Flexible Packaging Engineering

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SAFEPAK

UNIVERSITY OF TWENTE.

Flexible Packaging Engineering

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Eductational program	Master Mechanical Automation - faculty CTW
Period	13 October 2014 – 6 February 2015
Context	20 EC internship

Abstract

For my 20 EC internship I have been working from 13 October 2014 until 6 February 2015 at SafePak, a company in Cape Town which produces flexible packaging. The company has the following departments: extrusion, printing and slitting, and bag making as well as a workshop which mainly serves for repairing breakdowns. Besides there's office staff who do planning, administration and management. In total the company has about 200 employees. There's no engineering department, so the intern is the only engineer. However, the factory manager, who supervises the interns, has a mechanical engineering background.

I worked as mechanical engineer on different projects concerning design of new machines or improvement of existing machines. Some of the projects include (management of) prototyping, manufacturing and commissioning.

The first project was about designing a pre-sealer in order to improve sealing quality and speed. Due to folding the bottom of the bags consist of four layers of plastic where the rest of the bag has two. This makes that for sealing more heat is required at the bottom of the bag. Different options have been considered and tested. Eventually a bottom part is designed to be mounted on an existing actuator system.

The second project concerns adjusting the location of punched holes due to slightly changing bag sizes. Currently this is done by hand. To be able to automate this adjustment, a measurement system, an actuation system and a control system have been designed. Measurement will be done with a rotary encoder and actuation with a geared DC-motor which moves the complete punch carriage driven by a timing belt.

The third project is the design of a belt sander to be able to polish the drum of printing machines. The sanding belt is actuated by an angle grinder and guided by pulleys. This is mounted to a vertical plate which is driven by a lead screw to move across the drum. The whole design is mounted onto a frame which can be clamped into the printing machine.

Some smaller side projects concern the design of a mechanical unfolding system, a parking layout and crate and hanger system.

Contents

Introduction

This report is written in the scope of the internship for the master Mechanical Engineering. During the projects it has served to structure my work. Now when it is finished it serves to inform my UT supervisor R.G.K.M Aarts about this internship.

For my 20 EC internship I have been working from 13 October 2014 until 6 February 2015 at SafePak, a company in Cape Town which produces flexible packaging. The company has the following departments: extrusion, printing and slitting, and bag making as well as a workshop which mainly serves for repairing breakdowns. Besides there's office staff who do planning, administration and management. In total the company has about 200 employees. There's no engineering department, so the intern is the only engineer. However, the factory manager, who supervises the interns, has a mechanical engineering background.

I worked as mechanical engineer on different projects concerning design of new machines or improvement of existing machines. Some of the projects include (management of) prototyping, manufacturing and commissioning. This report describes the three main projects and three smaller projects that I have worked on.

I would like to thank Mr. Grant Thorburn for his supervision.

1. Design of pre-sealer

Problem description

Bags are folded and thermally sealed afterwards. The sealing speed is critical since it determines the speed of the whole process. Near the bottom the bag is folded so that there at that place are 4 layers instead of 2. Pre-heating or sealing these layers two by two before final sealing step would improve the quality of the seal as well as the speed of the process.

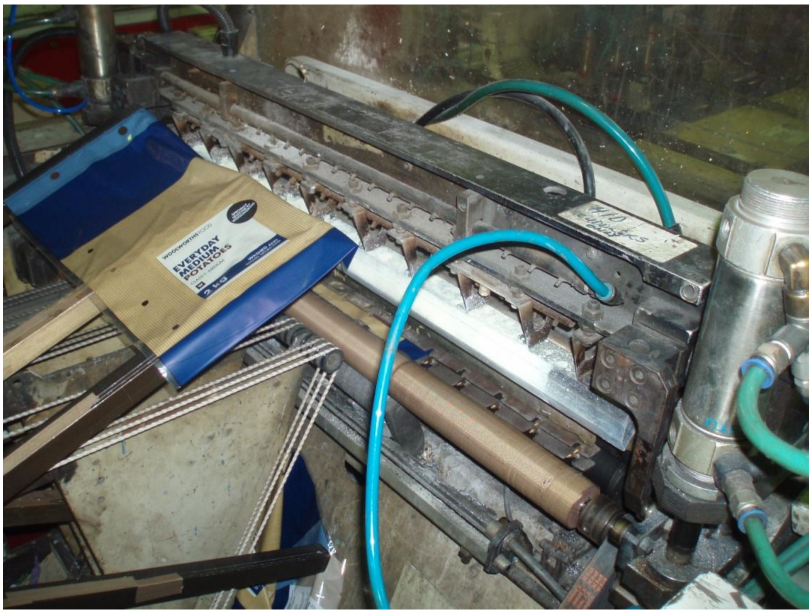


Figure 1 – Sealing bar

Requirements

1. Reliable, compact and integrated into punch carriage
2. Central separation plate/film
3. Perfect quality
4. Be able to speed up with 50%
5. Position should be adjustable due to different size bags

Function definition

The following functions have been defined:

1. Way of heating
2. Actuation
3. Connection
4. Adjusting mechanism

All relevant ways to fulfill these functions are figured out and summarized below.

1. **Way of heating**
    a. Ultrasonic
        i. Pro
            1. Not hot
        ii. Con
            1. Expensive
            2. Large
    b. Thermal continuous
        i. Pro
            1. Cheap, easy and effective
        ii. Con
            1. Stays hot, so heat element should be moved away from plastic when machine stops.
    c. Thermal impulse
        i. Pro
            1. Compact
            2. Switches off when machine is off and cools down quickly
        ii. Con
            1. Needs some time to warm up
            2. High current

The ultrasonic way of heating is quite unknown in the sealing industry. The ultrasonic vibration causes friction between the plastic layer which heats the plastic. No external heat source is required. To see how it works a manual sealing unit was set up to make some samples. The sealing time is 0.2s and the intensity is varied from 10-60%.

Figure 2 – Test results for different settings

During tests the machine gave errors a lot of times, because of the pressure. If the pressure is too high or too low, it will either give an error or a bad seal. The pressure is difficult to control with a thin film. Also, the seal quality was poor because the heat was concentrated around the centre of the sealing bar. This makes the ultrasonic element less suitable for sealing of thin films.

2. **Actuation**
    a. Servomotor with eccentric
        i. Pro
            1. Only one motor needed for sealing from both top and bottom (coupled motion)
            2. Long lifetime: about 900 million cycles [1]
            3. Controllable
        ii. Con
            1. Vibrations
            2. Heavy
            3. Expensive
            4. Requires much space (~500mm for an existing machine) but a more compact design may be possible.
    b. Pneumatics
        i. Pro
            1. Compact
            2. Cheap
        ii. Con
            1. Shorter lifetime: about 5 million cycles [2]
            2. Actuator needed on each side

3. **Connection**

The pre-sealer should be mounted somewhere between the folding station and the sealer. Just before the sealer there's a movable carriage at which the hole punches are mounted. At the punch carriage there's about 250-300mm of width available for the pre-sealer. Another option is to make a separate carriage and place it between the punch carriage and the sealing bar. The pros and cons are listed below.

a. At punch carriage.
    iii. Pro
        1. Doesn't require extra carriage
        2. Benefit of the adjustment system
    iv. Con
        1. There might not be enough space because of the star punches
        2. Might cause vibrations which disturb the position of the punches
        3. Bars where the punches are mounted on may be in the way
b. Between punch carriage and sealer, as close as possible to sealer.
    v. Pro
        1. Doesn't affect the punching process
        2. Can be fixed thoroughly
    vi. Con
        1. There may not be enough space
        2. May reduce flexibility of the production line

4. **Adjusting mechanism**
    a. Gear and rack
    b. Clamp on a rail
    c. Worm gear (no clamp required)

Concepts and choice

1. Way of heating
   First the ultrasonic is tested. This didn't work, so try impulsive thermal. If that doesn't work, use continuous temperature heat elements.
2. Actuation
   Eccentric is durable and better controllable than pneumatics.
3. Connection
   A new carriage gives more design freedom if possible.
4. Adjusting mechanism
   Worm gear would be a good solution, depending on how the connection is done

Probably for the testing one of the current pre-sealers can be used. Then only the sealing bars and the adjusting mechanism have to be built.

Prototyping

A prototype for the sealing bar is made to test the principle of pre-sealing with a resistance wire. It is mounted on an existing frame with pneumatic actuators from top and bottom and a plate in the middle. It is made from available materials.

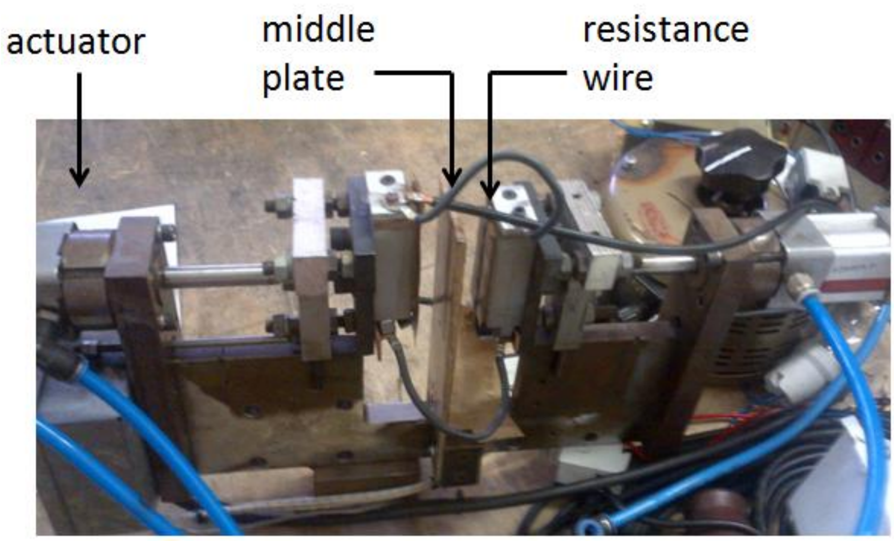


Figure 3 – Prototype

In the testing phase it appeared that the resistance of the heat seal wire is very low and therefore leads to very high current. This means that the lifetime would be short. Besides, to control the temperature a sophisticated control box is required. Therefore the best way of heating for this application will be with a constant temperature heat element, controlled with a thermocouple.

Final design

Eventually, it is chosen to use the actuation mechanism of an existing pre-sealer for the first version of the pre-sealer. This mechanism consists of a short stroke actuator in series with a long stroke actuator. The short stroke can operate at high speeds while the long stroke can get the hot element far away from the plastic when the machine stops.

Figure 4 – Existing pre-sealer

The part to modify is the sealing bar which now has a sharp triangular shape. The required shape is rectangular and flat. The design of the bottom part is shown in the figure below. The fins will reduce heat transfer to the rest of the machine. The two rods are meant to wind Teflon film around and over the sealing bar to prevent sticking of the plastic to the sealing bar. At the time of writing this report it has not been produced yet.

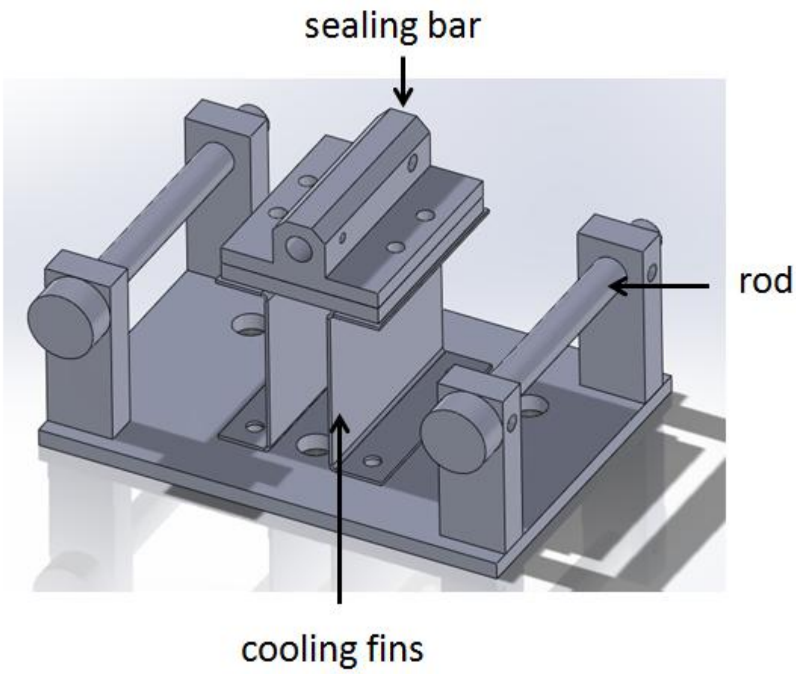


Figure 5 – Bottom part of pre-sealer

Recommendations

1. Implement this pre-sealing quickly because it will improve the seal quality and production speed. The drawings are given to the workshop and are also available on the network drive in the factory drawings folder.
2. If the principle works well and after some time the actuation mechanism fails due to wear, design an eccentric driven mechanism which will be more durable.

2. Punch carriage optimization

Problem description

In most bags two round wicket holes are punched during the production process. These holes are later used to fill the bags. Therefore it is important to have the holes at the right position. However, due to thermal expansion the bag sizes change slightly. This causes the round punched holes being not exactly aligned in the middle; the deviation is about 2mm. This should be compensated by a control mechanism.

After the punches is the sealing bar which seals and cuts the sides of the bags. Just before the sealing bar is an eye which recognizes the edge of the bag and makes the feed stop so that the seal comes at the right place. Once the eye is at the right place, this doesn't have to be changed. The only part to be adjusted is the punch carriage. Currently it can be adjusted manually. The punch carriage has gears which run at a fixed rack.

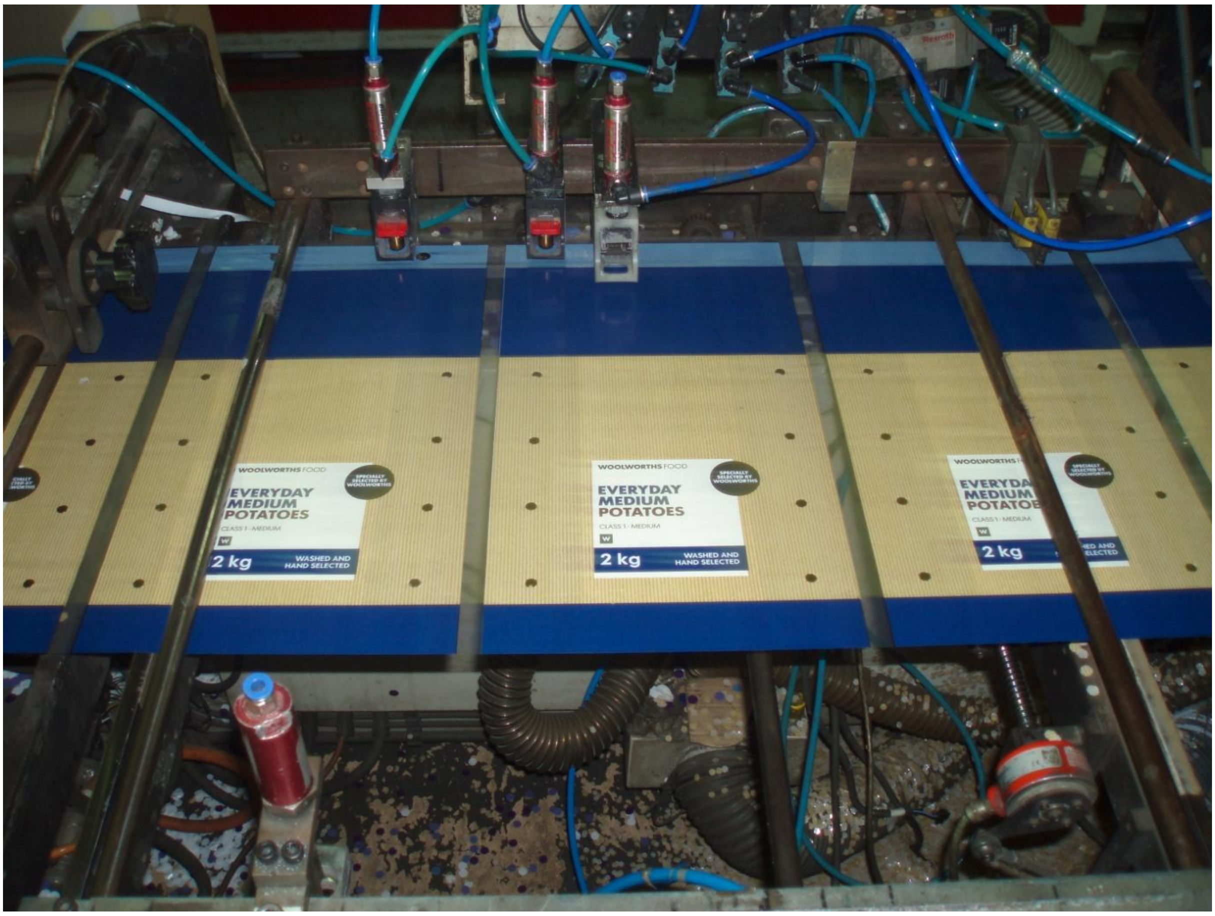


Figure 6 – Punching of wicket holes

Specification of existing part

- Two round punches
- Distance between punches is adjustable
- Weight of the part to be moved: max. 20kg
- Size of punch carriage at machine at machine C11: 625x940mm.

Requirements

1. Decrease the deviation to max. 1mm.
2. Minimum stroke: 10 mm in both directions, (based on thermal expansion) dependent of the max. amount of bags between punches and sealing bar.
3. Take the average of a series of bags and adjust periodically.
4. Should fit on the existing machine
5. Robust design
6. Size measurement and control system with HMI for operator.
7. Universal and adaptable to machines C10, C6,7,8.

Function definition

The following functions have been defined:

1. Measuring
2. Mechanism
3. Actuation
4. Mechanism measuring system(s)
5. Frame

All relevant ways to fulfill these functions are figured out and summarized below.

Measuring

Options:

1. Another eye
   This eye is attached at the punch carriage and measures the distance to the edge when the bag stops. It is even better if the punch carriage is far away from the sealer, because then you can measure better. Costs about R1500.
2. Linear encoder
   a. With scale
   b. Without scale (like a computer mouse)
3. Ultrasonic, more suitable for long distances
4. Inductive/ proximity sensors (range of mm's)
5. Put encoder on the adjusting motor or use a servomotor. (Problem with backlash, but if the backlash is smaller than 0.2mm it could be sufficient.)
6. Rotary encoder with a wheel. Costs R1500.

Combined with:

1. New rotary encoder to measure bag size.
   Using a rubber wheel which rides on the bags. Every time it stops is +1 bag and it measures the total size. Next the average is calculated. Based on this, the punch carriage is adjusted (number of bags between seal and punch should be known.) Here it is important that the initial configuration is correct, it should be mounted very precise based on the nominal bag size.
2. Use the encoder of the servo drive for the sealer to measure the bag size.
   Same principle as point 1. Has to be calibrated.

When starting with a new type of bags the operator will have to enter the number of bags between punch and seal.

Choice
My suggestion is to first only use a stepper motor (point 5) and put the punches far away from the sealing bar. If it doesn't work because of backlash, the backlash can be reduced or an encoder can be used. So design the encoder part already but don't buy it.

Mechanism and actuation
Options:

a. Adjusting the complete current carriage
    i. Use current rack
        1. Use the current rack with an extra gear, driven by servo motor with encoder.
        2. Replace the hand wheel by a servomotor. Make buttons on it for the manual adjusting.
    ii. Add linear ball screw actuator (with base on another carriage)
b. Creating a new carriage on top for just the punches
    i. Flexure mechanism
        1. Voice Coil Motor driven
        2. Screw spindle motor driven
    ii. Straight guidance
        1. Belt driven
        2. Rack and gear
        3. Screw drive

Mechanism concepts and choice

Below some schematic drawings are shown of the concept and pros and cons are listed.

Concept 1

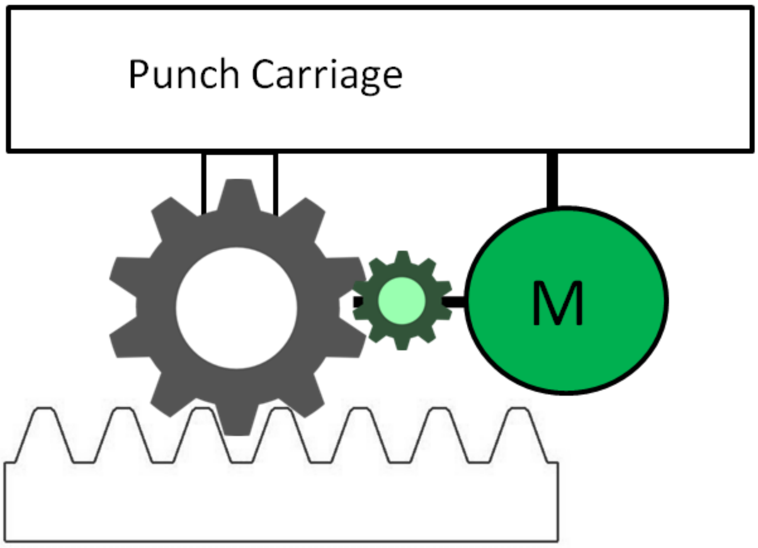


Figure 7 – Concept 1 (grey is existing, green is new)

Manual adjustments should still be possible, so motor should not lock or the motor should be able to be used manually.

- Pro
  - Simple
  - Applicable everywhere
- Con
  - If there's no feedback this is not very accurate because of backlash. A possible solution is using a spring loaded gear.

Concept 2

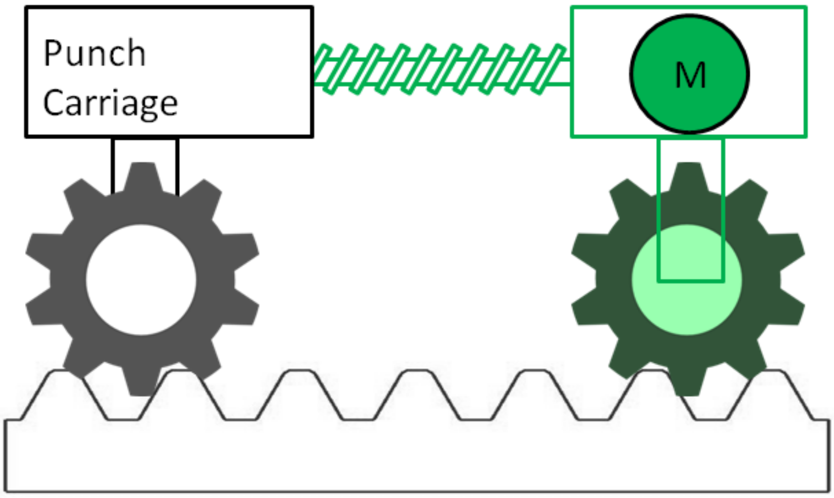


Figure 8 – Concept 2 (grey is existing, green is new)

i. Pro
   - Accurate

ii. Con
   - The motor needs to be on a separate carriage which requires an extra pneumatic clamp.
   - Probably a straight guidance is required

Concept 3

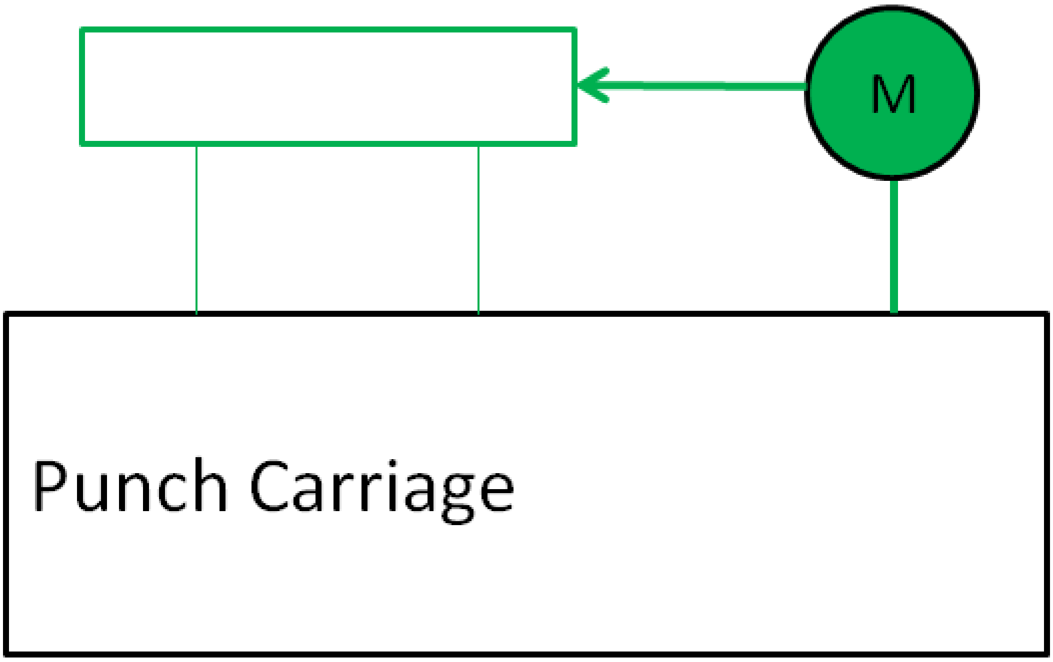


Figure 9 – Concept 3 (grey is existing, green is new)

The mechanism can either be straight guidance with bearings and slides or flexure mechanism (simpler). The motor can either be Voice Coil Motor or screw spindle drive (probably more durable).

i. Pro
   - No bearings and slides required
   - No backlash: most accurate

ii. Con
   - Durability and stiffness of flexure mechanism are unknown yet, my experience with it is light precision mechanisms but the punch carriage is quite heavy.
   - More complex than concept 1

Concept choice

Concept 1 is the easiest one. The only problem is the backlash. This can be overcome by (1) introducing feedback and/or (2) adjusting the gear to reduce backlash by gear spring system or by milling the tooth rack/gear. Concept 1 is chosen.

Detail design

Measurement system

a. Sensor selection: Because of price and availability, a rotary encoder will be used to measure the displacement of the punch carriage.

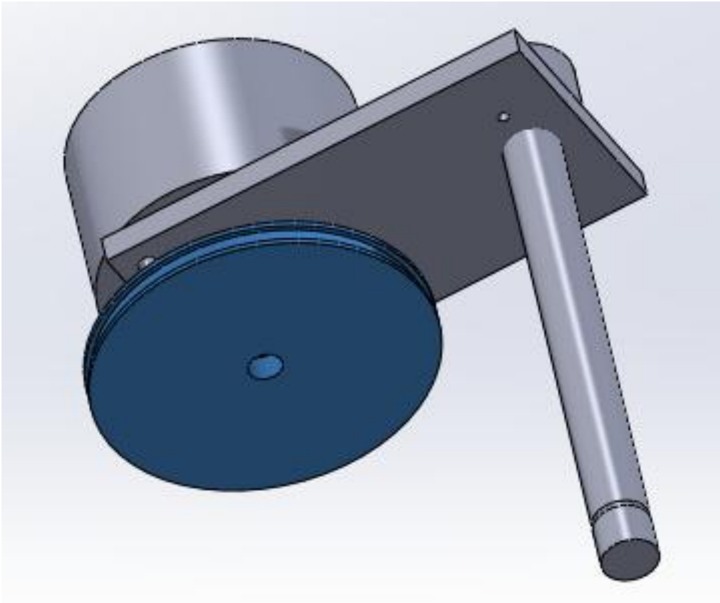


Figure 10 – Encoder with wheel

Motor selection

Choose depending of the price between

1. Stepper motor
2. DC motor with gearbox

Figure 11 – Stepper motor

Theoretical torque investigation
The motor needs to

1. Accelerate the punch carriage to a speed of max 0.3 m/s in 1s, so $a = 0.3\ m/s^2$. According to $F = m \cdot a$, with $m = 20kg$,the required acceleration force on the punch carriage is 6N.
2. Accelerate the rotor inertia. $T = I \cdot \alpha$ (this is negligible)
3. Overcome friction of max. 5N.

So $11N$ in total.

$$P = F \cdot v = T \cdot \omega$$

P and v are known from the above and ω follows from the transmission ratio (1 rotation is 0.04m -> $\omega = 7.5 \frac{rad}{s} = \cdots pulse\ per\ second$) . So now the required motor torque can be calculated.

$$T = 0.44Nm = 440Ncm = 44kg \cdot cm$$

- A suitable stepper motor is the Mantech FL57STH76-3006A with a pull out torque of 140 Ncm at 311pps [5]. Costs R614[3]
- A suitable geared DC motor is the Bircraft CGM6D15-24 with an output speed of 15rpm and a maximum torque of 3Nm.

Experimental torque investigation
Because it is impossible to determine the friction force theoretically, the required torque to move the carriage is determined experimentally. This is done by clamping a plier at the shaft with the gear to act as a lever. On the lever a bucket is attached which is filled with water until the carriage starts moving. The details are shown below:

- Plier of 0.49kg which is a lever of 20cm. COG at 10cm.
- Empty bucket of 0.40kg at 20cm.
- Starting torque = 127Ncm.
- Every kg of water means 196Ncm extra torque.
- At machine C11 the full bucket is about 2kg -> 440Ncm in total.
- At C6 the full bucket is 3.6kg -> 755Ncm (this is due to irregularities in the rack, usually it is smoother than C11 because of bearings).

Figure 12 – Principle of the experimental torque investigation

The geared DC motor can deliver the required torque. Besides that, DC motors are more durable than stepper motors. Therefore the geared DC motor is chosen and ordered.

Attachment to punch carriage

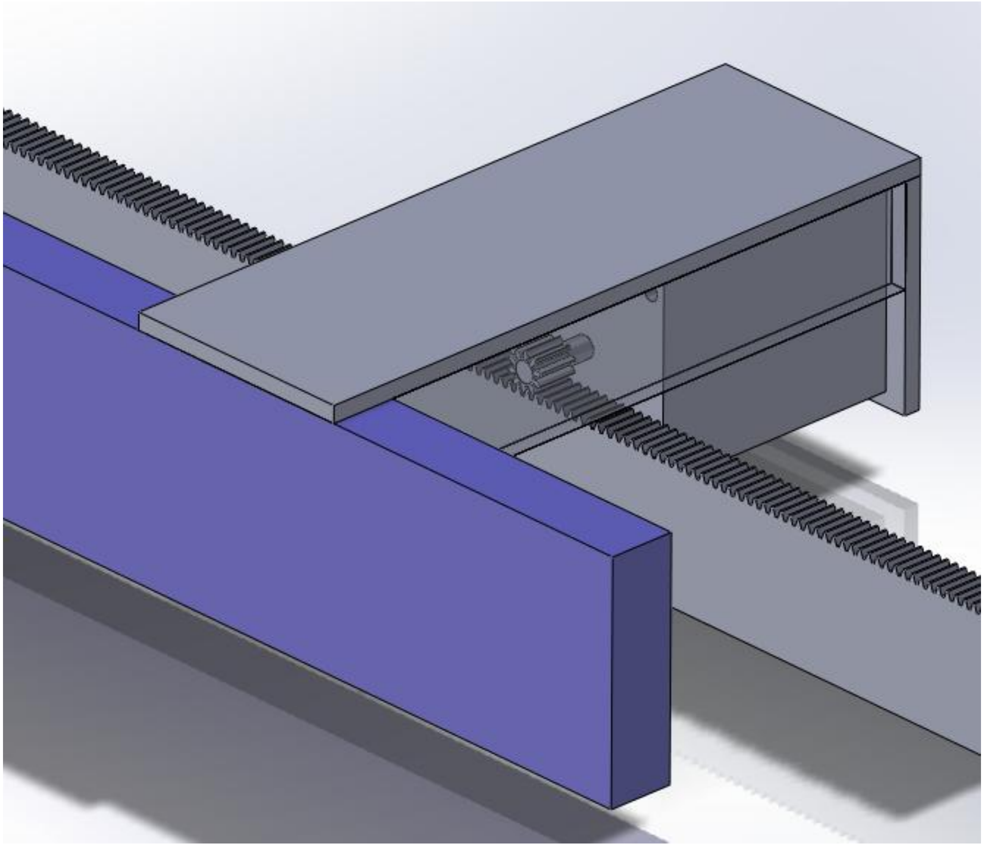


Figure 13 – Idea for the attachment. The blue bar is part of the punch carriage.

The first idea of the attachment of the motor to the punch carriage is shown in the picture above. The drawback is that the actuation is on only one part, so it may pull the carriage skew. Therefore it is better to drive the existing shaft which has gears on both sides of the punch carriage. The new situation is shown below. The existing shaft is now coupled to the motor with a timing belt.

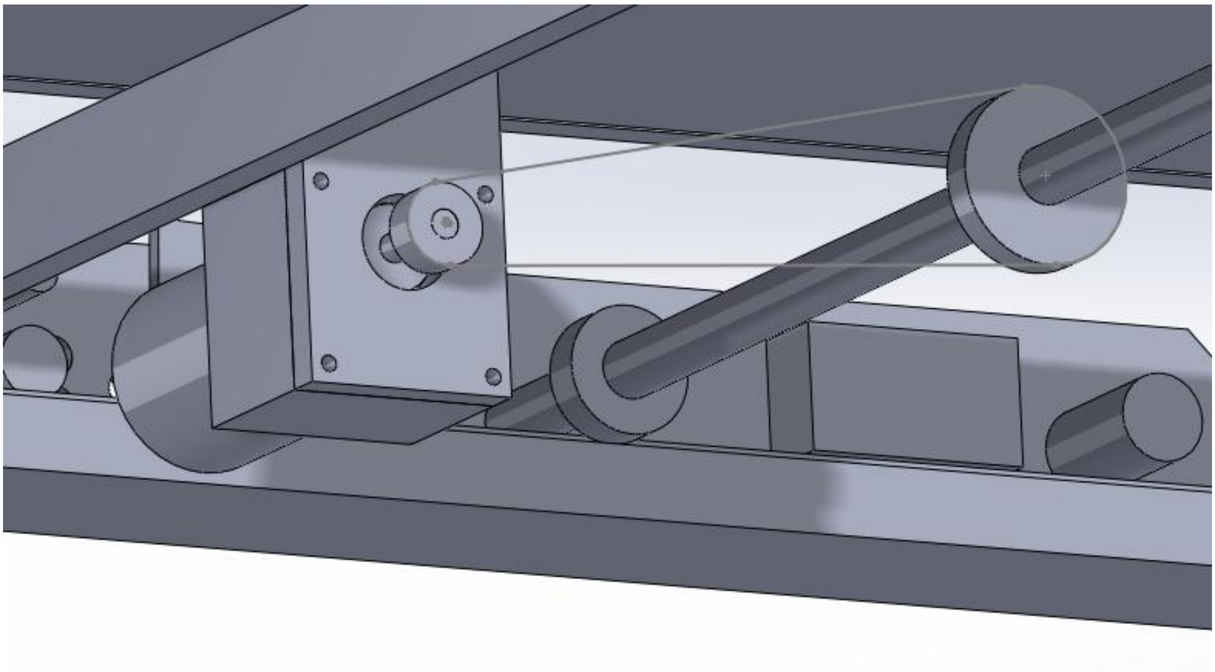


Figure 14 – New idea for the attachment, using timing belt.

The output of the DC-motor is 15rpm. When applying a 1:1 ratio this would make the speed of the punch carriage about 30mm/s. To slow down, the motor will be provided with a small pulley and the other pulley will be bigger, diameter about 70mm.

Eye position

To make space for the pre-sealer (other project) the existing eye sensor will be on the punch carriage and should be adjustable in one direction. This can be done by clamping it to the same bar as the punches. Also it should have a 'reflector' below of above.

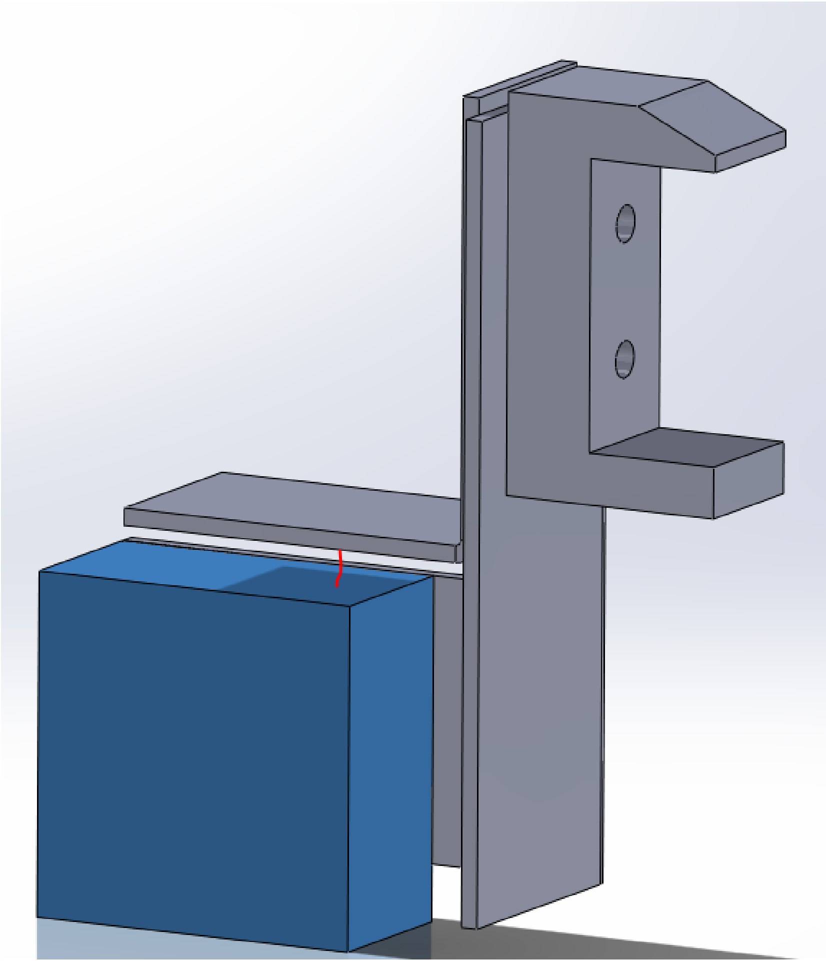


Figure 15 – Eye position

Control interface

Position options

- At punch carriage
- In panel in front of punch carriage

Contents:

- LCD display or touch screen for nr of bags between eye and sealing bar.
- Reset/new setup button
- 2 buttons for 'manual' movement left and right.
- Button to increase nr of bags
- On/off switch

Control logic

a. If carriage and eye are mounted correctly initially, measure the current bag size and save this (take average of first 100 bags, count to 100 with help of the eye or the valve signal. Measure 100 bags, take average and subtract from initial bag size and send this to motor. This is the desired position. The new average is the current bag size from now.
b. Release the clamp (slightly) and activate the motor to go to the desired position. fix the clamp again afterwards.

The program has been written in ladder logic for a PLC and tested.

Production

The manufacturing drawings have been made. At the moment of writing it has not finished yet.

Recommendations

1. Train operators how to use this.
2. Initial configuration of the punch carriage is still of major importance.

3. Drum grinder

Problem description

Due to wear of the drums of two printing machines, the crystal structure of the drum becomes visible on the print. Therefore the drum needs to be polished. The objective is to design a polishing machine. The design is inspired by the Bosch tube polisher (Figure 17). While operating, the polisher should be able to move automatically in a slow linear motion along the drum.

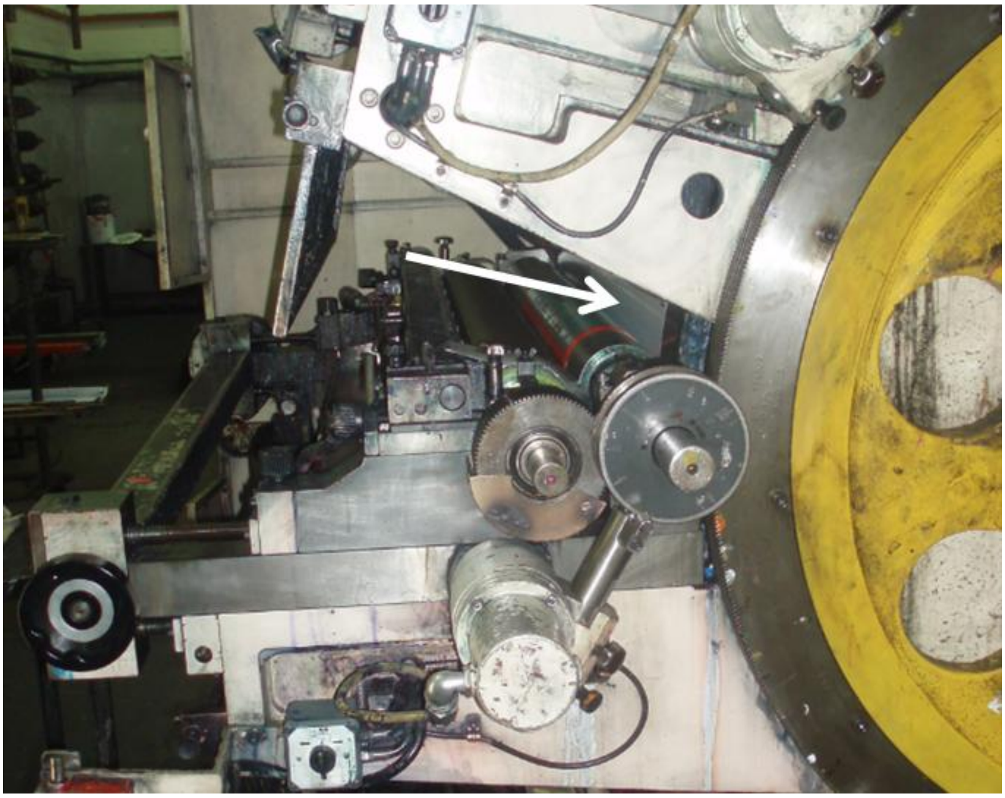


Figure 16 – Printing machine (the white arrow points to the drum)

Figure 17 – Bosch tube polisher [4]

Specifications

1. Motor driven straight motion along the drum, stroke 1400mm, speed about 2mm/s
2. Adjustable towards and from the drum
3. Belt needs to be tensioned
4. Belt speed around 20 m/s.
5. 1 adjustable pulley to align the belt and prevent it from running off the pulleys

Functions and solutions

1. Belt actuation
2. Belt tensioning
3. Linear motion along the drum
4. Grinding belt and pulleys
5. Frame
6. Alignment adjustment

Belt actuation

Options:

a. Drilling machine
b. Angle grinder (better bearing than drilling machine)
c. DC motor
d. Pneumatic machine

An angle grinder will be used because it is relatively cheap and effective.

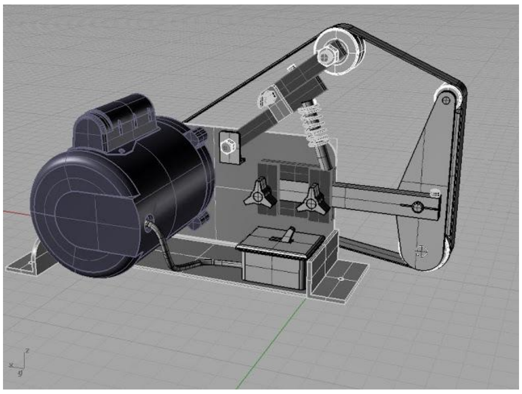
Tensioning
One of the pulleys needs to be tensioned. Options are the following.

a. Torsion spring
b. Linear spring
c. Pneumatic actuator to move
d. No spring, fix motor at required tension


[6]


[7]


[8]

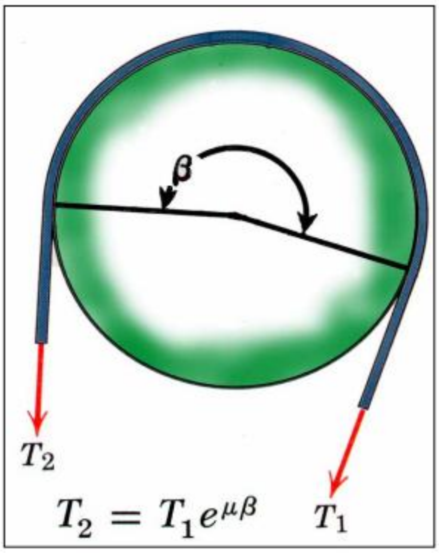

[9]

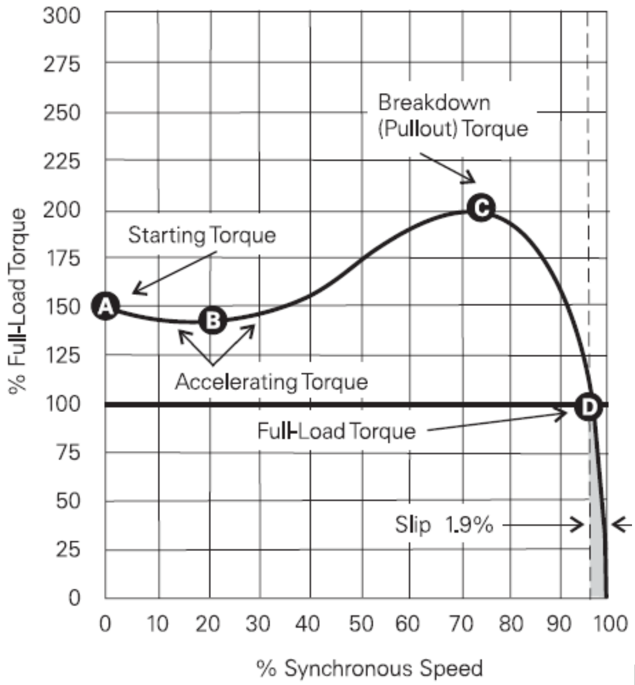

[10]

Figure 18 – Different ways of tensioning

A linear spring is effective enough and the easiest, and therefore will be applied.

The tensioner should be able to take up the difference in belt length between contact and non-contact and it should deliver enough pre-tension to have enough grip. For this the belt friction equation is used:





[11]

Figure 19 – Belt friction [12]

Where

- T_2 is the tension at the pulling side
- T_1 is the tension at the slack side
- μ is the friction coefficient, assumed is $\mu = 0.5$ [13]
- $\beta = 90° = \frac{1}{2}\pi\, rad$

Theoretically, the maximum tension at the pulling side can be found by applying $P = F \cdot v$, where P=$1400W$ is the motor power and $n = 12000\ rpm$. The continuous torque is at about 90% of the speed. The pullout torque is twice as big as the continuous torque.

$v = 22\ m/s$ is the maximum belt speed. In practice the full motor power will not be used, but it is useful to calculate the worst case required tension. Hence, $T_2 = 63N$ and

$$T_1 = 29N \tag{1}$$

According to the figure below, the required spring tension force $F_s = 2T_1 \cos\alpha$. Assuming $\alpha = 45°$, this results in $F_s = 41N$.

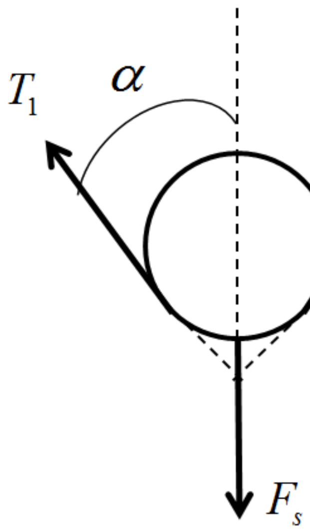


Figure 20 – Pre-tension

Linear motion

Worst case loads

- Gravity of max. 200N
- Resistance force between sanding belt and drum of $\frac{P}{v} = \frac{850}{25} = 34N$
- Neutral force by drum of max. 50N at 1m moment arm
- Distance between shafts 150mm
- The displacement should be max. 1mm.

These forces cause moments. Worst one is the 50N with a moment arm of 1m, so T=50Nm. This leads to a vertical force of $50 \cdot \frac{1}{0.15} = 333N$. Together with the gravity force (worst case it's all on one shaft) this makes the vertical force $433N$.

This leads to a shear force and an internal moment. From this, using standard beam formulas, the maximum deflection can be calculated. Also the maximum stress can be calculated.

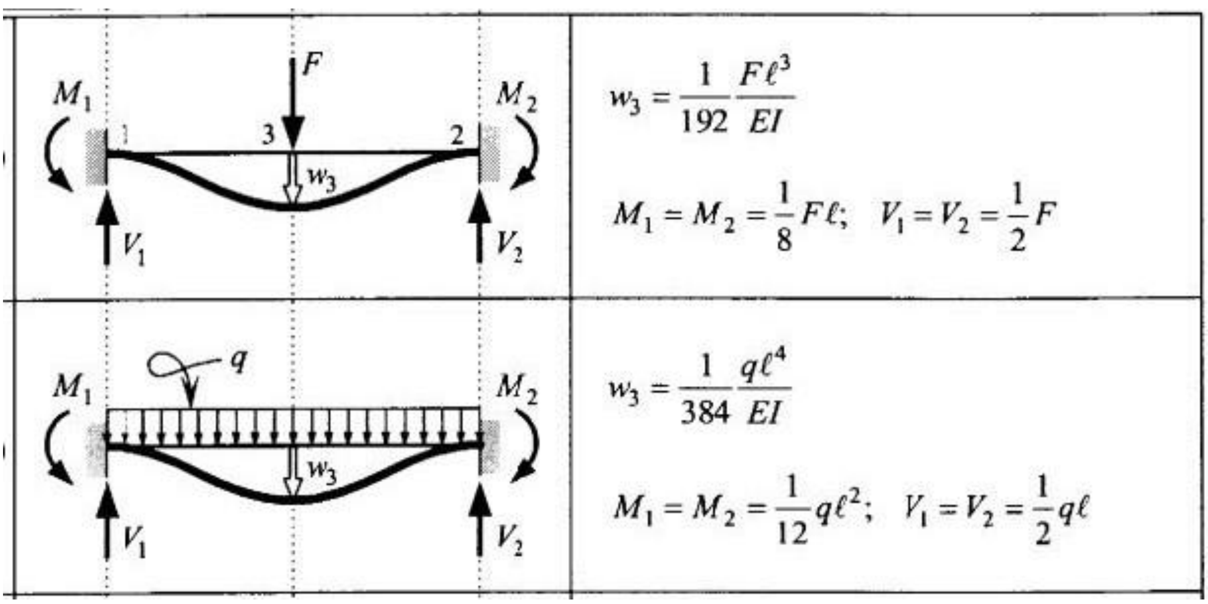


Figure 21 – Internal moment and shear force [14]

Actuation

a. Lead screw
   This is often used for slow, accurate movements. Able to transfer large forces.
b. Timing belt
   Used for fast movement. Loads are limited by the strength of the belt.

   The stepper motor which is available for this job runs from 300pps, which is 1.5rps. Desired is to travel 1280mm in 10min, which is 2.1 mm/s. Therefore a 1:2 ratio will be applied between the motor and the nut on the lead screw. The motor has as output shaft diameter of 8mm. A 12 teeth pulley fits nicely.

Bearing

Options:

a. Ball bearing
b. Plastic slider bearing

A slider bearing has a larger contact area and is therefore preferred.

Rail type

All can be either with ball or slider bearing. [15]

a. Drylin T (around profile rails)
b. Drylin N (inside rails)
c. Drylin W (double cylinder)
d. 2x Drylin R (round)
e. Drylin Q (square shaft)
f. Drylin E complete drive [16]
g. Ball bearing system

Figure 22 – Linear guidance systems

Option	Cost	Comment
Two chromeshafts with screw in the middle	R4140 (shaft) + R150 (screw) + bushes + flange bearings	Think about how to apply fixed-floating concept
Drylin system	R7750 + channel + R150 (screw)	
Ball bearing system	R8000 + channel + R150 (screw)	
Two leadscrews	R570 + bushes + flange bearings	Probably not really straight and not accurate

The Drylin W system with slider bearings is a complete and working system. So that will be used.

Grinding belt and pulleys

Grinding belt
Standard grinding belts with different grid will be used. The width is 50mm and length 2000mm.

Pulleys
In order to let the belt run at the right speed, the driving pulley diameter will be 35 mm. It will be rubberized for grip. The idler pulleys are made from a 38mm available tube.

Frame
The frame will be made from thick plate material, comparable with the figure below.

Figure 23 – Belt grinder

Angle grinder to plate

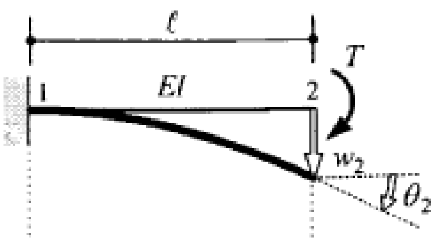
1 or 2 bolts and a clamping mechanism, covered with rubber to absorb vibrations.

Structure

1. Single supporting the pulleys. Not ideal stress distribution but most simple.
2. Supporting pulleys from both sides. Better stress distribution. Constrained by belt, it should still be possible to take belt off. More complex frame than single support.

Plate thickness

The required plate thickness is determined by the critical loads that cause out of plane bending. For convenience the standard beam formula below is used.



$$\theta_2 = \frac{T\ell}{EI}; \quad w_2 = \frac{T\ell^2}{2EI}$$

Figure 24 – Internal moment and shear force [14]

Where the torque results from a maximum force of 500N at 50mm, so $T = 25Nm$, $l = 0.2m$, $E = 70GPa$ (aluminium) and I dependent of the plate thickness. Assuming a thickess of 10mm and a width of 200mm, $I = \frac{bt^3}{12} = 1.67 \cdot 10^{-8}\ m^4$. Hence $w = 0.4mm$. This is acceptable. In the design the bending length l will be minimized.

Alignment adjustment

To track the grinding belt an adjustment system is necessary. There are different options to do this:

1. The fixture of the grinder can be made in a way that it is adjustable by rotating it slightly around the axis of the bolt hole where the handle is usually attached. Then the bolt behaves like a shaft, so it should not be too tight but also not too loose because of vibrations. Maybe a bearing is required.
2. Fix the grinder on a plate and make this plate adjustable.
3. Adjust one of the idler pulleys, comparable to a sand grinder. Complex solution.

Option 2 will be applied because option 1 is not really robust and option 3 is very complex. Option 2 is simple and effective.

Detail design

All the details and dimensions have been worked out. They will not be discussed here. The total assembly is shown in the figure below.

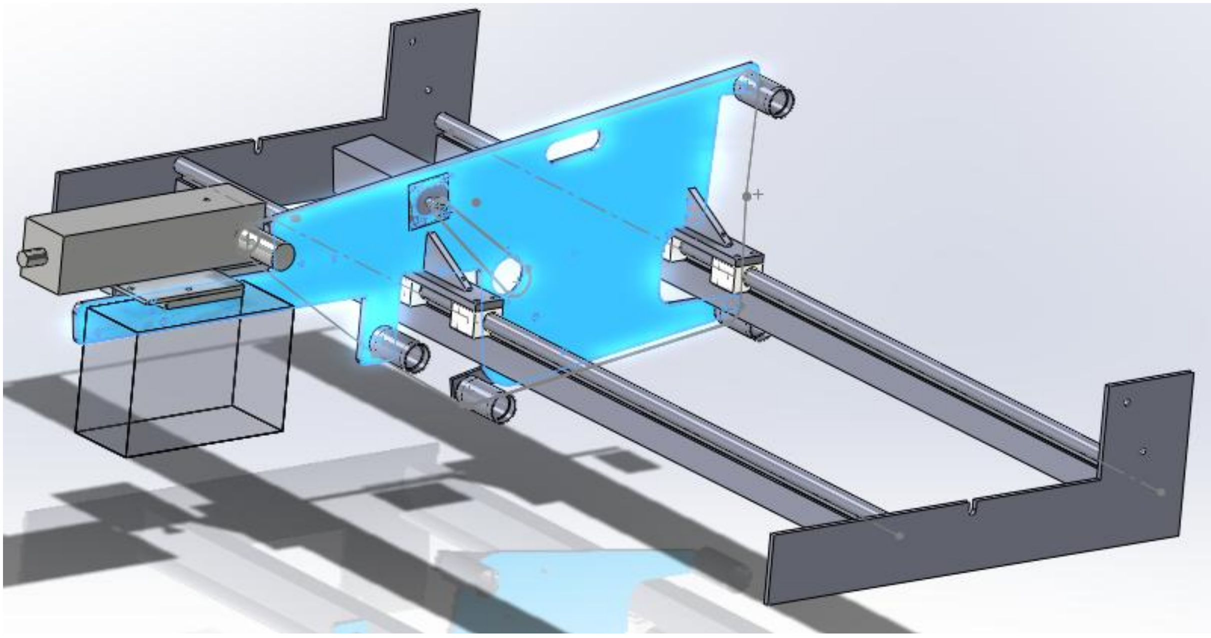


Figure 25 – Final design of the drum polisher

Commissioning issues
The stepper motor has slightly too little torque to overcome the friction. This is the FL56ST56-0606A. Therefore there's an investigation done at other motors. A stronger, available motor is chosen.

The machine has been commissioned and works well. Some improvements can be done to make it better:

1. Replace left limit switch
2. Paint frame
3. Fix bush flange properly
4. Round sharp corners which can damage the grinding belt
5. Put bigger washer in slot
6. Make holes for the tensioner spring according to marked points
7. Make cap according to drawing
8. Make belt tracking adjustment system with spring and one bolt instead of two bolts
9. Add water supply, inspired by spray bottle

Recommendations

1. Make sure that the all the improvements will be done
2. Find a suitable place to store the machine

Smaller projects

Three smaller projects are described briefly

Mechanical unfolding system

Reels which are too wide for the printer are folded in at the sides before printing and folded out afterwards. This unfolding currently happens by blowing 'brute force' compressed air. This causes a lot of noise and costs a lot of electricity, a rare good in South Africa. Therefore a mechanical fold out system is designed. Key issue here is creating slack to make the path length equal over the width of the reel.

Safepak parking layout

The small parking area outside the gate does not have lines, so people park according to their own wisdom. This sometimes leads to difficulties with reversing out of the parking bay. To overcome this, a layout is designed and lines are made. A trial is done with lines of limestone powder and people have been noticed with a friendly note. The new lay out works very good and I recommend making permanent lines soon, before a rainy day washes the lines away.

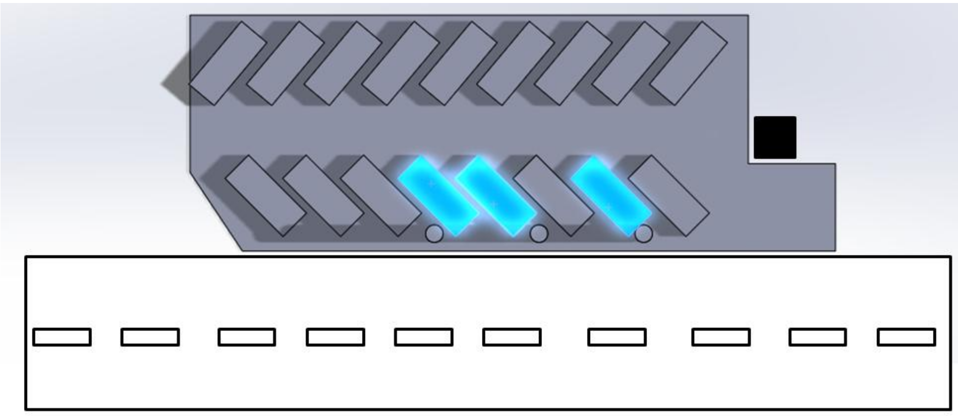


Figure 26 – New parking layout

Collapsible crate system

Currently the wicket bags are stacked in cardboard boxes. To prevent them from folding a pieces of cardboard is attached to every 100 of bags. This requires quite some work and material. The idea is to have reusable crates in which the bags can be hanged on rails instead of stacked. This makes filling and emptying the crates easier. A suitable crate is selected and trial has started.

Figure 27 – Prototype for hanger system

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