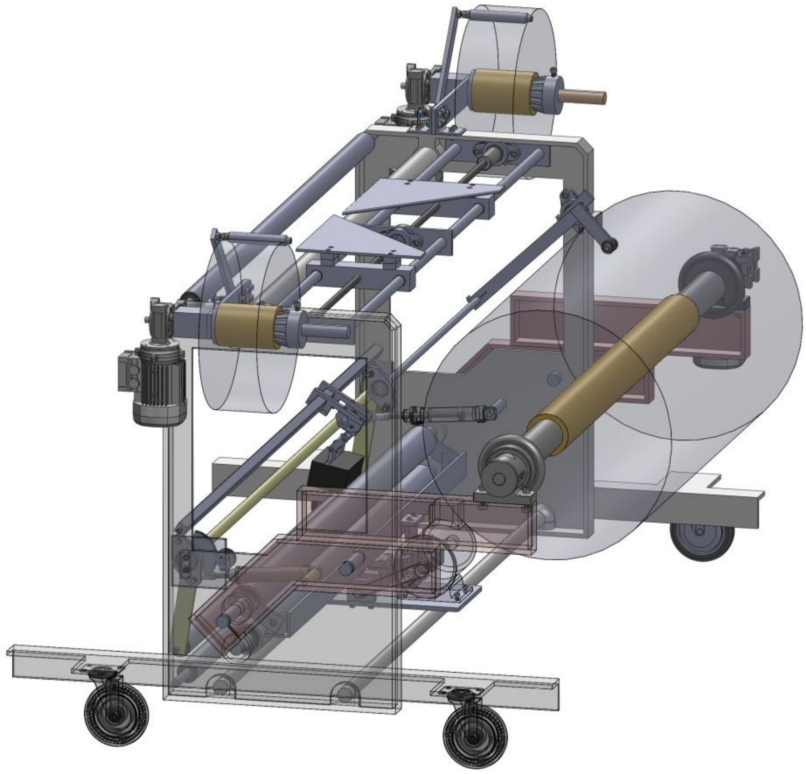
INTERNSHIP REPORT

OPTIMIZATION OF BAG FORMING MACHINE C20

Tom Eller (s0169625)
Applied mechanics, CTW
29-08-2011 to 30-11-2011



UNIVERSITY OF TWENTE.

University of Twente
Enschede, The Netherlands
Academic supervisor: Prof. dr. ir. A. de Boer

SAFEPAK
Manufacturers of Flexible Packaging

Safepak (Pty) Ltd
Cape Town, South Africa
Supervisor: Grant Thorburn

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Safepak (Pty) Ltd
16 Old Mill Road
N'dabeni, 7405
Cape Town
South Africa

Supervisor:
Grant Thorburn
grant@safepak.co.za

University of Twente
PO Box 217
7500 AE Enschede
The Netherlands

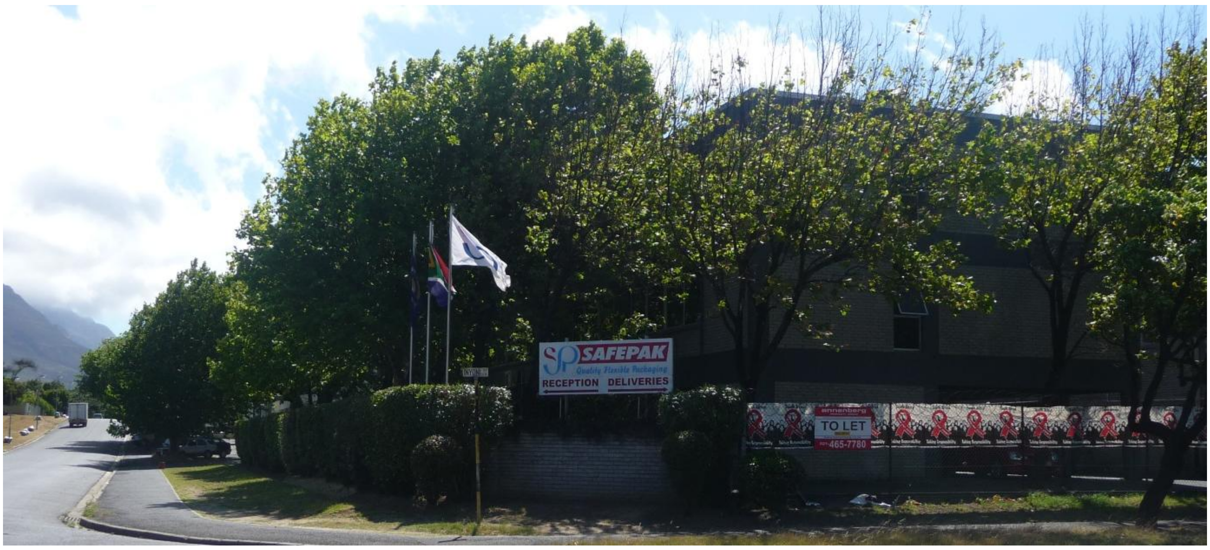
Academic supervisor:
Prof. dr. ir. A. de Boer
a.deboer@ctw.utwente.nl

1 PREFACE AND ACKNOWLEDGEMENT

From the 29th of August until the 30th of November 2011 I did an Internship at the South African packaging company Safepak (Pty) Ltd. Safepak is situated in Cape Town and serves a variety of industries throughout South Africa as a manufacturer of high quality flexible packaging products. The internship is part of my 2 year master programme which I conduct at the University of Twente in The Netherlands. The master programme consists of a year of courses specialized on applied mechanics, a three month internship and 9 months graduation.

The factory manager of Safepak, Grant Thorburn, set me up with a project to improve the performance and dramatically decrease waste rates on one of the bag forming machines in the plant. This machine used to make bags for all different kinds of customers, but will be redesigned and optimized for making diaper bags with strip handles. Grant exposed me to all kinds of stand-alone side projects to get me acquainted with the various technical subjects involved in bag making. Together with my main project, the redesign of machine C20, I gained a lot of practical experience. Mechanical design, motor, gearbox and bearing selection, making technical drawings, getting feedback from the workshop and training machine operators were all part of the assignment. Not less important is the experience of working in a business environment, communicating with managers and other staff, both within and outside the company. In the last week at Safepak I had the opportunity to present my achievements to the management board, convincing them not only of the benefits for Safepak, but also of the benefits for all other Dutch students to come.

To conclude, the internship at Safepak offered me a personal experience and a personal development at the same time. I developed new skills, especially on practical engineering matters, became more independent and gained professional experience. By learning and understanding a different culture, I now have a broader perspective of the world which is a personal gain of this internship. During this process, Grant gave me extensive guidance sharing his knowledge and experience. Not only was he always ready to help me with my assignments at Safepak, also outside working hours he showed personal interest and invited me for various leisure activities in and around Cape Town. For that, I would like to express my gratitude to him. I would also like to thank Greg Sayers for his practical advice and feedback from the workshop, Aard Duivenvoorden for setting up my first contacts with Safepak and Tony Aspeling for arranging my accommodation in Cape Town.



2 MANAGEMENT SUMMARY

This report covers the main design decisions made during the re-engineering of bag forming machine C20. Machine C20 is situated in the conversion department of the plant and has several operational shortfalls, causing long downtimes and high waste rates.

First, the current setup of machine C20 was analysed with specific reference to these operational shortfalls. It was found that a difference in tension between the main film and the strip films was causing problems in the final product. Furthermore, the machine produces bad seals when it is stopped and restarted by machine operators. These operators didn't seem to work very structured either: they hardly ever notice a reel running out and don't have a systematic set up plan to do job changeovers on C20. Finally, there were several alignment problems to be solved.

The re-engineering of machine C20 can be split up in four different parts: the unwind system for the main reel, the unwind system for the strip reels, the folding frame and some smaller, remaining projects. For the unwind system of the main reel, a tensioning system, a line guide and safety chucks were implemented. The tensioning system consists of a pneumatic system with a dancer roller and brakes and makes sure that the tension in the film remains constant. The line guide controls the horizontal position of the film in the machine, tracking a printed line and actuating the position of the main reel. The safety chucks enable machine operators to quickly change the reel. The advantage of a safety chuck is that the driving mechanism of the shaft does not need to be removed when the core holding shaft is exchanged. Total costs for this subsystem are estimated at R 70.500, in which workshop hours and materials are the biggest expense.

For the unwind system of the strip reels, a braking mechanism was selected with total costs as main criterion. An AC motor with variable speed drive was selected to deliver the braking moment, an arm with a rotational potentiometer measures the current reel diameter and gives the necessary feedback. With this system, the tension is controlled at the same tension as the main film. The strip unwinds will be mounted on the sides of the unwind station, under a 90° angle with the main reel. To guide the strip films to the correct location on the main film, an adjustable 'fold-in'-mechanism will be incorporated in the frame. Total costs for this subsystem are estimated at R 62.800, again with workshop hours and materials as the biggest expense.

The folding frame was redesigned to incorporate the gusset folder. In the old situation, the folding mechanism consisted of two separate stations: at the first station, the plastic film was folded in half using a so-called A-frame folder, the second station created a gusset into the folded side of the film. Disadvantage of having two separate stations is the difficult alignment procedure when setting up the machine. The new design incorporates both folders into one frame and has a spring loaded mechanism to avoid tearing the film. Total manufacturing costs are estimated at R 25.000.

Finally, the flying knife attachment was reconsidered to enhance operator friendliness and bigger pneumatic pistons were selected for the nip rollers. A systematic set up procedure was developed to reduce waste during product changeovers. During machine set up, operators wasted hundreds of meters of high quality, printed plastic film. After the first test with the new set up plan, only 3 meters of material was wasted, which is a promising result.

The total re-engineering costs are estimated at R 162.200.

3 CONTENTS

4 INTRODUCTION

Safepak is an expert in the extrusion, printing and conversion of flexible packaging materials. The company is involved in every stage of the process. Polyethylene, polypropylene and paper bags are produced with various features on customer demand. The production line can be divided into three main steps:

1. Blow extrusion. Raw polymer material is converted into film.
2. Printing. The film is printed on multiple-colour presses.
3. Conversion. The film is folded and sealed into bags and covers.

This report focusses on machine C20, which is situated in the conversion department of the plant. Reels with more than $200\ kg$ of printed film are the input material for this machine. Unwinding, adding strips for the handle, folding, punching various types of holes into the bag and cutting it to the right length are just a few of the converting operations C20 is capable of doing. The physical layout of the current setup of C20 and its operational shortfalls will be discussed in chapter 5. The intended improvements and design goals will be presented in this chapter as well.

Chapter 6 will give a quick preview of the final design of the unwind station for C20, solely for readability reasons of the subsequent chapters. In chapter 7, the main design considerations for the unwind system of the main reel will be discussed. The line guide and the tensioning system are the main points of attention. Chapter 8 covers the redesigned unwind system for the strip reels. The current strip unwind station will be evaluated and a new braking mechanism and tension control system will be presented.

The folding station and the gusset folder of machine C20 will be reconsidered as well. In chapter 9, first the current folding mechanism will be analysed, focussing on operational shortfalls, after which a redesigned folding station with integrated gusset folder will be presented.

Although machine C20 has a lot of shortcomings, most of the waste is caused by machine operators. Currently, they don't have a systematic method for setting up the machine. As a result, set up times are unnecessarily high and hundreds of meters of film are wasted during product changeovers. In order to reduce set up times and waste and to enhance product quality, a systematic set up procedure will be presented in chapter 10.

Chapters 11 and 12 cover some side projects on machine C20 and a cost estimation of the total redesign respectively. In chapter 13, one of the many side projects will be discussed: the design considerations for an adjustable punch clamp. Finally, in chapter 14 the conclusion and recommendations can be found.

In the appendix, among other documents, a few of the many technical drawings made during the internship can be found. Not all drawings are included, because they were merely made for manufacturing purposes. Furthermore, an example of a systematic set up sheet as described in chapter 10 can be found there.

5 EVALUATION OF THE CURRENT BAG FORMING STATION

In this section the existing diaper bag forming station (C20) will be evaluated with specific reference to the operational shortfalls. The machine under consideration is situated in the conversion department of the plant. This department produces up to $600\ kg$ of waste per day consisting of valuable semi-finished products (colour printed plastic film, see figure 5.4). Reducing waste and improving bag quality are the main priority. First, in order to create an understanding of the machine, an overview of the current setup will be discussed focussing on the critical working principals. Later in this section, the operational shortfalls and the proposed improvements will be presented.

5.1 CURRENT SETUP OF C20

The bag currently produced on C20 is shown in figure 5.1. It consists of a main printed part ('main film') with a transparent handle ('strip'). The first part of machine C20 is schematically displayed in figure 5.2. The processes will be discussed in the order that the film runs, starting at the unwind of the two strip reels and the main reel. To align the strips with the main film before sealing, the strip reels can be moved perpendicular to the running direction by hand. The main reel is guided by an automatic edge guide system, moving the reel with a motor to ensure alignment with respect to the machine. After the main film and the strips are joined, they are sealed in a separate device (at the left of figure 5.2). After the sealing process, the film travels back towards the A-frame folder to be folded in half.

Fig. 5.1 – Huggies® Gold bag

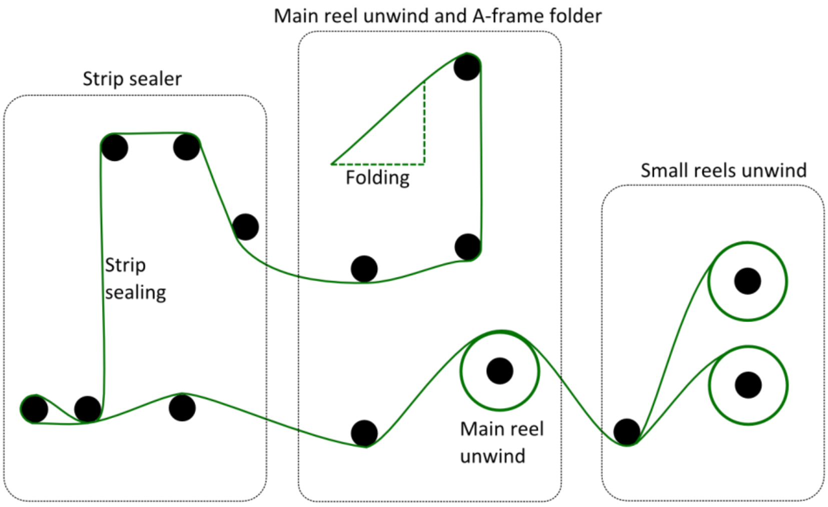


Fig. 5.2 – Schematic overview of C20 (part 1)

The next part of machine C20 is shown in figure 5.3. After the A-frame folder, the strips are folded back. Then, a gusset is created in the folded side of the film. Thanks to the gusset, a square bottom is formed when the bag is filled by the customer. After going back up again, the film goes down into the next sealer, sealing the strips together. Then, the strips are cut to the right size before the film runs into the machine buffer. The machine buffer converts the constant speed of the film needed at the unwind side (described above) to a pulsed movement. The constant speed at the unwind side is necessary to ensure a constant seal. The pulsed movement on the other side is needed to punch holes in the bag, cut out the handle and seal and cut the film into separate bags. The part of the machine after the buffer is not shown in a schematic overview, because the film just runs straight through the separate stations towards the end of the machine. Here, the final production step is performed by an operator: taking the bags, bundling them and putting them on a pallet.

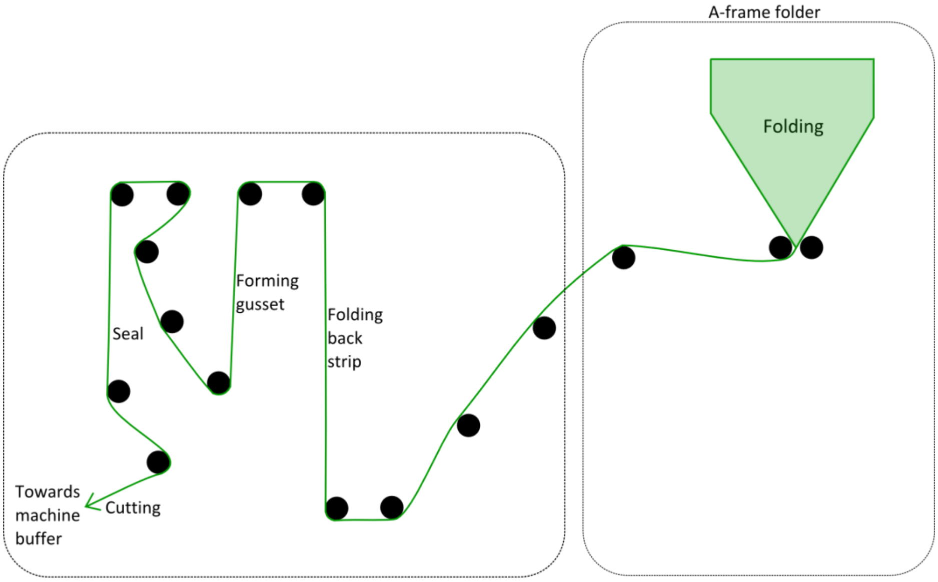


Fig. 5.3 – Schematic overview of C20 (part 2)

5.2 OPERATIONAL SHORTFALLS OF C20

The operational shortfalls of machine C20 were investigated by interviewing staff members and by observing the staff and the machine while running production. The main shortcomings can be summarized as follows:

- The tensioning systems of both the small reel unwinds and the main reel unwind are dependent on how much material is left on the reel. A weight attached to a strip of material creates friction on the reel unwinds, providing the necessary tension. The less material is on the reel, the less tension there is, because of the reducing diameter (see also figure 5.5).
- Operators don't notice it when the material on the reels is running out. The machine keeps pulling material until there is nothing left. When the operator finally notices it, he has to weave the material through the entire machine to get it back up and running.
- The machine consists of separate stations which have to be aligned to each other. When a fork-lift truck driver bumps into one of the stations, they will misalign and bad quality products/waste will be produced until one of the operators notices the issue.
- When the machine stops pulling material, the machine buffer causes the material flow to stop linearly to zero. The sealers stay pressed onto the material until it comes to a complete stop, causing the material to overheat resulting in a bad seal.
- The material travels an unnecessarily large distance through the machine causing set up times to be very high.

Fig. 5.4 – Waste produced in the conversion department

Fig. 5.5 – Current tensioning system

- Operators don't have a systematic method for setting up the machine. Different attachments (star punches, handle cut out punch, etc.) are randomly moved, hoping correctly sized bags will come out of the machine. This trial-and-error method is very time consuming and wastes lots of material.

5.3 Improvements / design goals

In order to improve the performance of C20, several design (re-)considerations are proposed and listed below:

- implement a line guiding system for the main reel unwind
- implement a tension control system and a buffer for the main reel unwind
- implement a tension control system for the strip unwinds
- implement an 'end of reel'-alarm system for strip and main reel unwinds
- integrate the gusset folder into the triangular folder
- incorporate the band sealer into the frame to ensure its positional location
- move the strip edge sealer to before the buffer storage station
- increase reliability and operator ergonomics for setting up and changeovers
- optimize the adjustment system of the flying knife cutter
- develop a set up procedure and specification for the diaper bags
- increase production speed to 60 cycles per minute
- train operators and setters

In the remainder of this report, the implementation of these design goals will be discussed in separate chapters. First, the unwind station will be reconsidered, integrating the line guide system, tension control and end-of-reel-alarm systems. Then, the redesigned folding mechanism will be presented. Finally, the smaller improvement projects on machine C20 will be discussed.

6 Final design of the unwind system

To enhance readability of the coming sections, first the final design of the entire unwind frame is presented in figure 6.1. As opposed to the current configuration of C20, both the main reel and the strip reel unwinds are now incorporated in one frame. The main reel unwind has a line guide system and a tensioning system with dancer roller. The strip reels have a tensioning system as well and are unwound from the side and folded in using adjustable folding triangles. Both the main reel and the strip reels are equipped with end-of-reel-alarm systems. The main components of the unwind system are:

1	Strip reel	6	End-of-reel-alarm for main reel
2	End-of-reel-alarm for strip reel	7	Safety chuck
3	Fold-in triangle for strip	8	Actuator of line guiding system
4	Braking system for strip reel	9	Line and contrast sensor
5	Main reel	10	Dancing roller

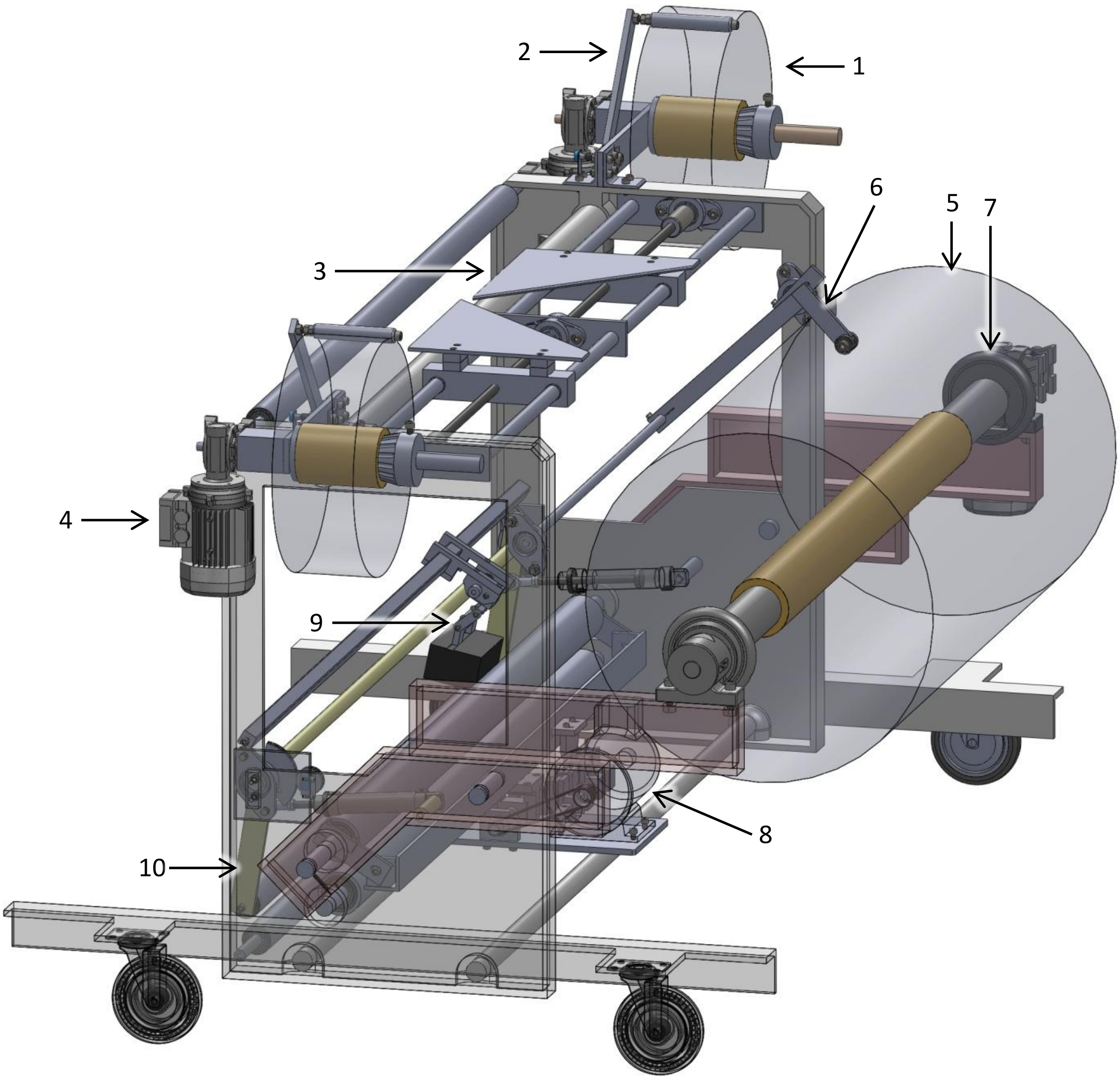


Fig. 6.1 – Final design of the unwind station

7 UNWIND SYSTEM FOR THE MAIN REEL

In this chapter the main design considerations for the unwind system of the main reel will be discussed. Important aspects of the main reel unwind are the line guide and the tensioning system. The line guide makes sure that the film is always at the same axial position, the tensioning system provides constant tension during the run through of a reel. First, the tensioning system will be discussed including the motor selection, the mechanical and the pneumatic design considerations.

7.1 TENSIONING SYSTEM FOR THE MAIN REEL

Constant tension in the film is necessary for the different production steps in the machine. The film gets pulled from the end of the machine, so applying a brake on the reel causes a certain tension. The current braking system of the reel consists of a weight attached to a strip of material causing a frictional braking force (as shown in figure 5.5). With this system, the tension in the film depends on how much material is left on the reel. To provide constant tension, a so-called 'dancer roller' will be used.

7.1.1 Dancer roller

A dancer roller setup consists of a roller connected to a pivoting arm (see figures 7.1 and 7.2). A pneumatic drive applies a constant tensioning force on the arm, tensioning the film. With a rotational potentiometer the current position of the dancer roller is measured. When the machine starts pulling material, the film pulls down the dancer roller (increasing the tension) while the change in angle gives a signal to the brake to decrease braking power (decreasing the tension). Depending on the desired (constant) tension in the film, the operator will only have to adjust the pressure of the pneumatic drive (see also the force diagram in figure 7.1). When in operation, the roller oscillates around its setpoint.

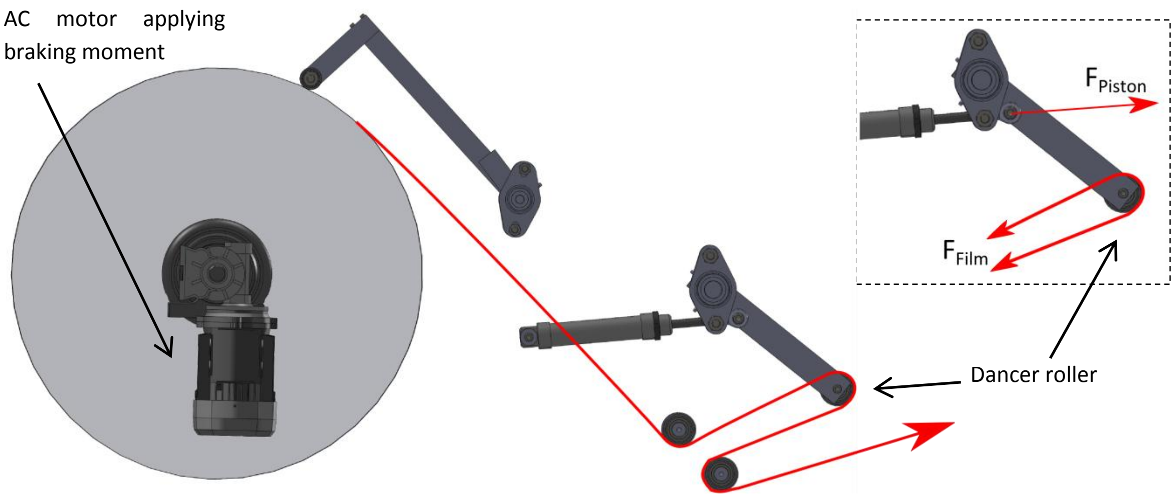


Fig. 7.1 – Dancer roller setup (detail: force diagram)

The dancer roller will be used for a second purpose. As described in chapter 4, the unwind side of the machine needs a constant speed to ensure a good seal between the main film and the strips. When an operator stops the machine, the sealbars pull away from the film and the film should stop immediately. Due to the high moment of inertia of the main reel, the brake can't stop it at once. The dancer roller will in this case move up with a linearly decreasing velocity, giving the brake time to stop the reel. On machine start-up, the same principles applies: the dancer roller moves down to feed material into the machine, while the AC motor has time to accelerate the reel.

7.1.2 Pneumatic design

Prior experiments have shown that the tension in the film should be around 5 MPa. With a film thickness of 50 μm and a width of 1200 mm, the required force F_{film} from figure 7.1 can be calculated as follows:

$$A_{film} = width * thickness$$
$$= 1.2 * 50 \cdot 10^{-6} = 6 \cdot 10^{-5}\ m^2$$
$$\frac{1}{2} \cdot F_{film} = tension * A_{film}$$
$$= 5 \cdot 10^{6} * 6 \cdot 10^{-5} = 300\ N$$

Taking the arm under which the forces act in consideration, the required piston force can be calculated. It was found that two standard Ø32 pistons will be able to generate the required force, using a safety factor of 1.5. Double acting pistons will be used, so that the exhaust side can be used to apply damping. For this purpose, a one-way reduction valve will be connected to this side of the piston.

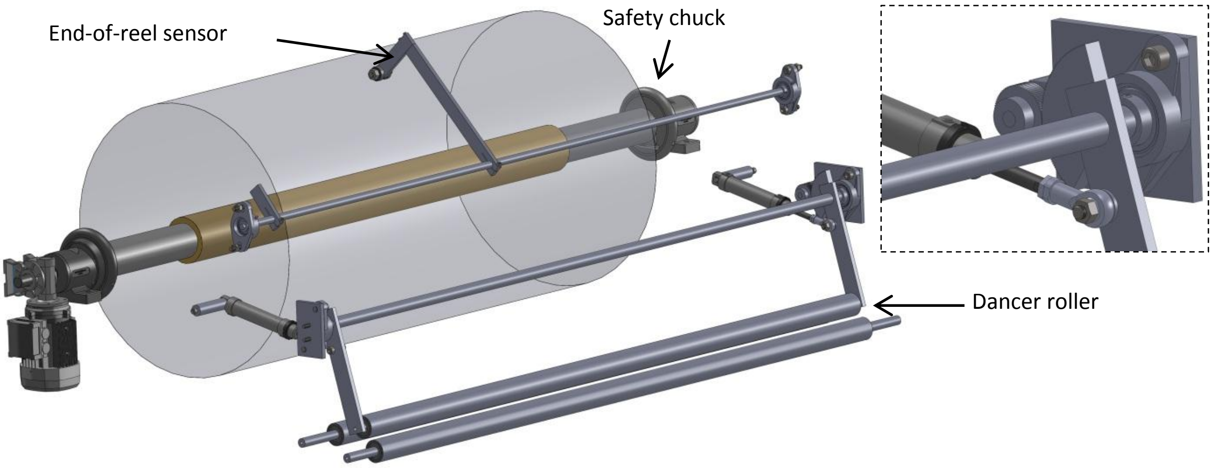


Fig. 7.2 – Tensioning system for the main reel (detail: geared sensor subsystem)

7.1.3 Sensors

Two different sensor systems will be used for the main reel unwind. The current position of the dancer roller will be determined with use of a rotational potentiometer. The range of the dancer roller is about $120°$, so a $1:3$ gear ratio will be used to generate the input for the potentiometer (see the detail in figure 7.2). The second sensor will be a limit switch, activating an alarm when the reel reaches a critical diameter (end-of-reel sensor, figure 7.2). The alarm should notify the machine operators to stop the machine before the reel runs out of material.

7.1.4 Motor selection

The main wheel will be braked and accelerated with use of an AC motor. To select a suitable motor, the required power and torque have to be calculated. The setpoint of the dancer roller will be in the lowest possible position, giving the main reel 0.7 m of extra film length to stop when the machine comes to a sudden stop. At 60 cycles a minute, with a bag width of 450 mm, the film travels with a velocity of $v_f = 0.45\ m/s$. The maximum diameter of the main reel is 0.5 m, leading to a rotational velocity of:

$$\omega = \frac{v_f}{\pi \cdot D} = \frac{0.45}{\pi \cdot 0.5} = 0.29\ \frac{rotations}{second} = 1.82\ rad/s$$

The braking system of the main reel will have $0.7/0.45 = 1.56\,s$ to stop the reel, leading to a deceleration of $\alpha = 1.82/1.56 = 1.17\,rad/s^2$. Together with the moment of inertia of the reel this leads to the required torque:

$$M_{req} = I \cdot \alpha = \frac{1}{2}m\left(r_o^2 + r_i^2\right) \cdot \alpha = \frac{1}{2} \cdot 250 \cdot (0.25^2 + 0.04^2) \cdot 1.17 = 9.4\,Nm$$

The required power of the motor is determined by calculating the kinetic energy of a rotating reel:

$$T = \frac{1}{2} I \cdot \omega^2 = \frac{1}{2} \cdot \frac{1}{2} \cdot 250 \cdot (0.25^2 + 0.04^2) \cdot 1.82^2 = 14\,J$$

which has to be stopped in $1.56\,s$, leading to a required power of $P = 14/1.56 = 9\,W$. To account for friction in the gearbox and other factors influencing the required power and torque, a slightly more powerful motor will be selected.

7.1.5 Safety chucks

To enable machine operators to quickly change the main reel, safety chucks will be used as supports for the shaft. A safety chuck is a quick coupling system used in wind and unwind applications. When using a safety chuck, the driving mechanism (in this case the motor described above) does not need to be removed when the core holding shaft is exchanged. Pillow block mounted safety chucks will be used (as shown in figure 7.3), which cost R4900 each at a local supplier and R2600 each when shipped in from India.

Fig. 7.3 – Pillow block mounted safety chucks

7.2 LINE GUIDE SYSTEM FOR THE MAIN REEL

To ensure that the film will always be at the same axial position in the machine, a line guide control system will be incorporated in the unwind system. An accurate axial position is necessary because it determines where the seals will be made and at what position the film will be folded in half. The line guide consists of a line and contrast sensor and an actuator. The sensor will track a line on the print of the film and give a signal to the actuator, which will move the main reel in axial direction accordingly. Figure 7.4 shows the final design of the line guide system incorporated in the unwind frame.

The main design criteria for the system are providing the control system with accurate measuring results and making the system easy adjustable for machine operators. The specifications can therefore be grouped as follows:

Measuring

- Measure as close as possible to the main reel to ensure accurate and quick feedback
- Measure on top of a roller to ensure a constant distance between scan point and sensor
- Paint the roller where the line guiding system is measuring on black, to provide a better contrast between the white bags and the roller. The current rollers are made of aluminium which provides very little contrast

Adjustment

- The sensor and the control panel should be movable along the entire width of the roller, but also have the option to be fine-adjusted
- The control panel should be easily accessible for machine operators
- Make clear to the machine operators how far the sensor will move upon one rotation of the adjustment screw

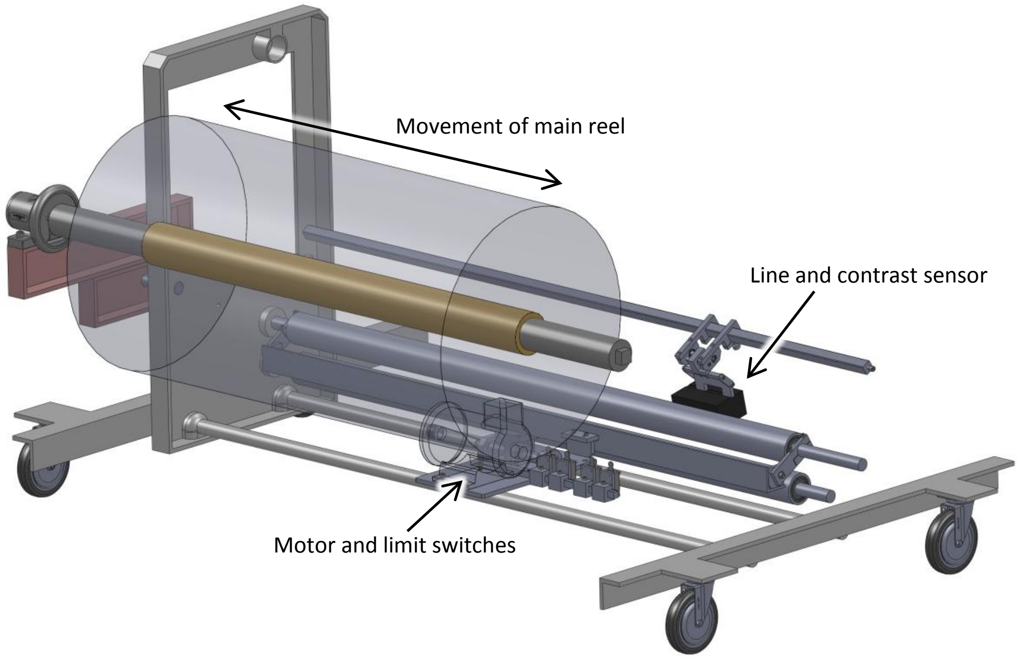


Fig. 7.4 – Final design of the line guide system

Figures 7.5 and 7.7 show detailed views of the motor/limit switch system and the sensor clamp respectively. An already available 180 V DC motor was selected as actuator. Four limit switches will be used: two to make the system able to centre itself, two to avoid the system from overshooting and damaging the frame. The cam activating the switches is designed such that one of the two centring switches is always activated, except for when the system is centred (see figure 7.6). With this design, the system will always be able to centre itself. The sensor clamp is movable along the entire roller width and has a fine adjustment screw to enhance user-friendliness.

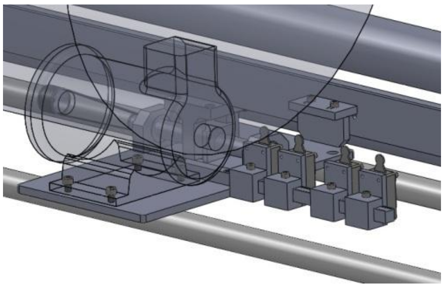


Fig. 7.5 – Motor and limit switches

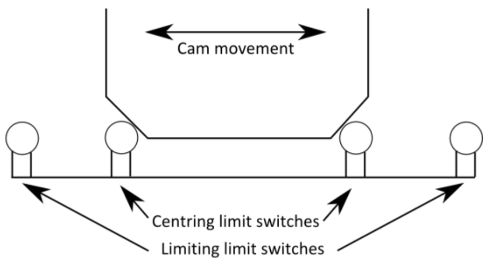


Fig. 7.6 – Limit switches

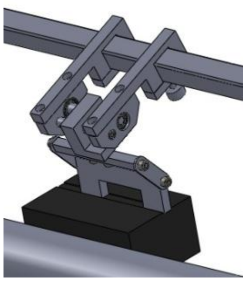


Fig. 7.7 – Adjustable sensor clamp

8 UNWIND SYSTEM FOR THE STRIP REELS

This chapter discusses the main design considerations for the unwind system of the strip reels. First, the current strip unwind station is evaluated and points for improvement are presented. Then, a suitable braking mechanism for controlling the tension will be selected. Finally, the physical layout and other design considerations will be discussed.

8.1 CURRENT STRIP UNWIND STATION

The current strip unwind station can be seen in figure 8.1. It consists of a frame with two reels on different heights. Operators can adjust the horizontal position of both reels separately by using the handles on the left (A). Tension in the strip films is provided for by the weights (B). The current unwind station has the following drawbacks:

- The tension in the film is not constant
- The strip unwind station is contained in a separate frame, so fork-lift truck drivers may bump in to it causing misalignments with the rest of the machine
- Operators don't notice it when the reels are running out
- Changing the strip reels is time consuming, because operators have to take the entire shaft out in order to remove and change the reel.

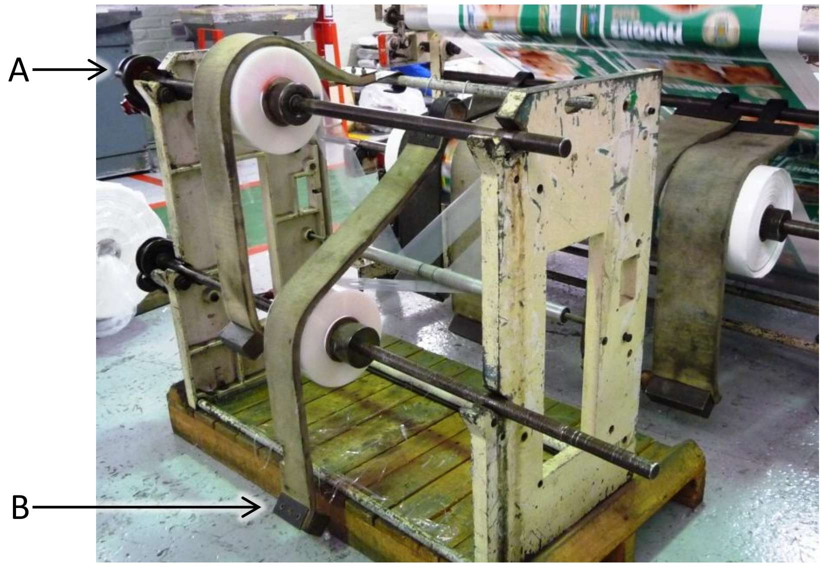


Fig. 8.1 – Current unwind station for the strips

As a design guideline to improve the performance of the current strip unwind station, the following specifications were brought up:

- Incorporate a braking system that provides constant tension
- Incorporate the strip unwinds into the machine frame
- Design an end of reel alarm system for the operators
- Make strip reel changeovers easier

8.2 BRAKING MECHANISMS

An important aspect of the strip unwind is that the tension in both strip films should be equal to the tension in the main film. In the sealer, the strips are sealed to the main film, which with different tension in the films would cause wrinkles to occur in the final product. As can be seen in section 7.1, the tension of the main film is controlled by a dancer roller with sensor in combination with an AC motor with variable speed drive. Because the strip reels are very light in comparison with the main reel ($\pm 15\ kg$ for the strip reels and $\pm 250\ kg$ for the main reel), other options will be investigated for controlling their rotational velocity. As the material gets pulled from the end of the machine, a braking mechanism for the unwind reel will create the necessary tension.

Currently, weights attached to a strip of material provide this tension (as can be seen in figure 8.1 and as shown for the main reel in figure 5.5). With this braking mechanism, the tension in the film depends on how much material is left on the reel. To provide constant tension in the strip films, a more sophisticated tensioning system will be used for which three options are considered:

- The first option for controlling the tension is using a similar mechanism as used for the main reel: a sensor in combination with a geared AC motor. The sensor gives feedback to the AC motor concerning the current diameter of the reel, creating a closed loop control system.
- The second option is using a servomotor in tension control mode. With this option the sensor mechanism would become redundant.
- The third option is using a magnetic clutch in combination with a sensor.

As the total price of the final system will be of overriding importance, a cost estimate of all three systems is made in tables 8.1 to 8.3. It can be seen that the third option – the magnetic clutch – would be far more expensive compared to the other two. The first two options are in the same price range, therefore drafts will be made for both systems and presented in the next section.

Description	**Manufacturer**	**Price (SAR)**
AC motor ($0.75\ kW$)	Control techniques	1.400
Variable speed drive for $0.75\ kW$ motor	Control techniques	2.800
Gearbox	Bonfiglioli	1.200
Workshop hours / materials for sensor	Safepak	3.000
Total system price		**8.400**

Table 8.1 - Prices for system with AC motor and variable speed drive

Description	**Manufacturer**	**Price (SAR)**
Servomotor ($0.75\ kW$)	Delta electronics, inc.	4.280
Servodrive for servomotor	Delta electronics, inc.	4.400
Power cable $5\ m$ for $0.75\ kW$ servomotor	Delta electronics, inc.	312
Total system price		**8.992**

Table 8.2 - Prices for system with servo motor and servo drive

Description	**Manufacturer**	**Price (SAR)**
Controller	Merobel	15.400
Magnetic clutch	Merobel	7.000
Round cylinder	Festo	977
Workshop hours / materials for whip/sensor	Safepak	3.000
Total system price		**26.377**

Table 8.3 - Prices for system with magnetic clutch

8.3 DESIGN OF THE STRIP UNWINDS

The drafts for both the servomotor and the AC motor variant of the unwind mechanism are shown in figure 8.2. The two main differences are the sensor arm for the AC motor variant and the difference in mounting the motor to the bearing housing. For a servomotor no gearbox is needed, so that it can be flange mounted to the housing. The AC motor will be mounted on the unwind shaft and fixed with a standard torsion bar. In consultation with Safepak, the AC motor variant was selected for the final design because of cost and material availability reasons.

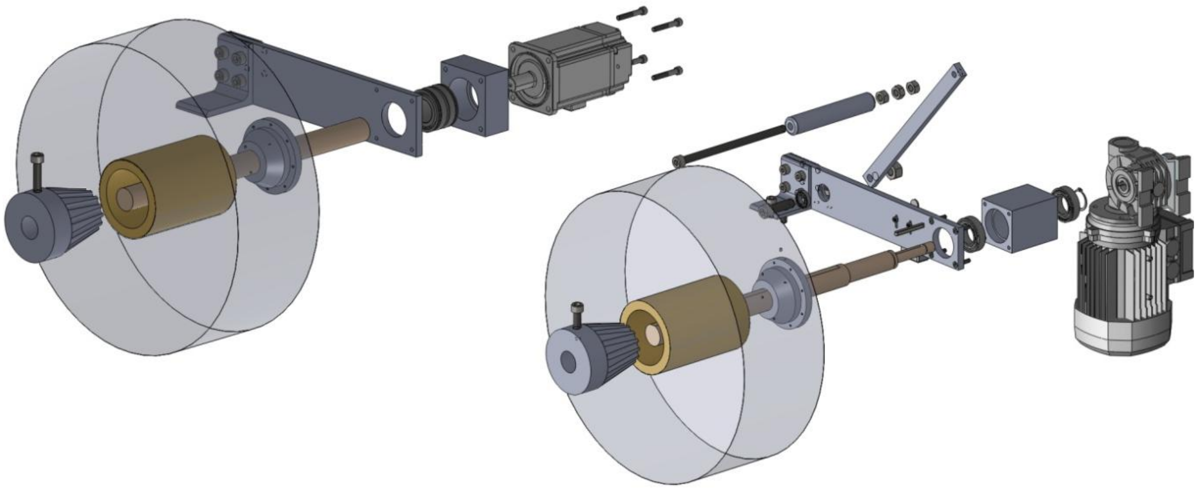


Fig 8.2. – Drafts for the strip unwinds with servomotor (left) and geared AC motor (right)

The remainder of this section discusses the design details of the AC motor variant, including the bearing design of the cantilevered shaft, the mounting mechanism of the reel and the design of the sensor feedback system.

8.3.1 Bearing design

The loads acting on the bearings will be mainly radial (the weight of the reel and the motor). However, when operators change the reel, they will hit the gripping cone with a hammer causing a load in axial direction. The bearings will have to take up this impact force as well, making deep groove ball bearings an appropriate choice. The force acting on the bearings can be calculated as follows (see figure 8.3):

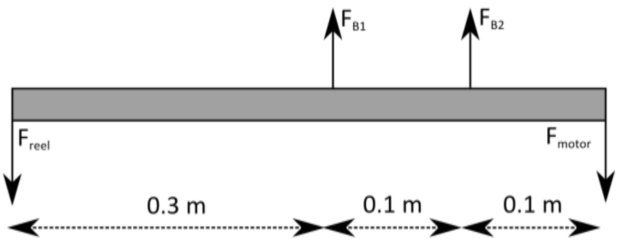


Fig 8.3 – Free body diagram of the shaft

$$\sum F_y^{\uparrow +} = F_{B1} + F_{B2} - F_{reel} - F_{motor} = 0$$
$$\sum M_{B_1}^{\circlearrowleft +} = F_{reel} \cdot 0.3 + F_{B2} \cdot 0.1 - F_M \cdot 0.2 = 0$$

The weight of the heaviest reel, including the weight of the mounting, is about 50 kg. The weight of the motor including mounting is 20 kg. Solving the equations for F_{B1} and F_{B2} yields the forces acting on the bearings:

$F_{B1} = 810\ N$
$F_{B2} = \ -110\ N$

The shaft will be running at relatively low rotational speeds ($< 60\ rpm$) and should have some protection against dust and small impacts from the sides. The 6005-ZZ deep groove ball bearing with metal shields on both sides satisfies all requirements and is therefore selected. A sectional view of the bearing housing with two 6005-ZZ bearings is shown in figure 8.4. The leftmost bearing is fixed between the stepped shaft and the bearing housing. The rightmost bearing is fixed between the bearing housing and a circlip. The gearbox of the AC motor is fixed between a step in the shaft and a circlip.

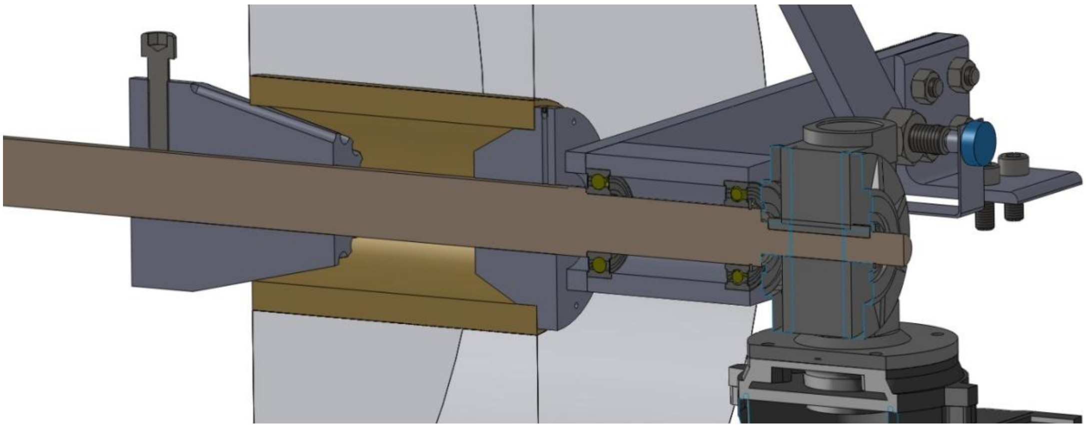


Fig. 8.4 – Sectional view of the bearing housing

8.3.2 Mounting of the reel

The mounting mechanism of the reel can be seen in the sectional view of fig. 8.4. Because the end of the machine will be pulling material from the reel, and the AC motor will create a moment in the opposite direction, the reel has to be stopped from slipping on the shaft. For this purpose two different mounting cones will be used: one fixed cone with sharp gripping pins to assure correct alignment in the machine (the right one in figure 8.5) and one removable cone with gripping slots (left in figure 8.5). The pins of the fixed cone will protrude into the paper core of the reel ensuring a tight grip.

8.3.3 Sensor feedback system

The sensor system will give feedback to the AC motor concerning the actual diameter of the reel. To provide a constant tension, the braking moment of the AC motor should increase linearly when the reel diameter decreases. Attached to the measuring arm is a rotational potentiometer (the blue component in figure 8.6), providing a different electrical resistance depending on the current angle. According to this signal, the variable speed drive of the AC motor will control the tension. Furthermore, an alarm will sound when the reel reaches a certain critical diameter, notifying machine operators to change the reel.

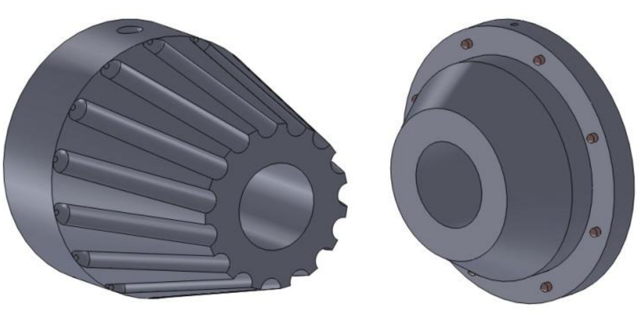


Fig. 8.5 – Mounting cones for the strip reels

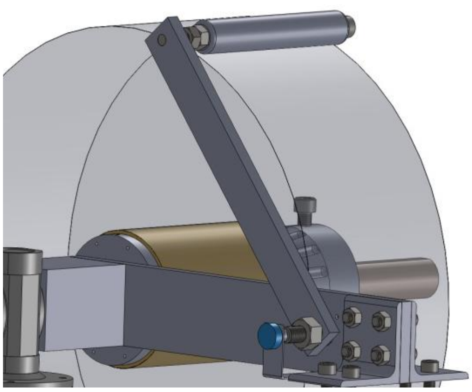


Fig. 8.6 – Sensor arm

8.4 DESIGN OF THE STRIP FOLD-IN

As can be seen in the overview picture (figure 6.1), the strip unwinds will be mounted on the sides of the unwind station. The strips will therefore be unwound under a 90° angle with the main reel. To guide the strip films to the correct location on the main film, an adjustable 'fold-in'-mechanism will be incorporated in the frame (see figure 8.7).

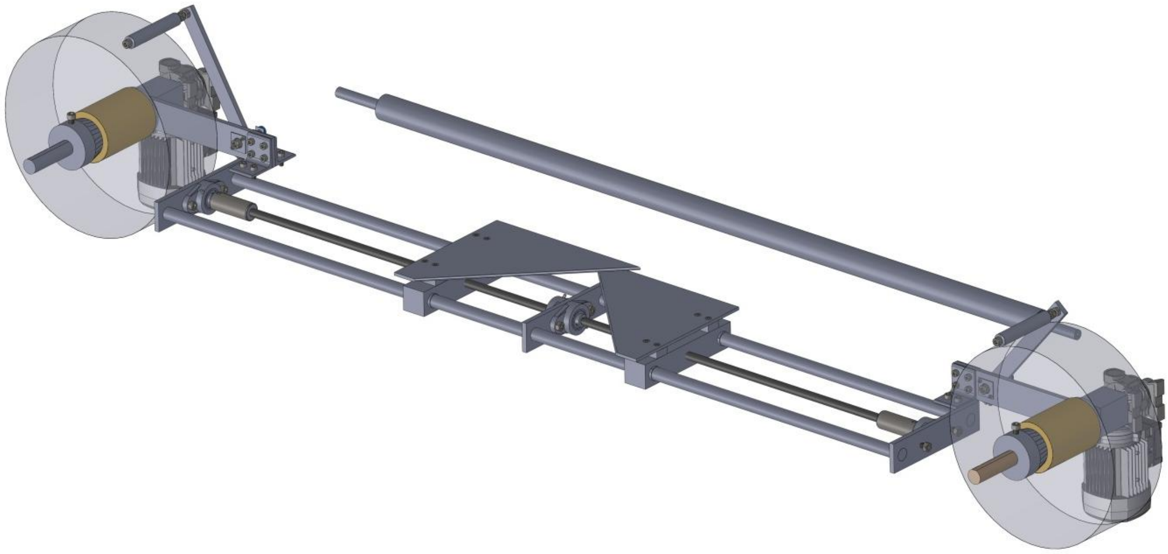


Fig. 8.7 – Overview of the total strips unwind system

The machine operators can easily adjust the location of the strips by moving the two fold-in triangles. The outer two crossbars are guiding rods, the middle one is a threaded bar to which a handle is attached. Turning the handle moves the fold-in triangle. The threaded bars are supported by self-aligning flange mounted bearings, ensuring alignment with the two guiding rods. The two fold-in triangles are positioned on a different height, making strip overlaps possible. A detailed view of the two fold-in triangles is shown in figure 8.8.

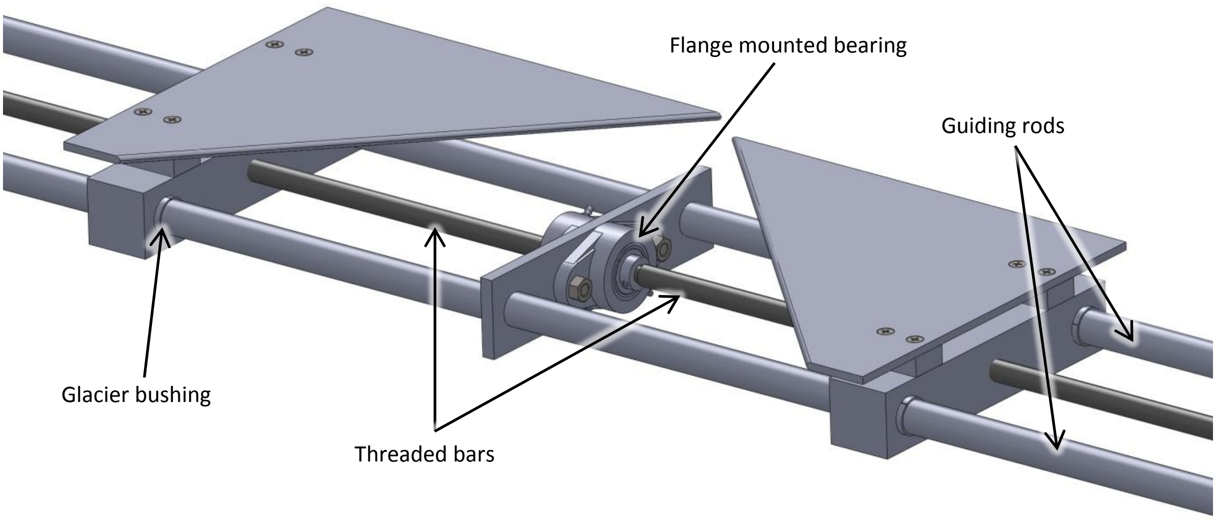


Fig. 8.8 – Detailed view of the two fold-in triangles

9 REDESIGN OF THE FOLDING STATION

As part of the redesign of C20, the folding mechanism will be reconsidered. First, the current folding mechanism will be analysed focussing on operational shortfalls, after which a redesigned folding station with integrated gusset folder will be presented.

9.1 THE CURRENT FOLDING MECHANISM

The current folding mechanism consists of 2 separate stations. At the first station the plastic film is folded in half using a so-called A-frame folder (figure 9.1), the second station creates a gusset into the folded side of the film. Both stations are mounted on separate frames which is a disadvantage when setting up the machine. Furthermore, the A-frame folder sometimes causes the film to tear (see figure 9.2), particularly when the machine has stopped and a bad seal has been produced.

Fig. 9.1 – A-frame folder

Fig 9.2 – Torn material on the A-frame folder

9.2 GEOMETRIC PROPERTIES

For a folding station to operate without tearing the film, all paths parallel to the travelling direction of the film should have the same length. Intuitively, the A-frame should be positioned at a $45°$ angle with the horizontal. Measurements on the existing A-frame however, show that the current angle is at about $37°$. To work out the ideal angle, the path lengths will be calculated as a function of x ($x = 0$ at the middle of the film, see figure 9.3).

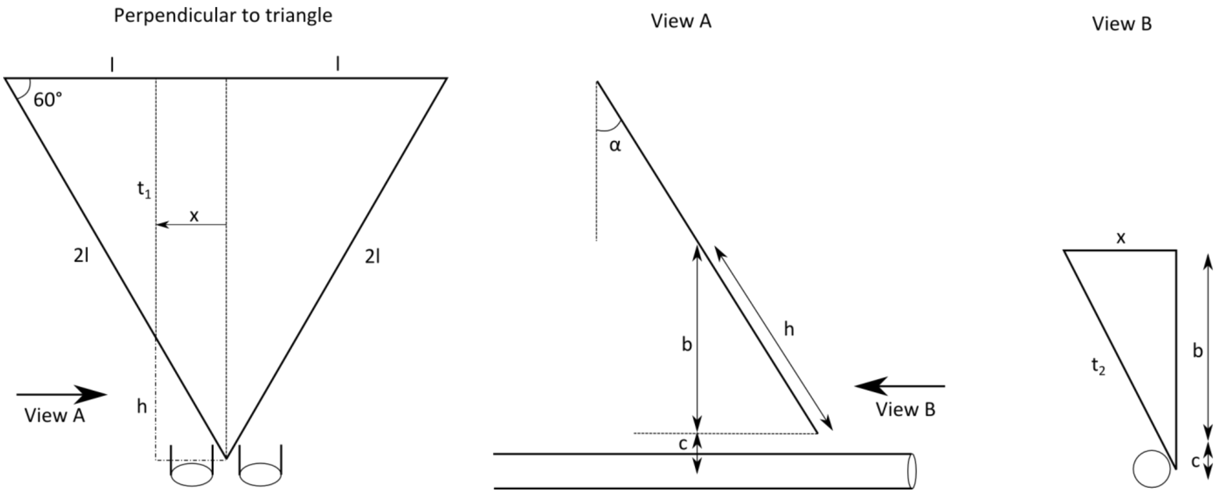


Fig. 9.3 – Geometric overview of A-frame folder

The angle α is the unknown angle to be calculated. The total path length of the film is divided into two sections, t_1 and t_2 (see figure 9.3). The length of the first section t_1 is in the plane perpendicular to the folding triangle and can be calculated as follows:
$t_1 = (l - x) \cdot \tan(60)$

The remaining part in this plane is length h:
$h = x \cdot \tan(60)$

Now length b can be calculated in the plane of view A:
$$\begin{aligned} b &= h \cdot \sin(180 - 90 - \alpha) \\ &= x \cdot \tan(60) \cdot \sin(180 - 90 - \alpha) \end{aligned}$$

Finally, the second section t_2 in the plane of view B can be calculated, as well as the total path length t_{total}:
$$t_2 = \sqrt{x^2 + (b + c)^2}$$
$$\begin{aligned} t_{total} &= t_1 + t_2 \\ &= (l - x) \cdot \tan(60) + \sqrt{x^2 + (b + c)^2} \end{aligned}$$

The total path length should be equal for all values of x. Figure 9.4 shows a plot of $t_{total}(x) - t_{total}(x = 0)$ for different angles of α. It can be seen that an optimal solution, where all path lengths are equal, cannot be found. The optimum angle α is found to be approximately 37.6°, at which the material at the outside shows less than 1% stretch (which is allowable). Small deviations from the optimal angle lead to high stretch rates, making the angle α to a critical design criterion.

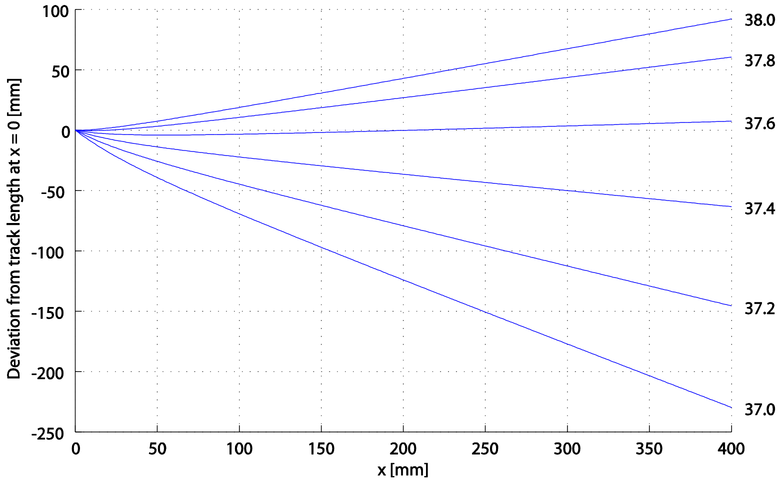


Fig. 9.4 – Plot of $t_{total}(x) - t_{total}(x = 0)$ for different angles α

9.3 Design specifications

The main design specifications of the folding station are:

- Both the A-frame folder and the gusset folder should be incorporated in one frame
- The folder should be able to create 90 mm, 110 mm and 140 mm gussets
- Easy changeover between different gusset sizes
- The folder should be able to fold the film without creating a gusset
- The folder should have a ‘safety mechanism’ to avoid tearing the film

9.4 FINAL DESIGN

The CAD-model of the final design is shown in figures 9.5 and 9.6. Detailed drawings and an exploded view can be found in the appendix. The station consists of a main folding triangle, which is an equilateral triangle with sides of $1600\ mm$. The lower tip of the triangle is 'cut off' to create the necessary space for the gusset folder. Exchangeable triangular plates can be bolted on to the main folding triangle to adjust it for folding 90, 110 or $140\ mm$ gussets.

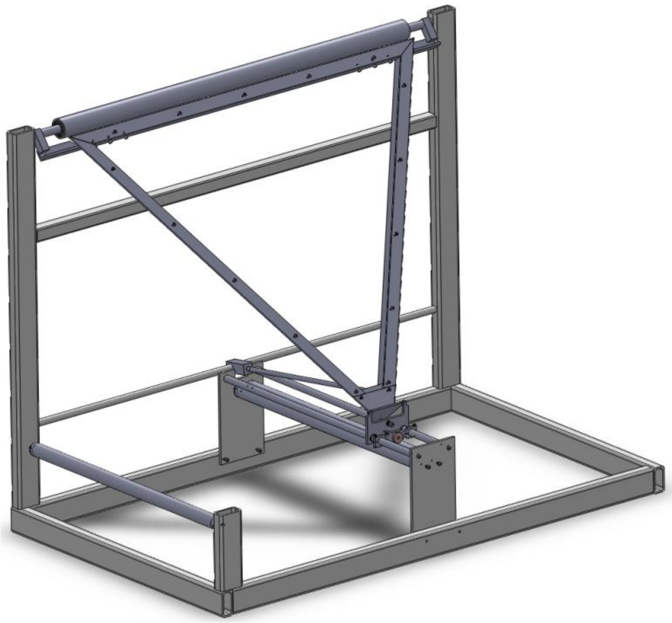


Fig. 9.5 – Final design of the folding station

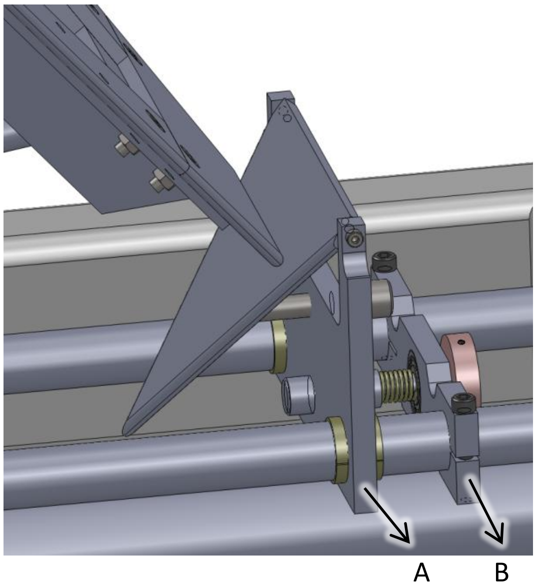


Fig. 9.6 – Detailed view of the gusset folder

The gusset folder (see figure 9.6) slides horizontally over two guiding bars. When the gusset size is changed, the machine operator has to turn the red handle in order to move the gusset folder into position. The spring loaded threaded bar is long enough to be adjusted between the most common gusset sizes ($90\ mm$ and $110\ mm$), so part B stays fixed and part A moves. While in operation, part A can move with respect to part B to avoid tearing the film. Glacier bushings are used for smooth guiding and the spring provides the necessary counterforce (the yellow parts in figure 9.6). Both the angles of the main triangle and of the small gusset triangle can be adjusted, as the angle has to be set very precise to avoid too large stretch rates in the film.

9.5 DESIGN FOR MANUFACTURING

The main folding triangle has to be a perfect equilateral triangle with smooth edges to prevent tearing the film. Because of the limited possibilities in Safepak's workshop, a detailed step by step manufacturing plan was created.

The step by step plan consists of 6 A3-pages with detailed, chronologically ordered manufacturing steps. An example of one of these pages is shown in figure 9.7, some of the pages can be found in the appendix as well.

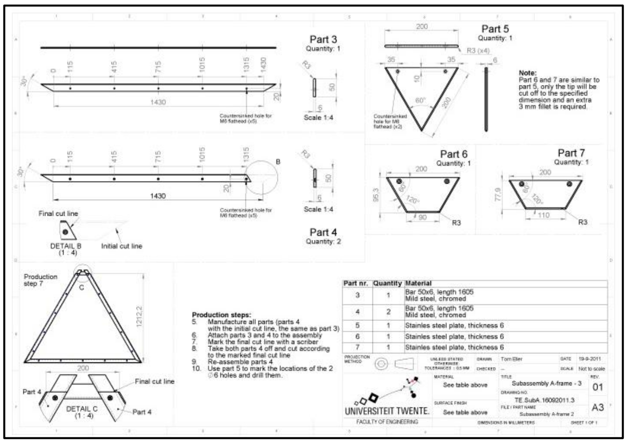


Fig. 9.7 – One of the A3-pages of the detailed production plan

10 SYSTEMATIC SET UP PROCEDURE

In order to reduce set up times and waste and to enhance product quality, a systematic set up procedure for the various punches and the handle cut out of C20 will be presented. Currently, operators don't have a systematic method for setting up the machine. The punches, the handle cut out and the 'eye' are randomly moved, hoping correctly sized bags will be produced. First, a short overview of the relevant machine parts will be given, after which the systematic set up procedure will be presented.

10.1 CURRENT SITUATION

There are in total 10 machine components to be relocated when there is a changeover on C20. These 10 components (8 punches, the handle cut out and the eye) are fixed on two different carriages: the flying knife carriage en the punch carriage (see figure 10.1). When, for example, one of the punches is out of position, the machine setters try to resolve the problem by moving the entire punch carriage. This changes the position of all the punches, and thus bad quality products will be produced. The same yields for the flying knife handle cut out and the position of the camera eye. The eye determines where the bags are positioned in the machine, when its position is changed, all the punches should be adjusted as well. Machine setters are not able to come up with a quick and reliable set up procedure themselves, so there are very high waste rates during product changeovers.

Fig. 10.1 – Flying knife carriage and punch carriage on machine C20

10.2 SYSTEMATIC SET UP

The systematic set up of C20 will be implemented with the help of set up sheets (see figure 10.2 and appendix B). For every different bag produced on the machine, a different set up sheet will be made. The top section of the set up sheet contains the product size specifications: outer dimensions of the bags, punch locations and tolerances. On the bottom part of the sheet the machine set up parameters are listed. These consist of the locations of the two carriages and of the punches within these carriages, the location of the eye and the width of the handle cut out.

To make sure that all machine setters use the same reference points for their measurements, metal rulers will be bolted on to the holding bars of the punches, the flying knife handle cut out and the holding bar of the camera eye (see figure 10.3 for an example). The setters were trained to use this systematic set up procedure and should be able to get it right the first time in the future.

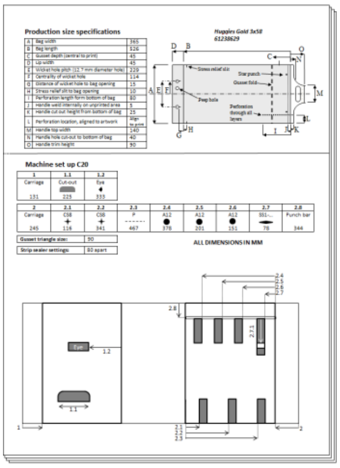


Fig. 10.2 – Systematic set up sheets

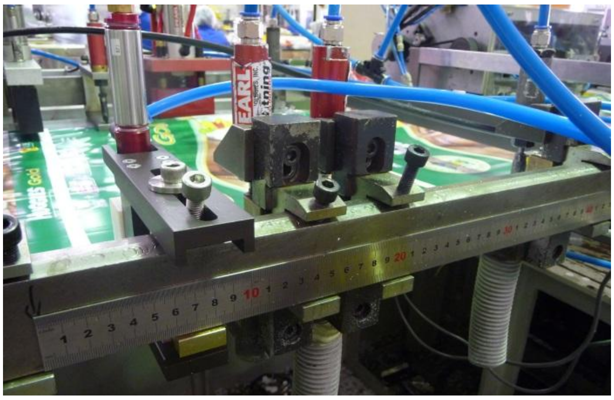


Fig. 10.3 – Fixed metal rulers to improve set up accuracy

11 OTHER PROJECTS ON MACHINE C20

This chapter gives a brief overview of two other projects on machine C20. First, the redesign of the flying knife attachment will be discussed, after which the pneumatic adjustments on the nip rollers will be illuminated.

11.1 REDESIGN OF THE FLYING KNIFE ATTACHMENT

The flying knife attachment on machine C20 is used to make the handle cut outs. In its initial design, two guiding rods and two threaded bars were used to adjust the size of the cut out. This highly overconstrained construction caused the necessary problems: when operators tried to adjust the attachment, the carriage got jammed and the guiding rods were scratched. In the new design, only two threaded bars are used, connected with a timing belt (the orange parts in figure 11.1). Furthermore, the red part is a newly designed guidance to support the film coming through.

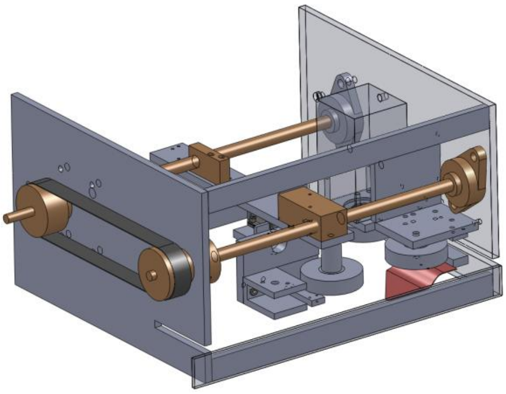


Fig. 11.1 – Redesigned flying knife attachment

11.2 PNEUMATIC ADJUSTMENTS ON NIP ROLLERS

The nip rollers are used to pull the film through the machine. It was found that the machine didn't pull the same length of material for every bag, because the pressure of the nip rollers was too low (slippage occurred). For this reason, larger pneumatic pistons were selected and implemented.

12 COST ESTIMATION

In this chapter an estimation of the total re-engineering costs of machine C20 will be presented. The total costs consist of, among others, workshop hours, production of outsourced parts and pneumatic components. Some of the prices are estimates, such as workshop hours and materials, others are prices as quoted by local suppliers or as found in supplier catalogues.

The costs per machine part are listed in table 12.1. It can be seen that both unwind systems are by far the most expensive parts. The workshop hours and materials for the strip reel unwinds are the highest debit item, because the two cantilevered reel mountings require quite some machining. Some of the costs can be saved by using available items from unused machines, such as motor gearbox combinations and pneumatic systems.

Unwind system main reel	
2 x Safety chuck	R 9.800
AC motor (0,75 kW)	R 1.400
Variable speed drive for 0,75 kW motor	R 2.800
Gearbox	R 1.200
2 x Ø32 piston + pneumatic system	R 15.300
Workshop hours and materials	R 28.000
Electronics and control systems (incl. programming)	R 12.000
	R 70.500
Unwind system strip reels	
2 x AC motor (0,75 kW)	R 2.800
2 x Variable speed drive for 0,75 kW motor	R 5.600
2 x Gearbox	R 2.400
Outsourced parts (folding triangles)	R 2.000
Workshop hours and materials	R 42.000
Electronics and control systems (incl. programming)	R 8.000
	R 62.800
Folding station	
Outsourced parts (all folding surfaces)	R 17.000
Workshop hours and materials	R 8.000
	R 25.000
Miscellaneous	
Parts for flying knife redesign	R 1.800
Pneumatic pistons for nip rollers	R 2.100
	R 3.900
Total	**R 162.200**

Table 12.1 - Cost overview

The total re-engineering costs are R 162.200 (with the current exchange rate about € 15.200). As there was no information about the exact downtime and waste of rates of machine 20 specifically, it is hard to quantify the return on investment of the re-engineered machine.

13 Side project: adjustable punch clamp

This section contains a brief overview of the design considerations made for the design of an adjustable punch clamp. Main design criterion is the fatigue strength of the clamp, as the punch will be operated 24/7 with a punch frequency of 300 punches per minute.

13.1 Design specifications

The design specifications as required by Safepak can be summarized as follows:

- The clamp should fit the standard Pearl Technologies, Inc. pistons and the standard Safepak clamping mechanism
- The clamp should be adjustable perpendicular to the film with a range of $50\ mm$ and be able to punch $70\ mm$ form the edge of the film
- The clamp should last for at least 10 years, making 300 punches per minute 24/7 (a total of $1.5 \cdot 10^9$ punches)
- Make use of standard/available aluminium sections

13.2 Final design

The only force acting on the clamp is the force of the spring, which was measured to be about $10\ N$. Due to the cyclic loading of the clamp, the maximum allowable stress will be lower than the ultimate tensile stress of the selected aluminium alloy. Of the wrought aluminium alloys, the $7xxx$ series has the best properties concerning fatigue strength, so this alloy is the recommended material to use. When not available, $2xxx$, $5xxx$ or $6xxx$ series are the second best choice.

Looking at S-N curves for different aluminium alloys, the fatigue limit when doing 10^8 load cycles is less than 50% of the yield stress of the material. The S-N curves for alloys 2024 & 7075 show that when doing $1.5 \cdot 10^9$ cycles, the maximum allowable stress in the material is less than $10\ MPa$. With some basic calculations and a finite element model as verification (see figure 13.3), the punch is designed such that the stresses do not exceed $4\ MPa$. The final design and an actual manufactured clamp can be seen in figures 13.1 and 13.2 respectively. The total price per clamp, when outsourcing to a local workshop, is R 947 (with $6xxx$ series aluminium).

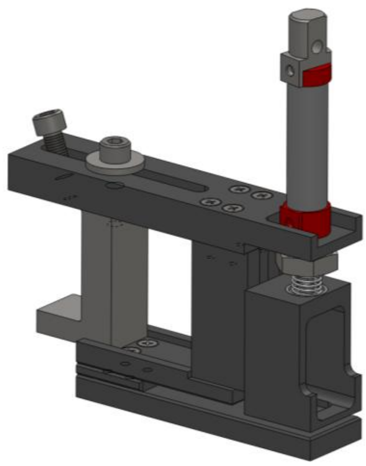


Fig. 13.1 – Final design of the adjustable clamp

Fig. 13.2 – Exploded view

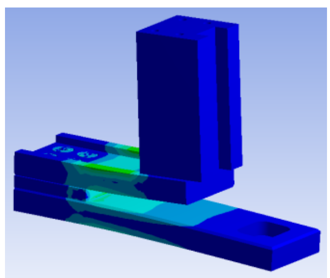


Fig. 13.3 – Ansys model of the clamp (high stresses are green)

14 CONCLUSION AND RECOMMENDATIONS

In this section the conclusions and recommendations for future work can be found.

14.1 CONCLUSION

The main reason for re-engineering machine C20 was reducing downtime and waste rates. During the evaluation of the current system, various operational shortfalls were found and improved in the new design. For the main reel, a new tensioning system and line guide system were implemented. Safety chucks will be used to enable machine operators to quickly change the reel. The strip reel unwinds are now incorporated into the same frame as the main reel unwind, preventing alignment problems in the rest of the machine. The tensioning system for the strip reels will make sure that both the main film and the strip films have the same tension. The folding frame has been adjusted to incorporate the gusset folder and a systematic set up plan has been created to assist machine operators at job changeovers.

Of all these changes, the new systematic set up plan might be the one with the most impact. During machine set up, operators wasted hundreds of meters of high quality, printed plastic film. After the first test with the new set up plan, only 3 meters of material was wasted, which is a promising result.

The main benefits for machine C20 can be summarised as follows:

- Increased efficiency
    - Shorter set up and changeover times
    - Possibility to speed up machine from 30 to 60 bags a second
    - Less downtime thanks to more robust design
- Better product quality
    - Better seal quality thanks to tensioning systems and constant speed at unwind station
    - Better sized products thanks to pneumatic adjustments on nip rollers and systematic set up plan
- Less waste
    - Systematic set up plan to reduce waste at machine set up
    - Less rejected product batches thanks to better product quality

14.2 RECOMMENDATIONS

Unfortunately, not all machine parts were available before the publishing of this report. However, all the engineering calculations and technical drawings are available at the company workshop, so it would be wise to implement the changes as soon as possible.

Furthermore, out of cost considerations, an available shaft with cone grippers will be used to support the main reel. To further shorten changeover times, an air shaft can be used. The same yields for the strip reels: a cantilevered latching roller chuck, for example from the supplier “Double E USA”, could further decrease changeover times.

Finally, operators should be trained on a regular basis to use the systematic set up plan.

15 REFERENCES

The following (supplier-)websites were consulted in the period 29-08-2011 to 30-11-2011:

Arvind Rubber (industrial rollers, safety chucks)	*www.arvindrubber.com*
Bearing distributors (bearings and drives)	*www.italbearings.co.za*
Delta electronics (motors, drives, sensors, alarms)	*www.delta.com.tw*
Double E company (industrial rollers)	*www.doubleeusa.com*
Festo (pneumatics)	*www.festo.com*
FLT bearings (bearings)	*www.fltbearings.co.uk*
Hudson sharp (plastic bag making machinery)	*www.hudsonsharp.com*
IPTCI (cad models of flange mounted bearings)	*www.iptci.thomasnet.com*
Italcuscinetti (flange mounted bearings)	*www.italcuscinetti.it*
Niika (safety chucks)	*www.airtek-niika.com*
Safepak (flexible packaging)	*www.flexiblepackaging.co.za*
SKF (bearings)	*www.skf.com*
Stone stamcor (safety chucks)	*www.stonestamcor.co.za*
Structural drafting (standard steel profiles)	*www.structural-drafting-net-expert.com*

The PROPAK Cape 2011 exhibition was visited on the 25th and 26th of October in the Cape Town International Convention Centre. Advice and insight on relevant machinery was gained by visiting stands of South African and international packaging companies. Website: *www.propakcape.co.za.*

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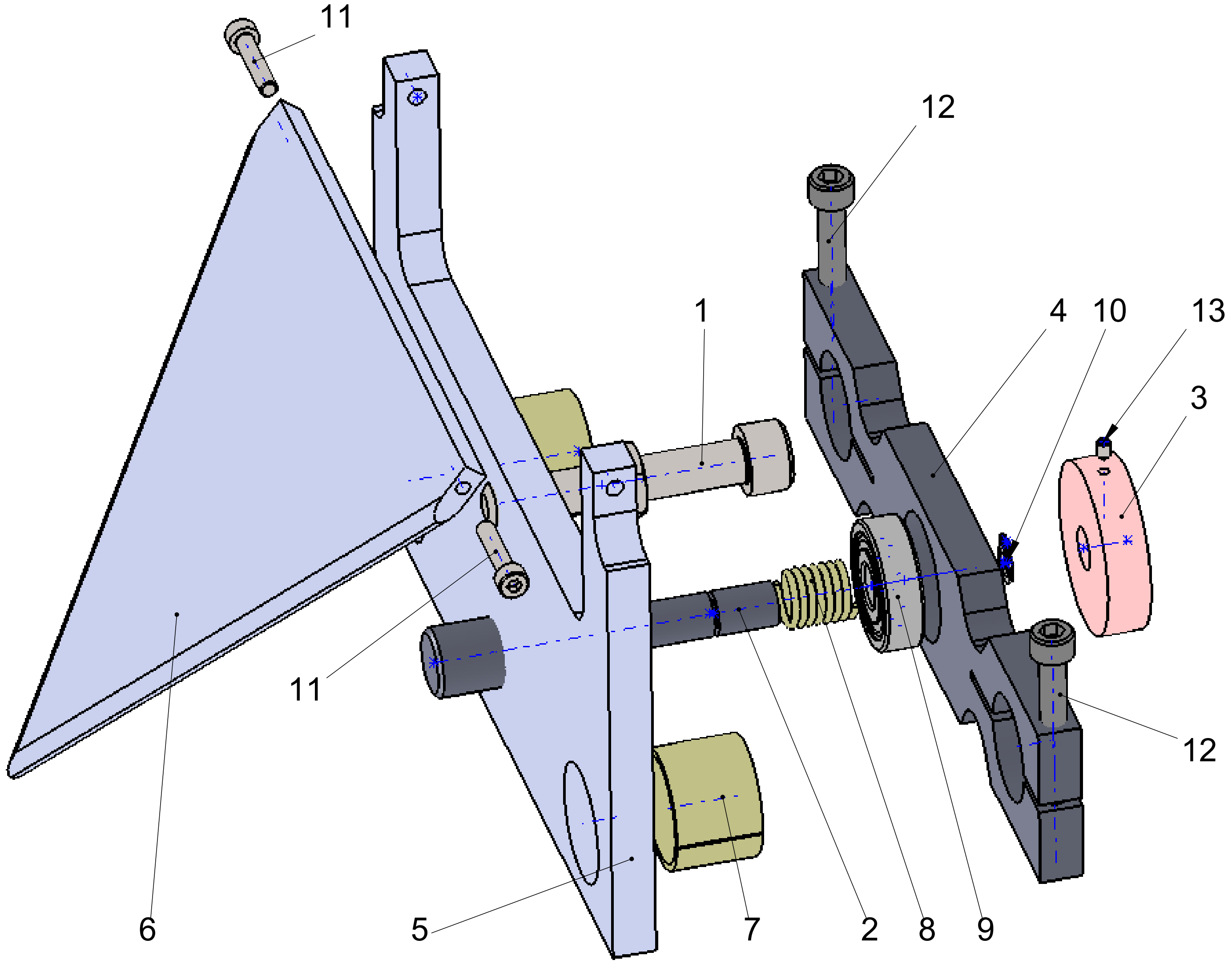
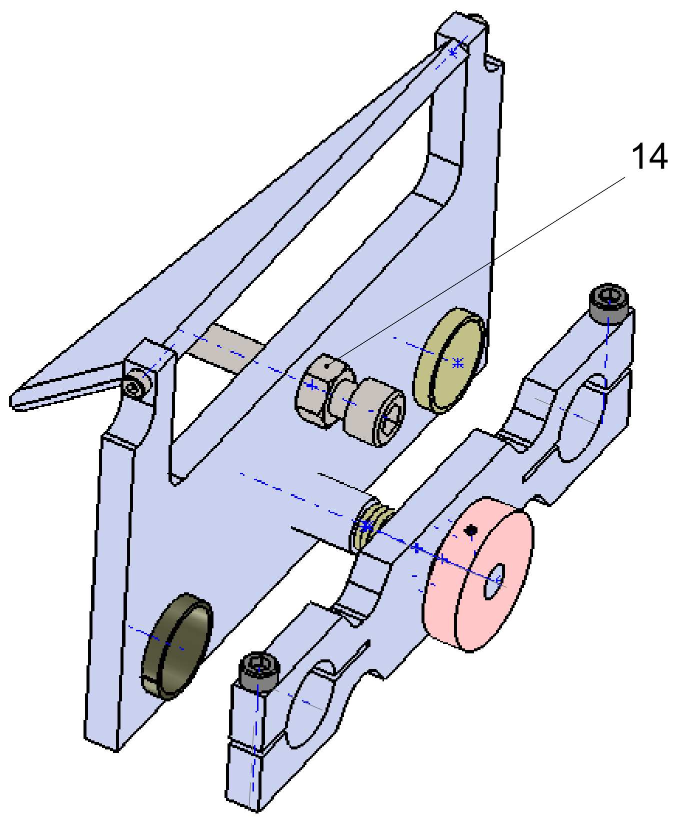
APPENDIX A – TECHNICAL DRAWINGS

On the next pages a few of the many technical drawings made during the internship can be found. Not all drawings are included, because they were merely made for manufacturing purposes. The first two A3 drawings are from the gusset folder with spring loaded safety mechanism. The other two drawings are part of the detailed, step by step manufacturing plan for the equilateral triangle of the A-frame folder, as described in chapter 9.





Nr.	Part name	Description	QTY
1	TE.SubGusset.15092011.2.Part 1	See detailed drawings	1
2	TE.SubGusset.15092011.2.Part 2	See detailed drawings	1
3	TE.SubGusset.15092011.2.Part 3	See detailed drawings	1
4	TE.SubGusset.15092011.2.Part 4	See detailed drawings	1
5	TE.SubGusset.15092011.2.Part 5	See detailed drawings	1
6	TE.SubGusset.15092011.2.Part 6	See detailed drawings	1
7	Glacier bushing	∅25 inside, ∅28 outside, length > 20 mm	2
8	Spring	Compression spring, length 25, ∅10 inside	1
9	Bearing	SNR 6200ZZJ30 FM2	1
10	Circlip	Circlip for ∅10 shaft	1
11	M4 bolt	M4x0.7x20	2
12	M6 bolt	M6x1.0x40	2
13	M3 grubscrew	M3x0.5	1
14	M10 locknut	M10x1.0	1

PROJECTION METHOD

UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM

DRAWN: Tom Eller | DATE: 15-9-2011

CHECKED: Grant Thorburn | SCALE: Not to scale

MATERIAL

SURFACE FINISH

TITLE: Subassembly Gutter - overview

REV. 02

DRAWING NO. TE.SubGusset.15092011.1

A3

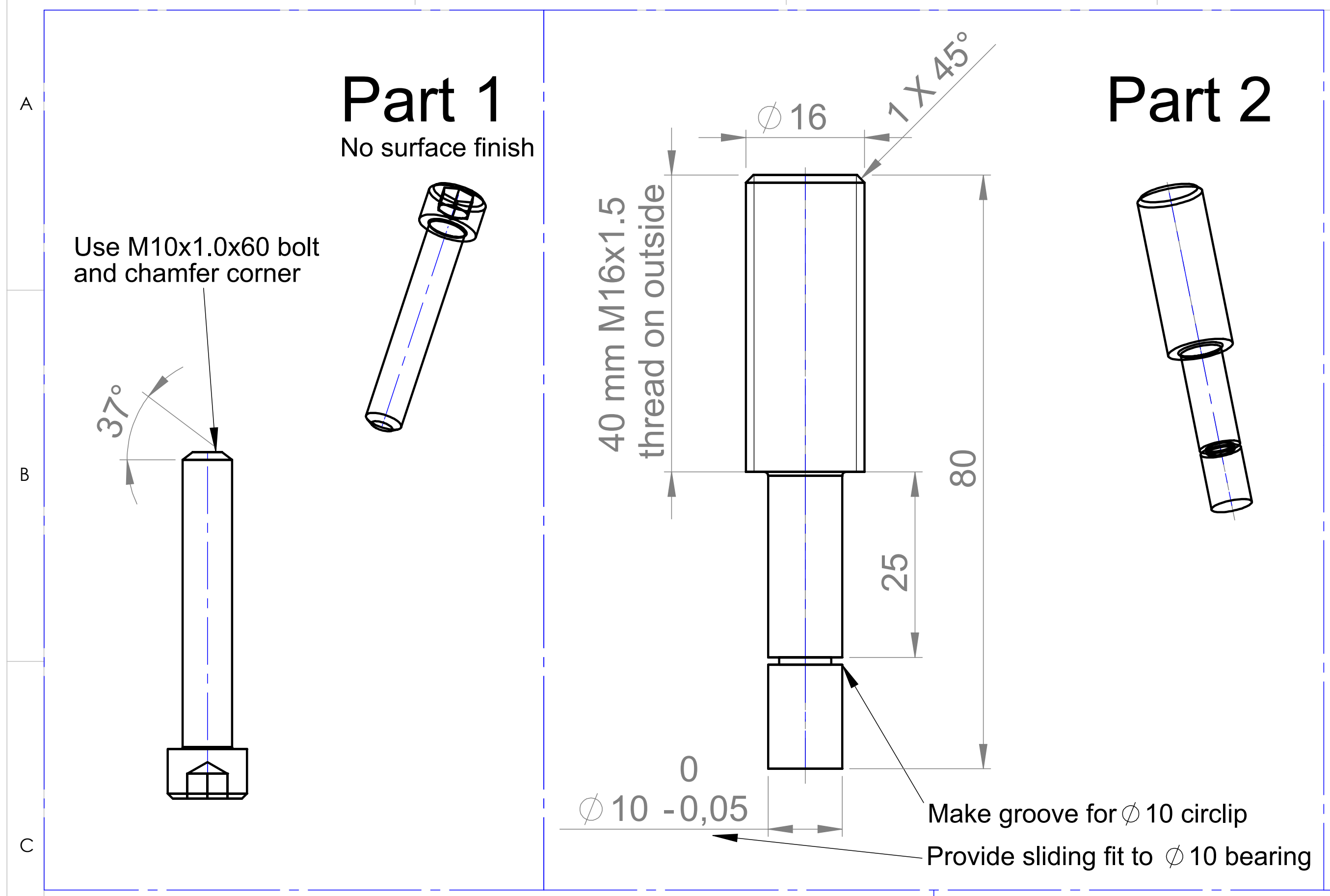
FILE / PART NAME: Subassembly Gutter - overview

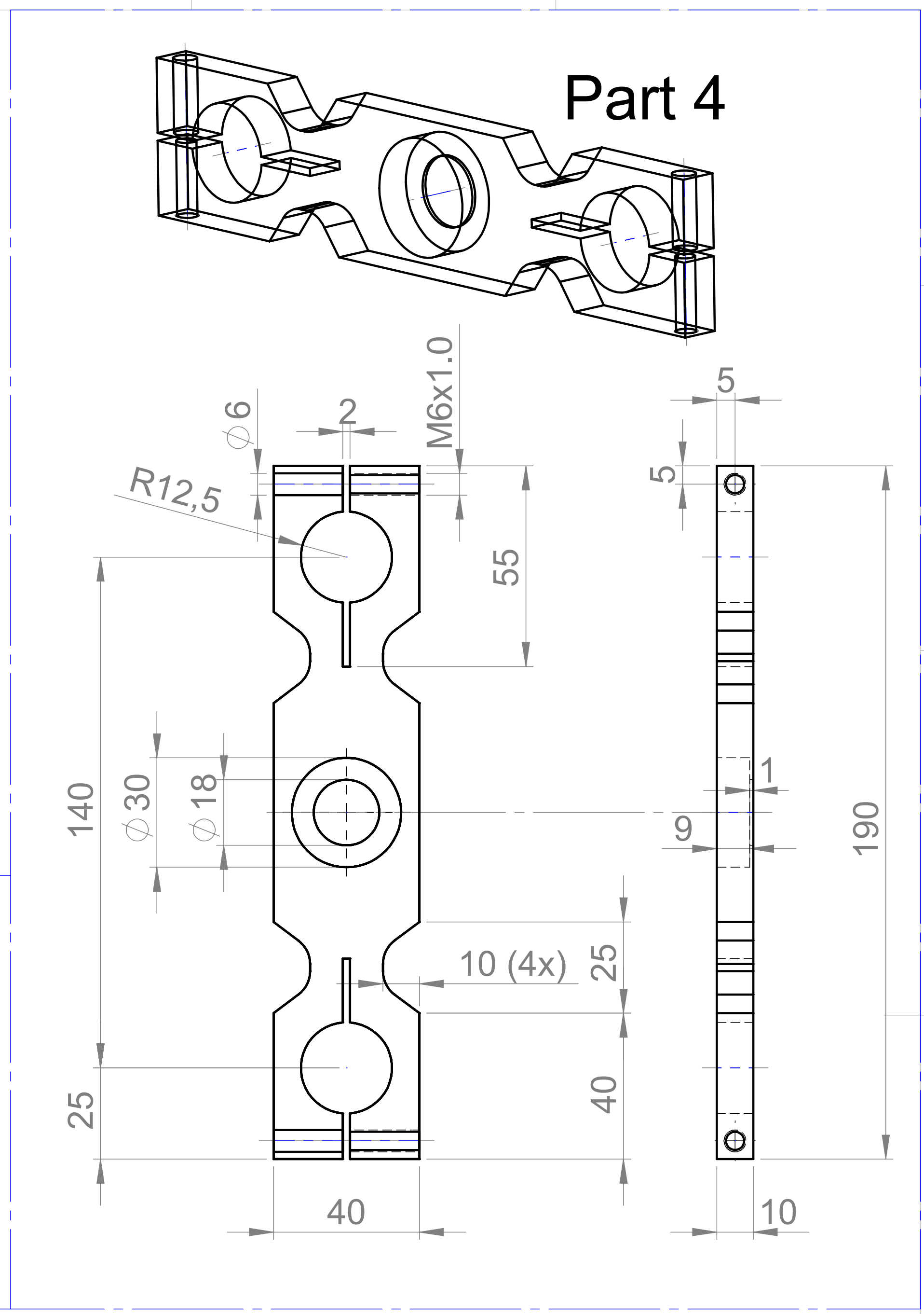
UNIVERSITEIT TWENTE.

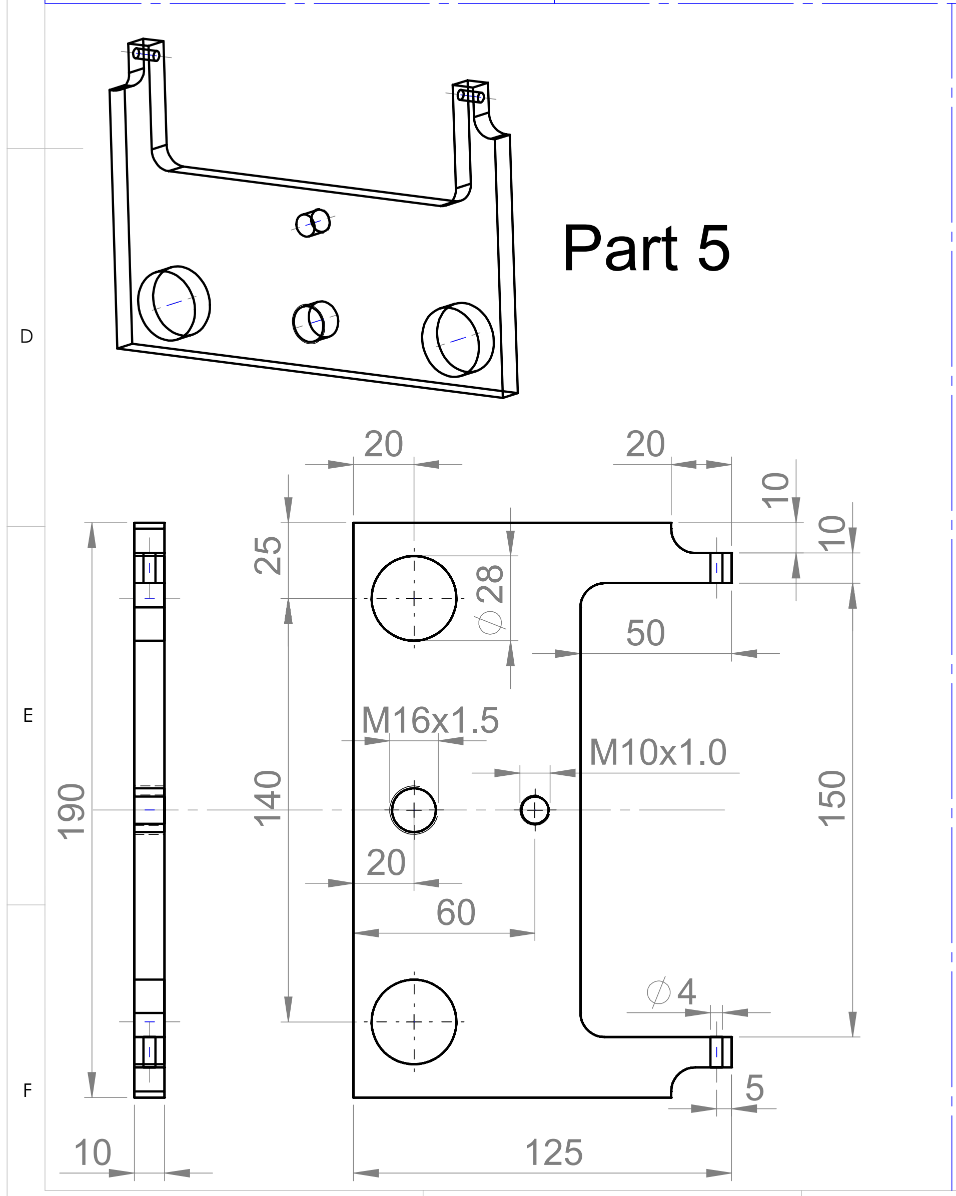
FACULTY OF ENGINEERING

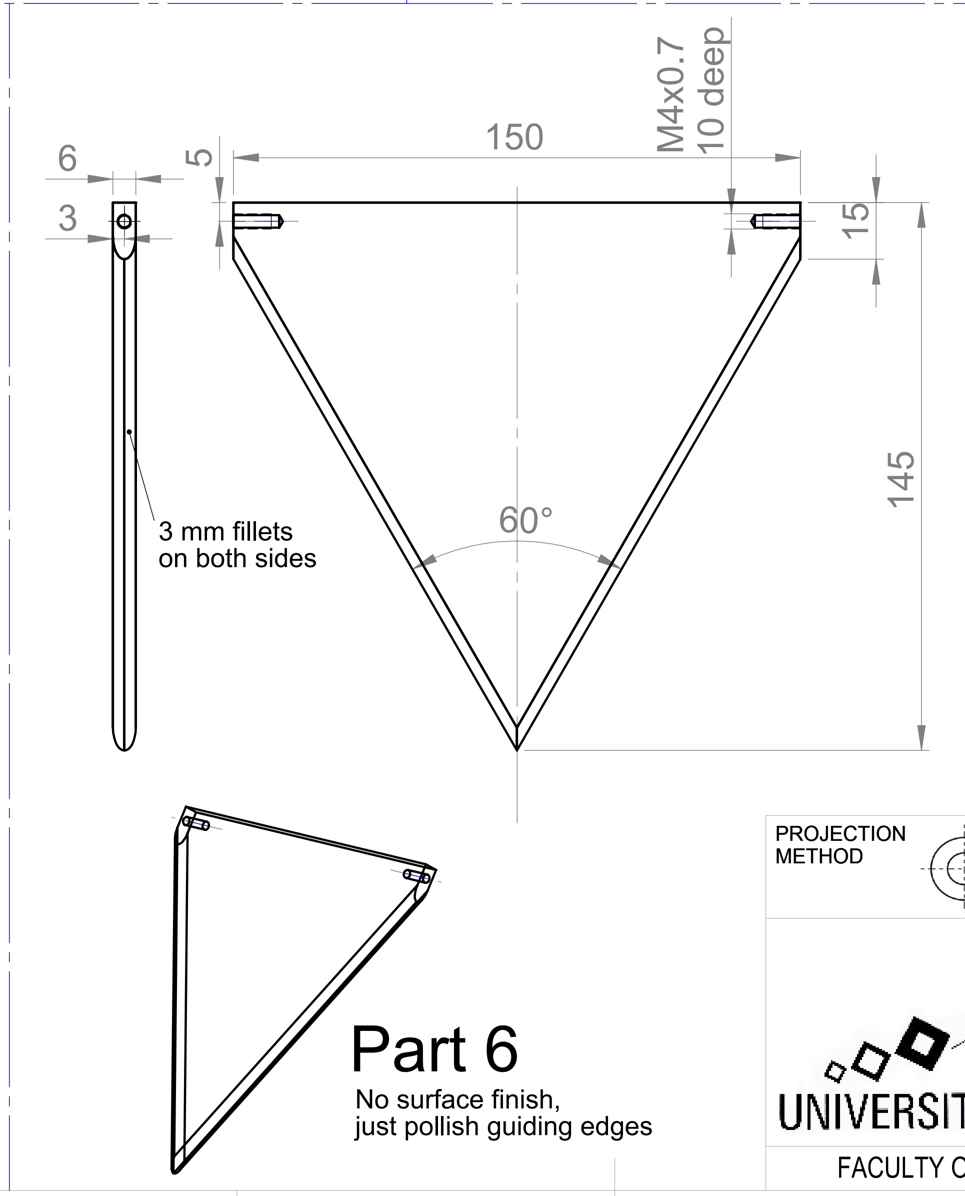
DIMENSIONS IN MILLIMETERS

SHEET 1 OF 1









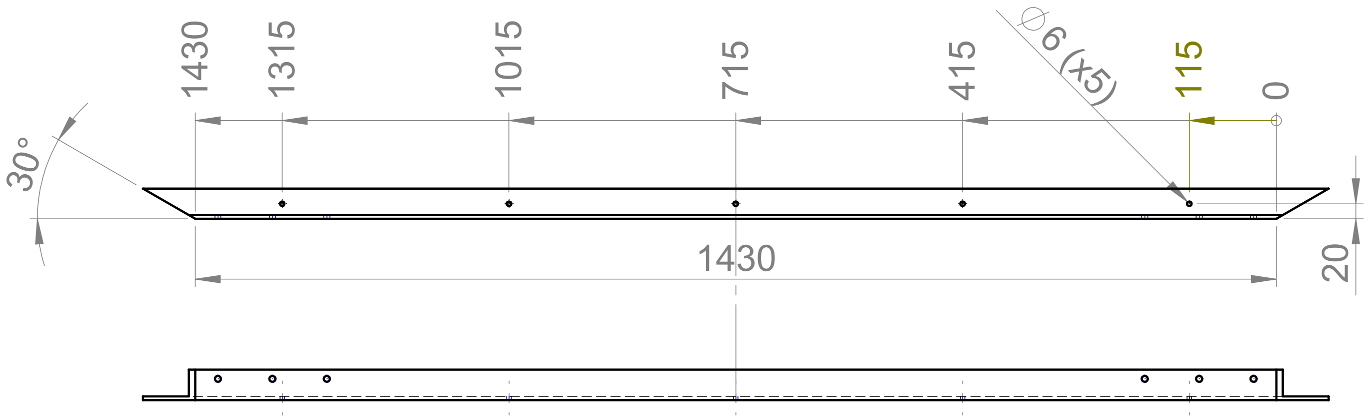
Part nr.	Material
1	M10x1.0x60 bolt
2	⌀16 shaft, bright mild steel
3	⌀40 shaft, bright mild steel
4	40x10 bar, bright mild steel
5	190x125 plate, thickness 10, bright mild steel
6	150x145 plate, thickness 6, stainless steel

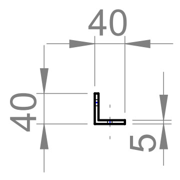
PROJECTION METHOD	UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Tom Eller	DATE	15-9-2011
		CHECKED	Grant Thorburn	SCALE	Not to scale

UNIVERSITEIT TWENTE.
FACULTY OF ENGINEERING

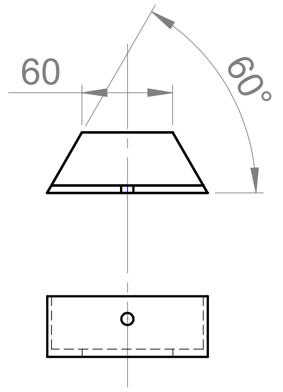
MATERIAL: See table above	TITLE: Subassembly Gutter	REV. 02
	DRAWING NO.: TE.SubGusset.15092011.2	
SURFACE FINISH: Electroplate galvanized, unless otherwise stated	FILE / PART NAME: Subassembly Gutter	A3
DIMENSIONS IN MILLIMETERS		SHEET 1 OF 1

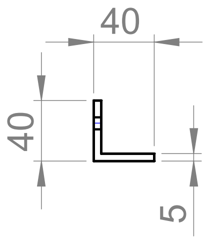
Part 1
Quantity: 3



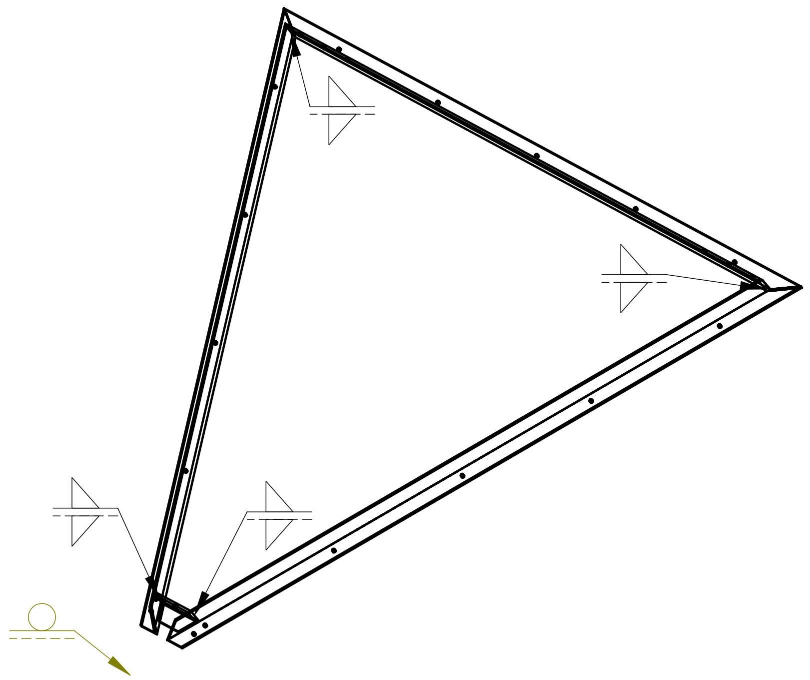


Part 2
Quantity: 1

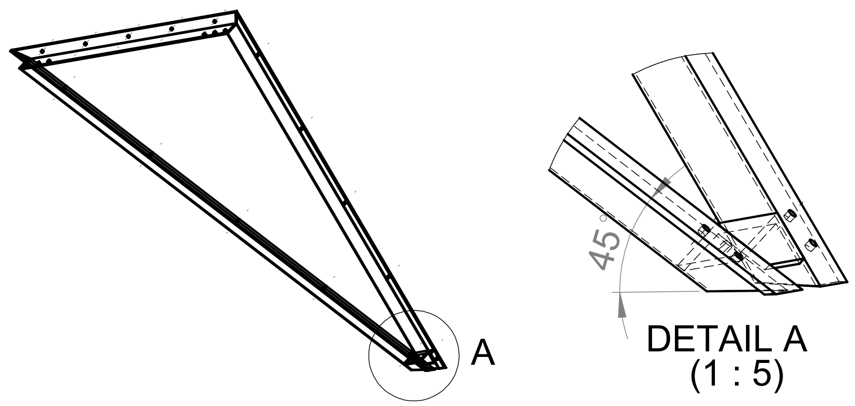




Production steps 1 and 2



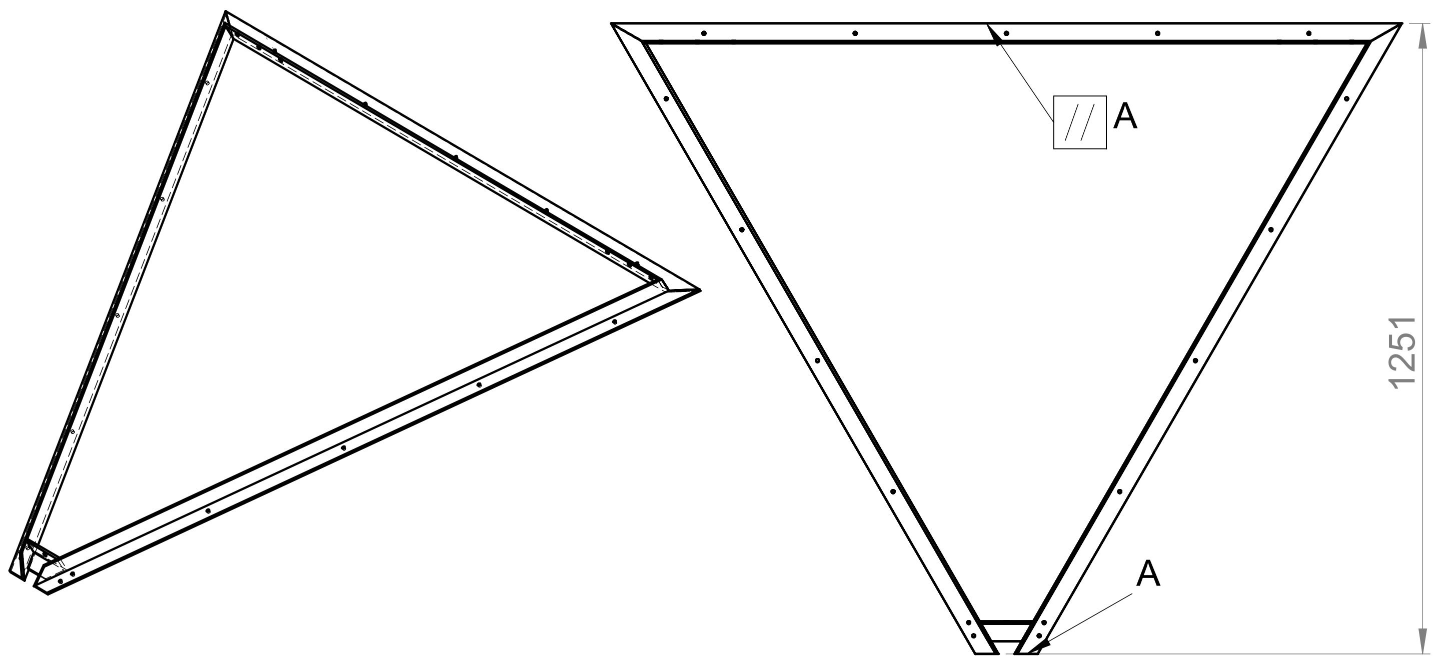
Production step 4



Production steps:

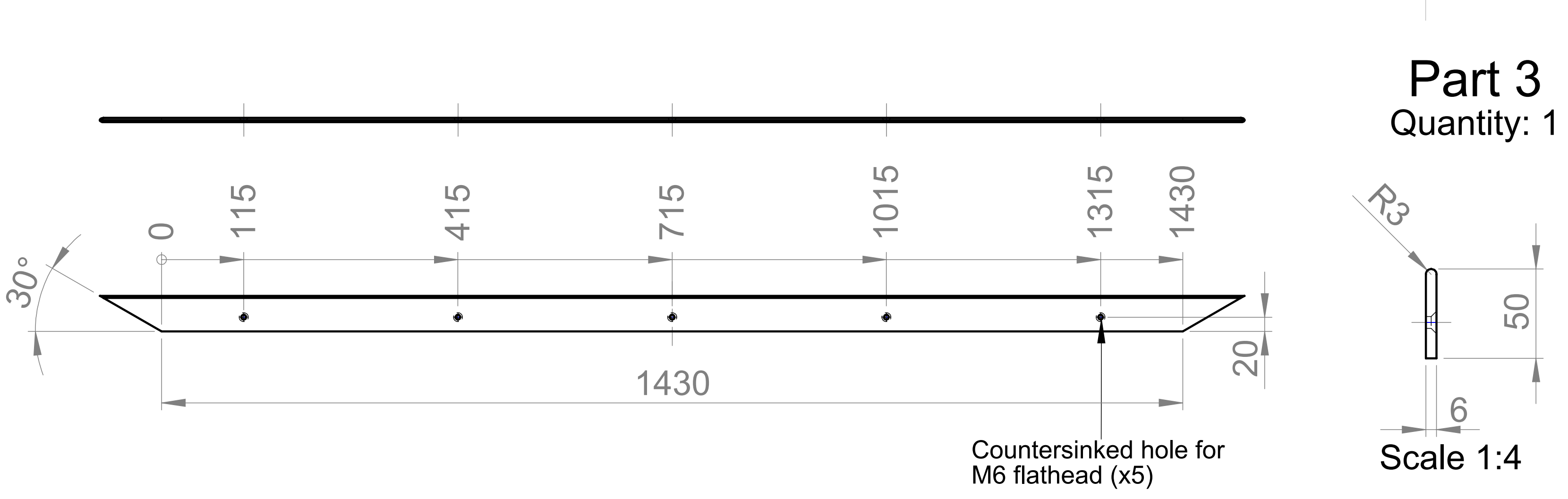
1. Weld parts 1 together to form an equilateral triangle (all angles 60°)
2. Weld part 2 to the assembly
3. Cut off the tip of the triangle parallel to the upper L-bar
4. Cut off the tip under a 45° angle

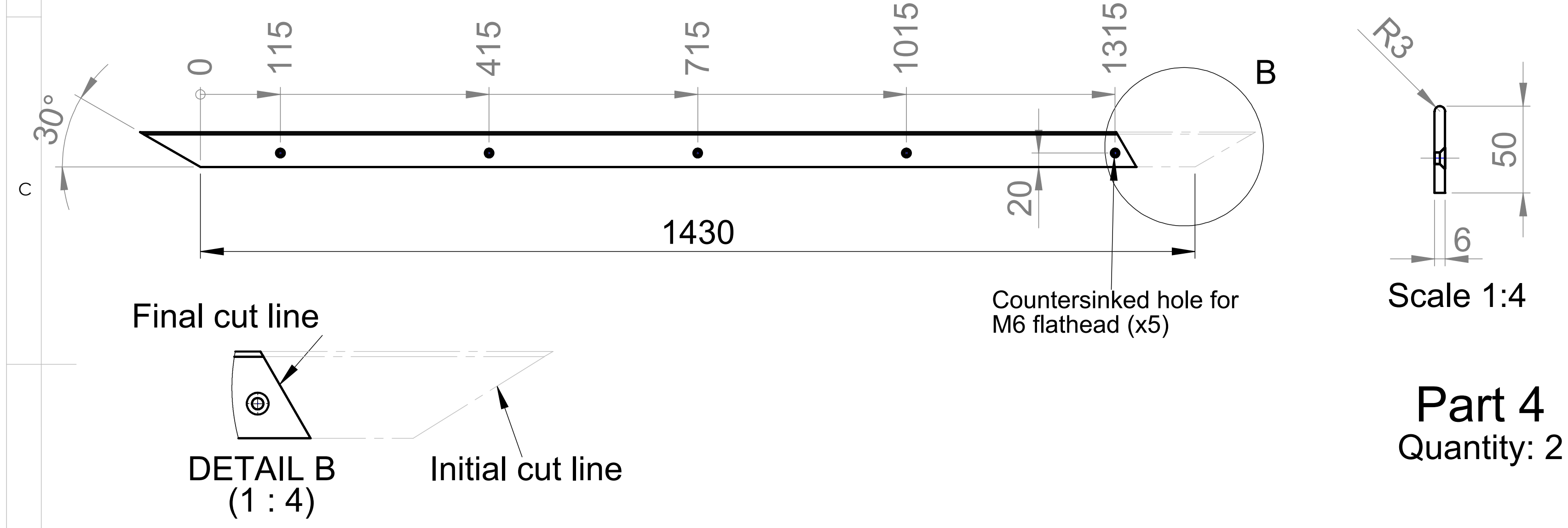
Production step 3

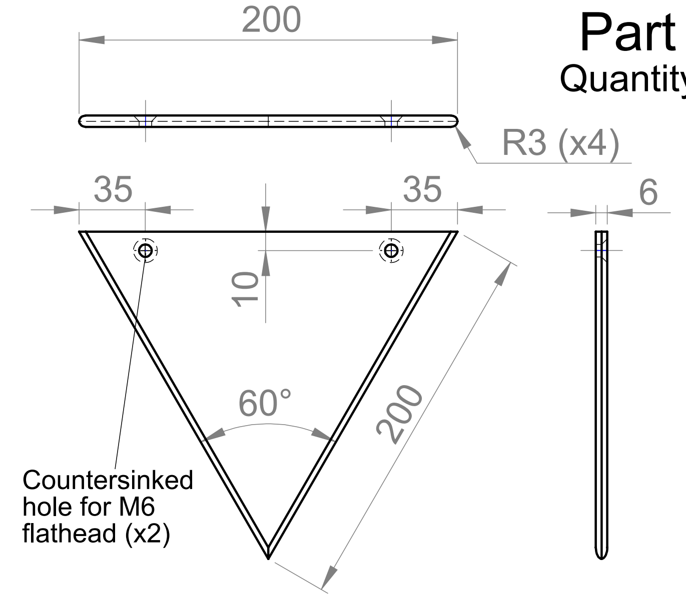


Part nr.	Quantity	Material
1	3	L-bar 40x40x5, length 1570 Bright mild steel
2	1	L-bar 40x40x5, length 110 Bright mild steel

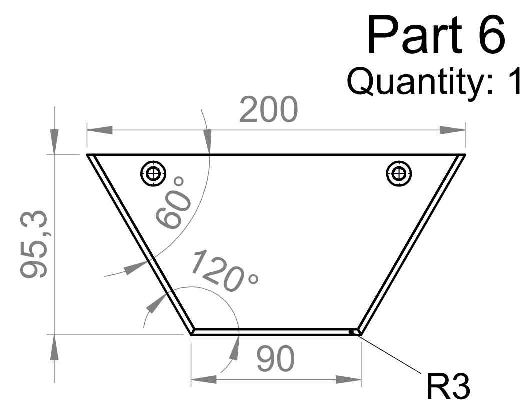
PROJECTION METHOD	UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Tom Eller	DATE	16-9-2011
		CHECKED	--	SCALE	Not to scale
UNIVERSITEIT TWENTE.	MATERIAL: Bright mild steel	TITLE: Subassembly A-frame - 2		REV.	01
	SURFACE FINISH: Electroplate galvanized	DRAWING NO.: TE.SubA.16092011.2			A3
		FILE / PART NAME: Subassembly A-frame			
FACULTY OF ENGINEERING	DIMENSIONS IN MILLIMETERS			SHEET 1 OF 1	

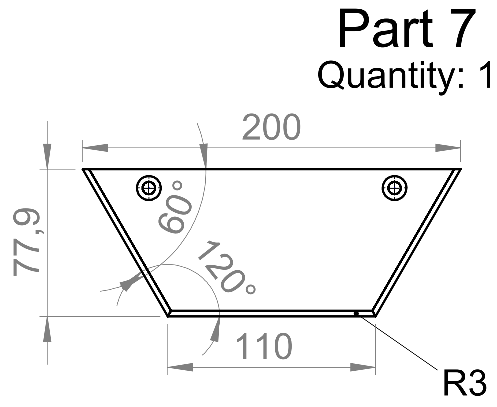


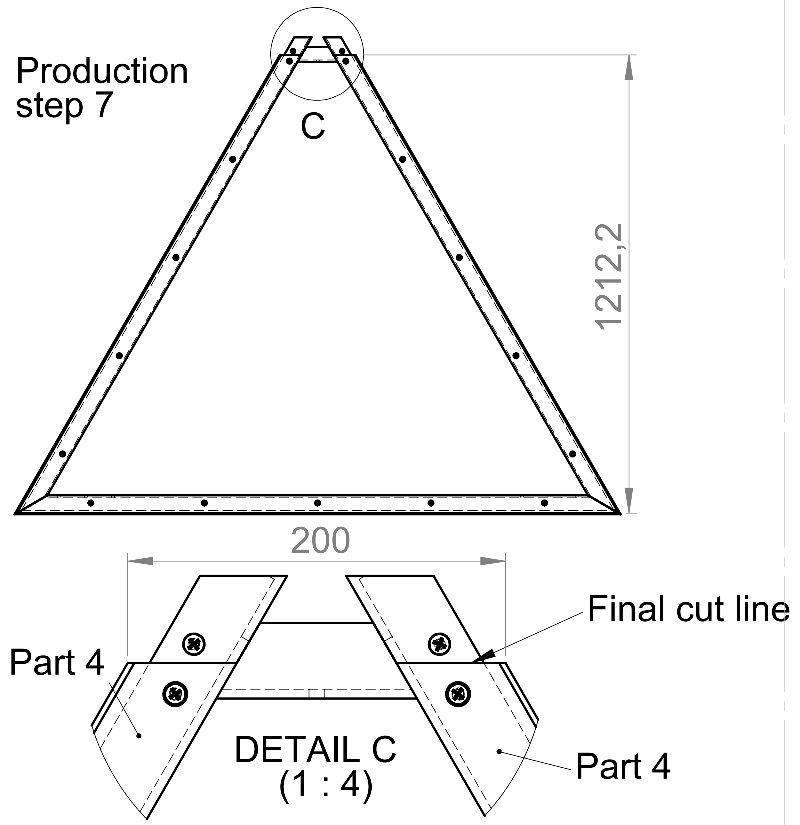




Note:
Part 6 and 7 are similar to part 5, only the tip will be cut off to the specified dimension and an extra 3 mm fillet is required.







Production steps:

5. Manufacture all parts (parts 4 with the initial cut line, the same as part 3)
6. Attach parts 3 and 4 to the assembly
7. Mark the final cut line with a scriber
8. Take both parts 4 off and cut according to the marked final cut line
9. Re-assemble parts 4
10. Use part 5 to mark the locations of the 2 ∅6 holes and drill them.

Part nr.	Quantity	Material
3	1	Bar 50x6, length 1605 Mild steel, chromed
4	2	Bar 50x6, length 1605 Mild steel, chromed
5	1	Stainles steel plate, thickness 6
6	1	Stainles steel plate, thickness 6
7	1	Stainles steel plate, thickness 6

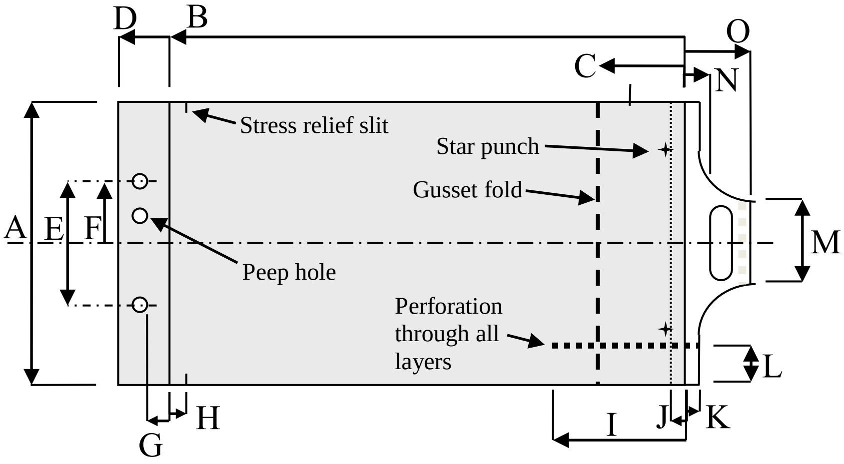
PROJECTION METHOD	UNLESS STATED OTHERWISE: TOLERANCES ± 0,5 MM	DRAWN	Tom Eller	DATE	19-9-2011
		CHECKED	--	SCALE	Not to scale
UNIVERSITEIT TWENTE.	MATERIAL: See table above	TITLE: Subassembly A-frame - 3		REV.: 01	
		DRAWING NO.: TE.SubA.16092011.3			
	SURFACE FINISH: See table above	FILE / PART NAME: Subassembly A-frame 2		A3	
FACULTY OF ENGINEERING	DIMENSIONS IN MILLIMETERS			SHEET 1 OF 1	

Appendix B – Systematic set up sheet

Production size specifications

Huggies Gold 3x58
61238629

A	Bag width	365
B	Bag length	526
C	Gusset depth (central to print)	45
D	Lip width	45
E	Wicket hole pitch (12.7 mm diameter hole)	229
F	Centrality of wicket hole	114
G	Distance of wicket hole to bag opening	15
H	Stress relief slit to bag opening	10
I	Perforation length form bottom of bag	80
J	Handle weld internally on unprinted area	5
K	Handle cut out height from bottom of bag	25
L	Perforation location, aligned to artwork	Align to print
M	Handle top width	140
N	Handle hole cut-out to bottom of bag	40
O	Handle trim height	90



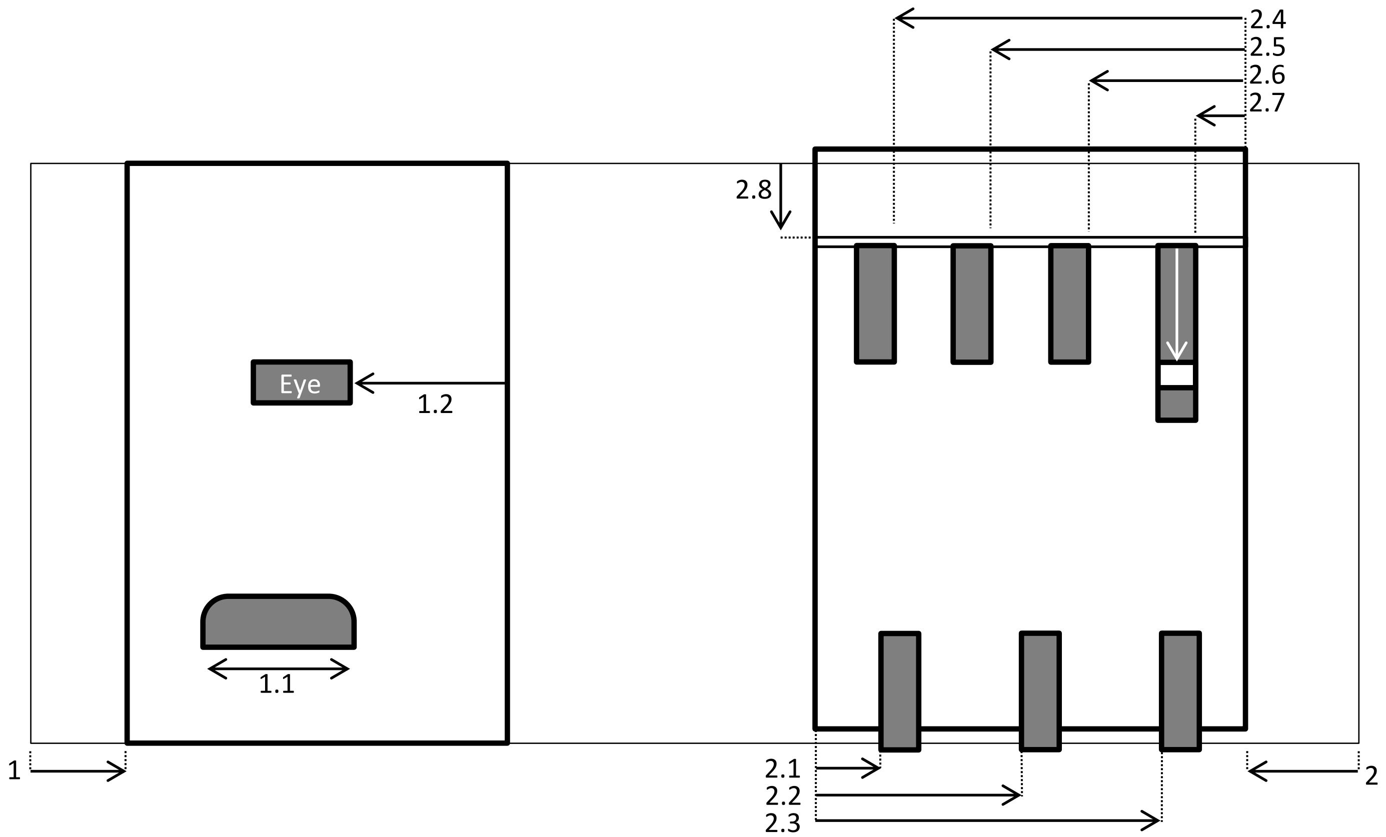
Machine set up C20

1	1.1	1.2
Carriage	Cut-out	Eye
131	225	333

2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
Carriage	CS8	CS8	P	A12	A12	A12	SS1-20	Punch bar
245	116	341	467	378	201	151	78	344

Gusset triangle size:	90
Strip sealer settings:	80 apart

ALL DIMENSIONS IN MM



APPENDIX C – TMF REPORT

The Twente Mobility Fund supports students from the University of Twente that want to do a part of their studies abroad. This chapter will give other students and the reader of this report insight on practical matters besides the internship subjects.

C.1 SHORT DESCRIPTION OF THE STUDY OR TRAINEESHIP PROGRAM

From the 29th of August until the 30th of November 2011 I did an Internship at the South African packaging company Safepak (Pty) Ltd. Safepak is situated in Cape Town and serves a variety of industries throughout South Africa as a manufacturer of high quality flexible packaging products. The internship was part of my 2 year master programme in Mechanical Engineering, specialization Applied Mechanics.

My task was to optimize and redesign bag forming machine C20. First, the current machine was evaluated with specific reference to the operational shortfalls. In consultation with Safepak, a final design was selected from several drafts and detailed technical drawings were made. After several reviews, the drawings were sent to the factory workshop and all the parts were produced.

During my internship at Safepak I gained a lot of practical experience. Mechanical design, motor, gearbox and bearing selection, making technical drawings, getting feedback from the workshop and training machine operators were all part of the assignment. Not less important is the experience of working in a business environment, communicating with managers and other staff, both within and outside the company. In the last week at Safepak I had the opportunity to present my achievements to the management board, convincing them not only of the benefits for Safepak, but also of the benefits for all other Dutch students to come.

C.2 LANGUAGE

While the most commonly spoken language in Cape Town is Afrikaans, English is understood by almost all people as well. English and Afrikaans are only two of the 11 official languages in South Africa. Another commonly heard language in Cape Town is Xhosa, recognisable by the different types of "clicks'.

The English of the Capetonians is very understandable, which makes communicating very easy. The Afrikaans language is, when spoken slowly, understandable as well: an estimated 90 to 95 percent of the Afrikaans vocabulary is of Dutch origin. Warning signs in the factory such as "Moenie bewegende masjinerie smeer of skoonmaak nie" ("Do not clean or oil moving machinery") are a good example of the readability of Afrikaans for Dutch speaking students.

C.3 FINANCES

The South African Rand (SAR) is the local currency. The exchange rate between the rand and the euro is very unstable and varies between 8 and 12 rand per euro. When I arrived in Cape Town (August 2011), paying my R4000 rent cost me 450 euro, when I left in December it was only 350 euro (the exchange rate changed from 9 to 11.5 rand per euro).

There are a lot of unemployed people in South Africa, which is the main reason why foreigners are not allowed to earn money in the country. To give an idea of the total costs of an internship in South Africa, I will try to list the main expenses and prices in a city like Cape Town:

Return tickets are between 600 and 800 euros (when flying via Dubai with Emirates or via London with British Airways). Renting a car costs between 350 and 450 euros a month, depending on extra's like air conditioning and power steering, petrol costs 1 euro per litre. Renting a room in the city bowl of Cape Town will set you back 300 to 400 euros a month. Although prices in the supermarkets are quite similar to the prices in The Netherlands, going out for diner is cheaper (6 to 10 euros for a main course). For an average weekend including trips, petrol, going out for diner and for a drink one should estimate total costs at about 100 euros.

C.4 PREPARATION

I started the preparations for my internship about 7 months before going abroad. Once you have found a suitable company, things can go really quick and can be arranged within a month. Finding a company in the first place is what takes some time.

When going to South Africa, it is not necessary to arrange a visa before stepping on to the plane. For students and tourists the visa will be arranged at the airport. You will get a 90 days internship visa and when you are planning to stay longer, you can apply for a renewal at the Home Affairs office. You do have to show a lot of documents when applying for the renewal: your passport, your return ticket, a document proving that you have enough money, an invitation letter from the company stating that you will not earn any money, a letter from your university stating that the internship is part of your educational program and, last but not least, 45 euros.

I found my internship with the help of a fellow mechanical engineering student who did his internship at the same company. For my room, my rental car and airport pickup I contacted an internship bureau in Cape Town. For 100 euros they arrange you a room in a student house with other Dutch students, a rental car, airport pickup and South African SIM card. The company is called 4exchange internships and they can be found at www.4exchange.nl.

C.5 ACCOMMODATION

As mentioned above, I arranged my accommodation with help of the internship bureau 4exchange. Although their rooms might seem quite expensive (in fact they are), it is an advantage that they place you in a house with other Dutch students. You will find that they are all of the same mind and that it's a real treat to share the weekends with them.

As mentioned above, my room in the student house cost me R4000 a month (between 350 and 450 euros depending on the exchange rate). This price was including water and electricity but excluding internet, which I had to buy for 7 euros per GB. Not all 4exchange houses have a washing machine, but bringing it to the local laundry store at 1 euro a kg is not that bad.

C.6 CULTURE

Cape town is the oldest city of South Africa and parts of it are very western. When living in one of the better neighbourhoods, one would not notice a difference with a big European city (except for the beautiful surroundings such as the Table Mountain). When walking in a township however, the differences between poor and rich become overwhelmingly clear.

Due to the history of South Africa, especially the time of the apartheid regime, the coloureds and blacks are generally poorer than the white South Africans. About 70% of the Capetonians live in townships, where the conditions are harsh. It is highly advisable not to go into a township alone, but with a tour guide (mostly an inhabitant of a township) it is perfectly safe.

C.7 LEISURE TIME

Cape town and its surroundings offer great possibilities to make your leisure time in South Africa the best time of your life! In Cape Town you can climb the table mountain, climb Lions Head by moonlight, go to Robben Island, go to Cape point (the most south-western point of Africa), go shark cage diving or skydiving and lots more. When you have a rental car the possibilities are even greater: whale watching in Hermanus, hiking in Cederberg and visiting the Addo Elephant National Park are just examples.

C.8 TRAVEL

Public transport in Cape Town is very unsafe (so is cycling), so unless your internship is at walking distance from your accommodation, a rental car is highly advisable. During peak hours traffic can get pretty bad, so I would advise taking an accommodation in the city centre. In this way you can always drive against traffic, avoiding traffic-jams. When driving in and around Cape town, watch out for mini-taxi busses. They drive like crazy and accidents happen with them on a daily basis.

APPENDIX D – ASSESSMENT FORM

On the next two pages the assessment form can be found as filled in by the factory manager, Grant Thorburn.

UNIVERSITY OF TWENTE.

Assessment form 'Internship'

Name student: Eller, T.K. (Tom; 0169625)

Master's Programmes: Mechanical Engineering and Sustainable Energy Technology

Specialisation: AM (Applied Mechanics)

Company or institution offering the internship: Safepak

Department:

Location (city and country)**:** N'dabeni, South Africa

Training period: 29-08-2011 till and including 25-11-2011

Name supervisor: Grant Thorburn (grant@safepak.co.za)

Note: If the information provided above is not correct, please fill in below the missing or corrected data:

City is Cape Town, N'dabeni is one of the industrial zones

---

	excellent	very good	good	satisfactory	sufficient	insufficient	not applicable
independence	x						
initiative		x					
technical knowledge	x						
critical judgement		x					
creativity			x				
output of work		x					
quality of work		x					
flexibility in case of problems or criticism		x					
co-operation with colleagues			x				
oral communication skills	x						
written communication skill		x					
total impression		x					

 (please continue on next page)

Could you give some remarks regarding Tom’s strongest points and on aspects which could be improved:
Tom has great communication skills combined with excellent technical knowledge and analytical abilities. He has a great work ethic and works independently. His independence is a strength but is also an area for development, as working as part of a team and later leading a team is a key skill which will be crucial for his future career.

Would you be interested to supervise in the future other students from the University of Twente?

☒ yes, from the following research areas: Safepak is a manufacturing company and can not offer research projects. Safepak can offer practical design projects, usually aimed at increasing the efficiency or for additional functionality of existing manufacturing machinery.

Safepak has been using students referred through a local company "4exchange Internships". As finding companies for internships is their business, I believe Safepak has an ethical obligation not to allow Safepak's contact details to be given to other students without the consent of "4exchange Internships".

☐ do not know yet, because

☐ no, because

Sometimes the report written by the trainee is considered confidential. Since recently all student’s reports are archived in our digital library, and possibly made public for third parties. Please indicate what is applicable to the report written by Tom:

☒ the report is public and can be read by everyone
☐ the report is confidential, but can be accessed by students and employees of the University of Twente
☐ the report is strictly confidential and will remain inaccessible to any other parties outside the agreed confidentiality loop

In case of the last option, could you indicate for how long the report is deemed confidential? N/A year

One final question, regarding feedback on our programme:
Tom is now approaching the end of his Master’s programme in Mechanical Engineering. Do you have the feeling that certain aspects where missing in his education, which you would consider essential for a mechanical engineer?
All the students I had, have had very little exposure to industrial pneumatics and their application in automation and machines. In our industry, we make extensive use of pneumatics and to a lesser degree hydraulics. I have found a similar apparent gap with their exposure to bearings and bearing selection.
I am sure one of the leading companies like SKF for bearings, and Festo for pneumatics, could give them an introductory lecture/workshop or demonstration.

Date: 25/11/2011
Signature supervisor: Grant Thorburn

A signature is necessary only in case this document is printed and handed over to the student to deliver it to the Student Mobility Centre personally. If you sent it back by email yourself, the signature is unnecessary. The Student Mobility Centre will make sure that the UT supervisor will receive a copy of this document for the final assessment of the student.