the slitter assembly can be controlled with the two knobs placed at the very front of the assembly, as depicted in Figure A 12. Pneumatic pressure is utilized for this task, supplied by some black rubber tubing which can seen in Figure A 12 as well.

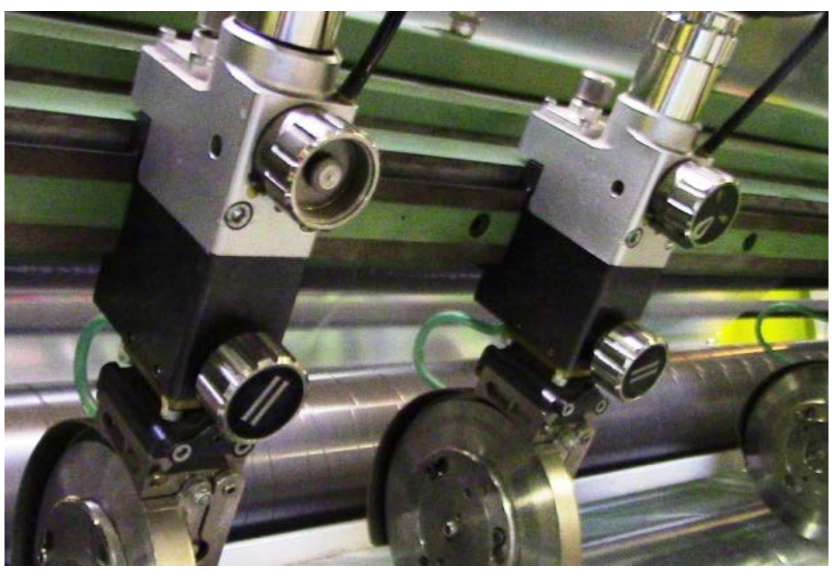

Figure A 12: Front view of male slitter blade assembly with pneumatic tubing [2]

The various dimensions of the male blade slitter are depicted in the following Figure A 13 which is a schematic drawing of the complete male slitter blade assembly.

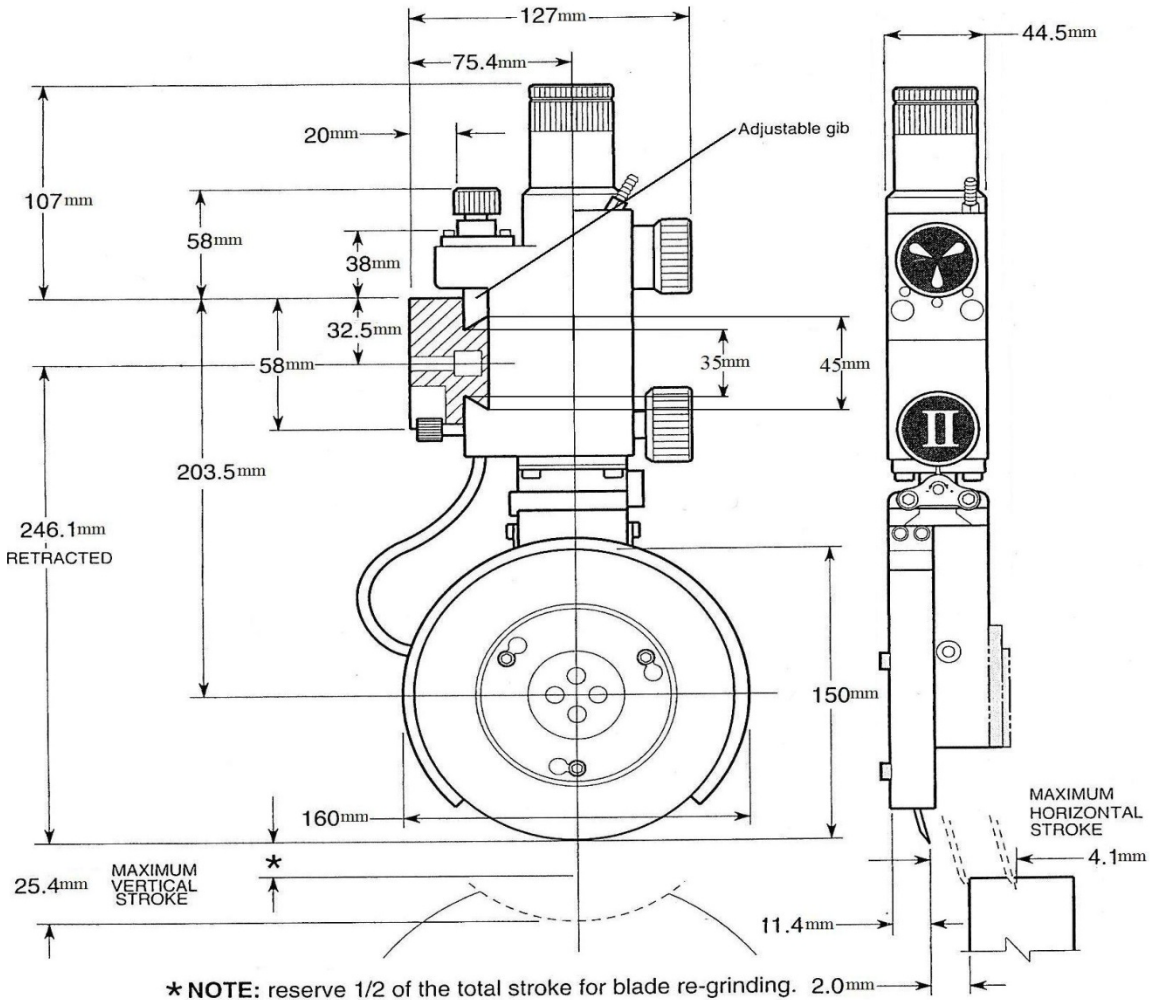

Figure A 13: Schematic drawing of male slitter blade assembly [3]

APPENDIX REFERENCES

[1] Safe Quality Food Institute, "One world. One standard.," [Online]. Available: http://www.sqfi.com/about-sqf/. [Accessed 22 October 2014].

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