YRKESHÖGSKOLAN
NOVIA

Development of Production Line

Quality Check Camera

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BACHELOR´S THESIS

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Abstract

This Thesis was commissioned by Edupower Ltd, the development is for a customer of Edupower Ltd. The purpose of the thesis was to plan an improvement of an existing production line, to develop the production line with a better quality check of the products being produced at the line. With higher quality from the production line the amount of waste production will be minimized which will result in less money loss and better products.

The whole project is a theoretical development and plan, how the development of the production line could be executed if the customer considers it necessary. The project includes different moments, all from gathering information and knowledge about the current production line and the production to research about different suppliers that offer smart cameras that could be used for this purpose. Comparison between different solutions and brands will be included as well.

The result of the thesis is a summary of what option would suit this purpose the best, both in quality and cost-wise. The result is also containing the choice of the supplier of the camera and how it should be executed for the most efficient performance.

Language: English Key Words: L27, Quality Check, Cognex

EXAMENSARBETE

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Titel: Utveckling av produktionslinje

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Abstrakt

Det här examensarbete är gjort på uppdrag av Edupower Oy, Projektet är gjort till Edupowers kund. Meningen med detta projekt var att förbättra en redan existerande produktionslinje. Detta projekt fokuserar på utvecklingen av en kvalitéts kontroll som skulle kontrollera produkterna som produceras vid linjen. Med högre kvalitét vid produktionslinjen skulle andelen felproduktion minimeras vilket i sin tur skulle bidra till mer lönsam produktion med högre kvalitét.

Hela detta projekt är endast en teoretisk utveckling, hur en eventuell utveckling skulle kunna genomföras om kunden anser det nödvändigt. Projektet omfattar många olika moment, allt från att samla information samt kunskap om den befintliga linjen och processen till att ta reda på vilken leverantör av kameror som skulle vara passande för detta behov. Jämförelse mellan olika lösningar samt leverantörer framkommer också i detta examensarbete. Även placeringen av kameran framkommer, vad det finns för för- och nackdelar angående placeringen av den vid produktionslinjen samt hur stor betydelse det har för det slutliga resultatet.

Resultatet i detta examensarbete består av en summering av vilken metod som skulle lämpa sig bäst, både kvalitéts- och kostnadsmässigt. I resultatet framkommer även valet av vilken kameraleverantör som skulle vara lämpligaste samt hur det skulle realiseras för bästa prestandan.

Språk: engelska Nyckelord: L27, kvalitetskontroll, Cognex

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Tiivistelmä

Tämä opinnäytetyö on tehty Edupower Oy:lle ja projekti on tehty Edupowerin asiakkaalle. Työn tarkoitus oli suunnitella ja kehittää jo olemassa olevaa tuotantolinjaa, ja projektin päätehtävänä oli kehittää tuotantolinjan laadunvalvontaa. Valmistettujen tuotteiden korkeampi laatu johtaa vähempään hävikkituotantoon, ja siten vähempään rahan menetykseen sekä korkeampaan laatuun.

Projekti on ainoastaan teoreettinen kehitys siitä, miten projektia voisi mahdollisesti toteuttaa todellisuudessa, jos asiakas näkee sen tarpeellisena. Projekti sisältää monta eri momenttia, mm. tiedon keräämistä ja tietoa olemassa olevasta tuotantolinjasta sekä prosessi, joka selvittää mikä kameratoimittaja sopisi juuri tähän tarpeeseen. Vertailu eri ratkaisujen ja toimittajien välillä on myös toteutettu.

Tämän oppinäytetyön tulos koostuu yhteenvedosta siitä, mikä menetelmä olisi sopivin sekä laadullisesti että kustannuksellisesti. Tuloksessa esiintyy myös valinta sopivimmasta kameratoimittajasta ja miten se toteutettaisiin saavutakseen parhaimman mahdollisen suorituskyvyn.

Kieli: englanti Avainsanat: L27, laadunvalvonta, Cognex

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1 Introduction

This thesis is a commission by Edupower Ltd. This thesis is a development of a production line with the focus on product quality check with help of some sort of camera and a scale for weighing the product.

My thesis is focusing on the camera part, another thesis will be focusing on the scale and weighing. The project has been mainly done by me and another student, which means some of the work will be very similar but with different main problems. This thesis will include some details about the scale as well because the camera and scale are both needed on the same production line.

The development of the production line is for a customer of Edupower, where Edupower also is active with other projects at the same time, so the expertise and help will be close.

This whole project is only theoretical planning, with the ability to execute everything in the future if the customer is willing to and likes the outcome.

1.1 EduPower

Edupower Ltd is a company located and founded in Vaasa in 2012. The company works with Lean leadership, coaching and education for companies in need. Edupower´s head office can be found Vaasa and other offices are located in Espoo and Turku, the company works also in selected foreign markets. (EduPower, 2021)

Figure 1. Edupowers logo.

1.2 Lean production

The word lean production is all about a systematic method to reduce and eliminate everything that is seen as futility and waste. This comes from the Japanese word “Muda” which means of uselessness and futility.

Muda, futility and uselessness can often be found at various production systems, this might be an unnecessary cost for the company and without this cost the company would be able to make a better profit from the production.

With lean production, overproduction is also considered and is called “Muri” and stands for overburden in Japanese. This means that producing to match is not a good thing either, because then money and time go to waste for something that not even is going to be used or sold.

Mura which also comes from Japanese and stands for unevenness, means that uneven production or other maybe unwanted action around the product and production.

(Leanempowerment.se, 2021) (kanbanize.com, 2021)

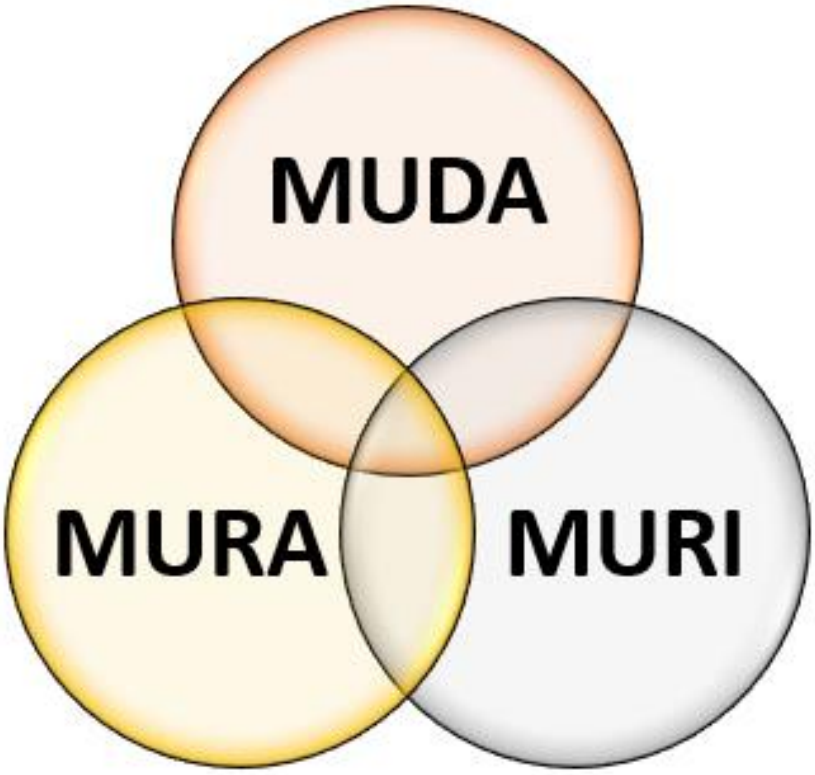

Figure 2. Illustration how these three words are overlapping each other and why they are important.

When talking and working with lean production, there are usually 7 factors even called the 7 wastes of lean production which are the following:

1. Inventory
2. Waiting
3. Defects
4. Overproduction
5. Motion
6. Transport

7. Over-processing

Figure 3. Illustration of the 6S cycle.

5S, sometimes even called 6S, the sixth S comes from safety, so when safety is added to the process in 5S it becomes 6S.

5S(6S) and Six Sigma are two different methods with separate main areas that they focus on. The 5S(6S) main focus area is to eliminate waste and inefficiencies at the workplace, this method can be applied to actions and departments in a company, all from small businesses to large industrial companies.

Six Sigma is a process improvement strategy that looks to eliminate defects by implementing standard procedures and processes, also by identifying where or what the problem area is and what it is due to.

In this case the customer is already familiar with this technique, they have been using similar methods earlier in the company but during the years the activity and the commitment are not at the same level as they were before.

But now when the company is using Edupowers' expertise, they have re-established the concept again and it is possible to see changes already from the start. The progress is usually quite slow just to get everybody used to the new changes that will appear in the production facilities and new standards to follow.

2 Problem

The main problem now is that the quality check at the production line is being done by the operator or some other person manually, by taking a sample of 10 pieces of the produced product and measuring and weighing it to see the quality. When everything is done by a person it means that it always requires someone to be able to do quality checks frequently.

With a separate module that is including a camera and scale the quality check would be much faster and more effortless for the company. It should also increase the amount of successfully produced products when every single piece is both photographed and weighed and then sorted as a qualified or incorrectly produced product. If qualified the product should continue the production line till on the end of the module where it would be ending up in a box for further steps as packing and be sorted as a finished product. The faulty product should immediately be pushed to the side to a separate container that contains waste that moves on to regrinding and could be reused.

The main problem is that the production line is an old and running line, the production line is almost running every week and producing products. But the customer wants a new module that could easily be attached to the existing line. The company already has several different modules that are used when certain different products are produced.

2.1 SWOT-Analysis

A very simple way to analyze what a company currently is doing best and what is needed to be changed. A SWOT-analysis is also a very common and easy way to create an understanding of a company or a production unit.

The SWOT-analysis in this case is being listed under each heading, the biggest factors in the production process.

Figure 4. Illustration of the SWOT.

Down below are points listed about the company, all from their strengths, weaknesses, opportunities and threats as a company.

- **S- Strengths**
    - Knowledge, maintainability, industry area, self-construction of machines.
- **W-Weaknesses**
    - Raw material, set-times, amount waste production.
- **O-Opportunities**
    - Wide range of usage, environmentally friendly, biodegradable plastic.
- **T-Threats**
    - Raw material, long shipments. High chance to failure in production phase.

3 Goal

The main goal of this project is to accomplish an even better and higher quality on the customers production line. Higher quality is important as well for the consumers and for the company producing the products.

With this renewed production line, or the quality check module that is being planned for the production line would help the process where the quality is controlled with help of a camera or two and a scale that weighs the products automatically, every single piece being produced will go through the quality check module.

With the quality check module there will no longer be any person who randomly picks different test pieces from the production and then is controlling them manually every now and then to check that the quality is the best the company can offer.

Also, the amount of waste production is something that the company wants to be much less than nowadays, because waste production means loss of money and time that could have been used for other important things.

Since the production line is producing a lot of different products and new models may appear the user interference will be easy to maneuver and to add a new product and make changes to already existing products if needed. All these settings would of course be behind password walls, secured that only competent employees have the rights to access it.

4 The production line at present

The company is running the line (L27) at present, the line has been in use since 2009, The production line has been under continuous development since the beginning, the strive is to develop a more efficient and smarter production line. Although the line has been in use since 2009 the production is not running every day or even every week. Sometimes the production line can stand on standby for even a longer time, a lot of this is due to demand and access to raw materials.

The production line today is operated by 5-6 different operators, the customer of the product requires traceability of the operators because the final product is medically used by hospitals, athletes, veterinaries' and many more.

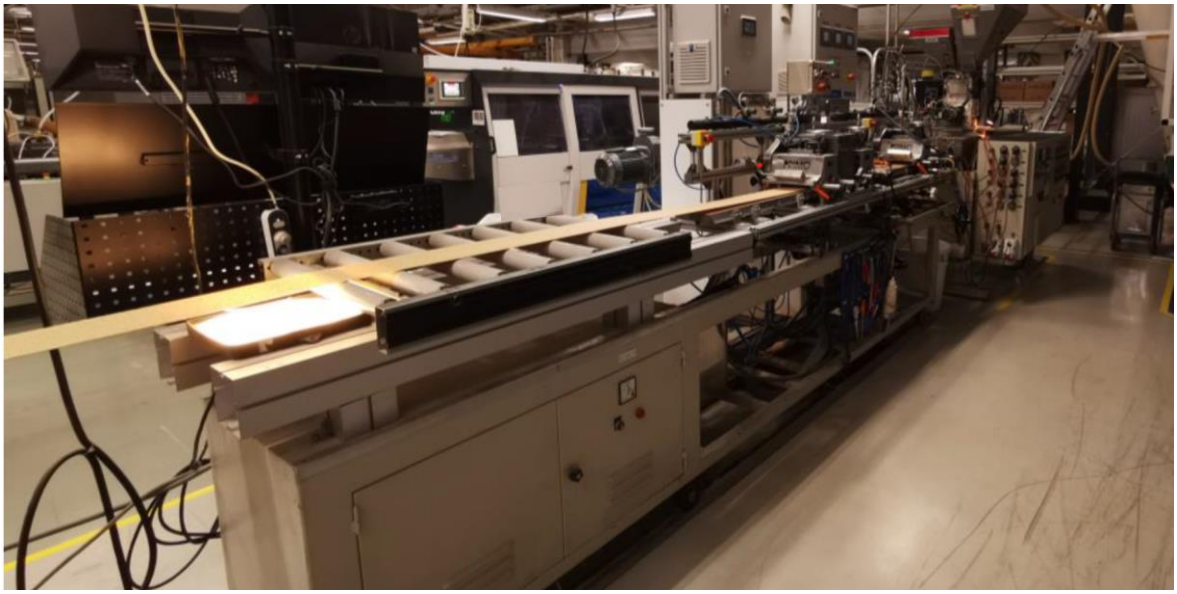

Figure 5. This picture is a part of the production line.

4.1 Waste production

At the moment the amount waste and scrap product is pretty large, one of the main reasons for the large amount is the time it takes before the operators can reach the right thickness and width of the product when starting the production at the production line.

In the start-up there are a few extra challenging steps such as the temperature of the mixture of the plastics and the woodchips mixture. Another is the speed of the process before the speed is good.

Normally the start-up time is all from 30 minutes to 2 hours before the right and approved product is produced, the time of the start-up is one very big and critical step in the order of the amount of waste product that is coming from the production line.

Therefore, the company strives to do longer production runs when possible, because of the long set time before all is set and running correctly. The percent on a longer shift with products being manufactured the percent is usually something around 25% waste of the whole production of the produced batch.

But sometimes the percent waste product can be as high as 40% of the whole produced batch that day. But usually when the waste rate is that high it depends on shorter productions intervals, that’s just because the start-up is such so critical and time demanding phase of the production.

At the moment the amount of waste production can be relatively high, why the waste or scrap is so high is the lack of knowledge of how to best start up the production when it has been on standby or been out of production for a time.

Down below is data from the production line (L27), as seen the planned scrap percent is relatively low compared to the actual scrap percent. The result of this scrap-check is that there is a way too high amount of material that is going to waste.

Planned Scrap %	Actual Scrap %	Planned vs Actual Scrap
11.3%	**40.3%**	**28.9**
11.5%	16.4%	4.9
11.5%	48.9%	37.4
10.0%	41.0%	31.0
10.0%	7.9%	-2.1
10.0%	70.7%	60.7
10.0%	45.4%	35.4
9.6%	57.5%	47.8

9.9%	60.6%	50.7
10.0%	20.4%	10.4
15.0%	59.9%	44.9
10.0%	72.3%	62.3
10.0%	47.8%	37.8
9.6%	38.9%	29.2
10.0%	80.3%	70.3
9.9%	47.2%	37.3

Figure 6. This picture is showing data from the production, the data is from L27.

4.2 Reuse of waste product

At the moment reuse of waste products is possible, but the rest product is only allowed to be used on animals by veterinaries, which means that the consumption is not as high as it could be if it was allowed to use in other areas where the ordinary product is used.

4.3 Production factors

The factors currently are different set-times, sometime the set-time can be very long. Especially when the start-up time can be up to hours at the moment. Usually, the normal start up time when starting the production line is all from 30 minutes to 2 hours. This is

something that would save a lot of time, money and accelerate the production rate, if some improvements would be done.

- What kind of product is going to be produced?
- Start up!
- Correct mixture, otherwise, the mixture is not homogenous.
- Packing, sorting
- Set times / Down times

4.4 Production Process (Current set-up)

Below is an illustrated picture of the production line and set up at the present.

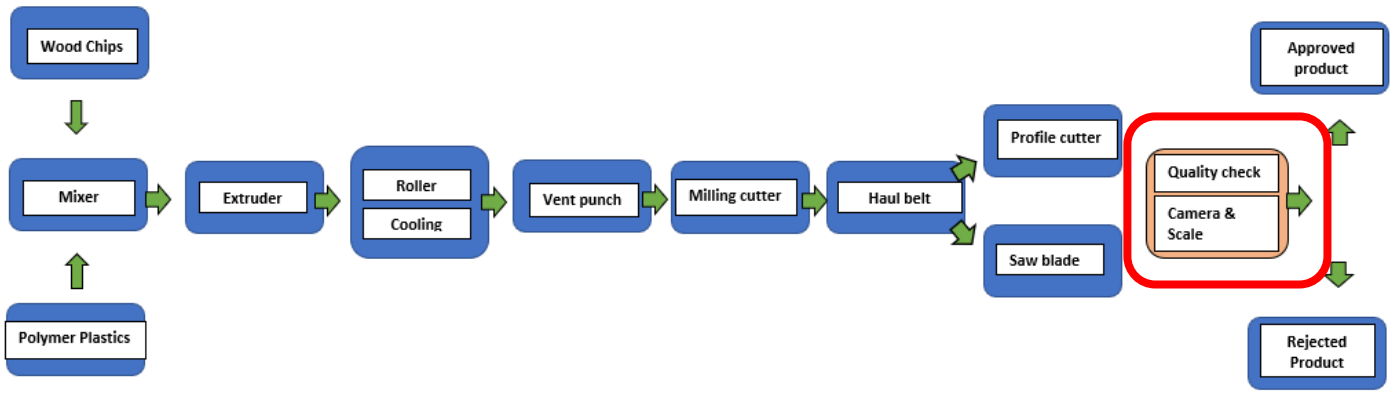

Figure 7. Illustration of the production line and the order of the process.

This illustration of the production process contains the different steps in the production at the production line. The box that is marked with the red box is the new module where the camera and scale will be placed in the production line.

The production process all begins from the raw materials, the materials come from different containers. The wood chips are delivered in big bags that is vacuumed to the mixer as well the polymer plastics come in smaller bags that are manually filled into a sort of funnel where it is later vacuumed into the mixer.

In the mixer the wood chips and the polymer plastic are mixed, then it the mixture goes into the extruder.

In the extruder the mixture is heated up to wanted temperature and being pushed through with the rotating screw that is pushing the mixture through the extruder nozzle. The nozzle is always changed depending on what kind of model being produced.

The next step is the roller where the mixture mass is coming from the extruder, the roller is shaping the hot mixture. At the same time the mixture is going through the roller it is cooled down with the integrated cooling bench, which means that cooling water is flowing in ducts in the bench.

Next in line is the vent punch which is punching small holes into the product while it is moving through the vent punch, afterwards the product has gotten its ventilation holes it comes to the next machine which it is going through.

The following step is the milling cutter because when the product is getting its ventilation holes punched it makes some small sharp points on the bottom side of the product. But then the milling cutter is making the bottom side smooth again for the best finish.

Following with the next step where the product is getting its shape, there are some options if the shape is going to be straight the product is just sawed with the saw blade module, but if the product is going to be some certain shape/model then the product is going to face the profile cutting machine, where the product actually is punched into the wanted shape.

Now the next step on the production line is the new module, where the final product is going through the most important check, to see if the product is good enough. The quality check is done by a camera and scale that is going to be an own module that is possible to move around in the production area.

Last but not least, the product is approved or rejected. If approved the product is moving along to a certain box where all approved pieces are stored, if some pieces are not qualified during the quality check they are immediately removed to the side so they are not going to be mixed with the good products.

These will be happening after the product has been weighed, because a product that would pass the camera check would not necessarily pass the quality check with the weight.

5 Planned new features

This chapter is going to include what kind of new features that are planned and wanted for the production line in the future. The following points are criteria and important things about the production line.

- Camera quality control
- Scale control
- Quality check will provide higher quality, which means more satisfied customers.
- Easy movable module, Movability
- Time is money, faster production with higher quality.
- Strive to Zero waste production!
- Sorter, pushing the not approved piece to side and the approved pieces is going to a separate place where they are packed.

6 Product

The product that is being produced at L27 has a very wide and large area of use but is mainly used by hospitals and veterinaries but also by professional athletics. The range that the product can be implemented in is very wide. The product is based on wood chips mixed with environmentally degradable polymer. The mix of the materials is produced with extruding technique.

The product is fully biodegradable by the environment, it only contains two well-researched elements. There are no phthalates, latex or isocyanates in the product, a completely non-toxic product.

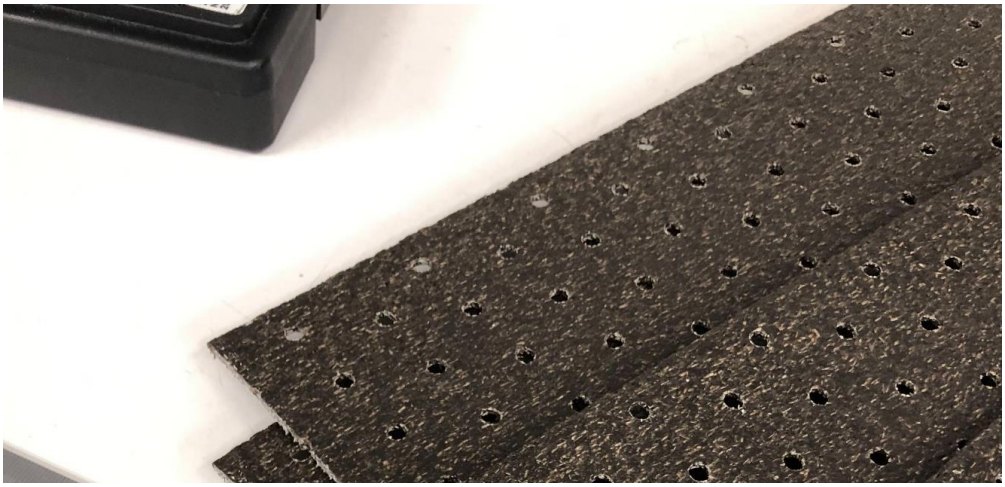

Figure 8. Snapshot of a produced piece from the production line (L27).

6.1.1 Quality criteria

The quality criteria are many, every different model has their own requirements regarding both measurements in width and thickness and the total weight of the product.

The following steps are order of importance:

1. **Weight**

   The weight of the final product is the most important factor if the product will make the quality check or not. By the weight it is possible to tell if the mixture of polymer plastics and wood chips is correct and homogenous. Preferred is that the final product is a weighing a little more than the requirements than less, because if it weighs less it will immediately be considered not passed.

2. **Measurements**

   As every model have different measurements requirements, they have to meet certain measurements. The product has a specific length and width to meet, there are small margins for both the length and the width how much they are allowed to deviate from.

3. **Shape**

   The shape of the products is also different, and some products contain small holes that are being punched. All products do also contain small ventilation slots on the back side.

   With the check of shape, the most important is the amount of the holes done by the punch, with more or less holes it will affect the weight quite easily if it is more or less than it should be.

6.2 Material

The raw material is wood chips from aspen and biodegradable polymer plastic, both materials have their countries of origin from Europe. The raw material is also not the easiest accessible and quite expensive. Also, since the coronavirus pandemic hit the world the availability and price have become even tougher.

7 Standards

The customer has three different standards, all of them are very well-known standards worldwide. These standards are highly valuable both for the customer and for consumers of the product, to ensure that the product is of the highest quality.

7.1 ISO 9001

- A standard that is used internationally ISO 9001, this standard demands the organizations quality check department. This standard is the most common tool for building and developing the quality check departments.

7.2 ISO 14001

- This is the most known standard of the environmental management system. This standard has the goal of developing the environmental aspects, such as sustainable development.

  ISO 14001 standard is defining resources, processes and methods, so the company is able to follow the criterias' what the standards is requiring.

7.3 ISO 50001

- This standard ISO 50001 is directing and guiding the organization towards the right and sustainable energy usage.

  With good control over the energy management the organization is not only saving the planet but also money for other things in the company.

  (SFS, 2021)

8 Flow Chart

This illustration of a flow chart shows the order in which things are being processed at the production line and in which steps they are going through.

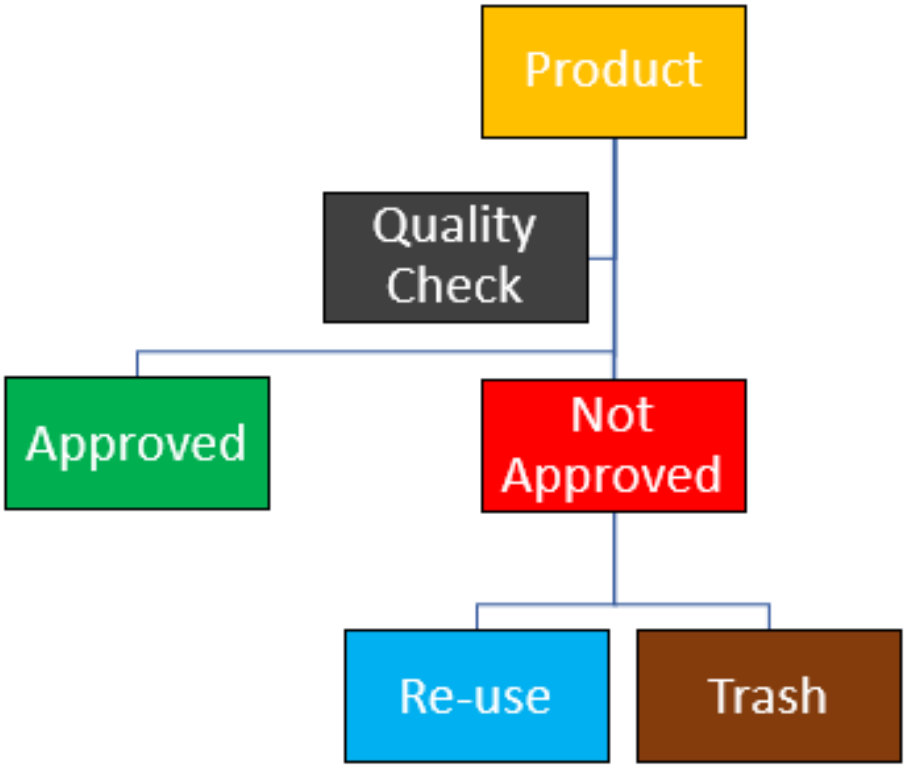

Figure 9. This image is illustrating the quality check process at the production line.

9 Quality check module

One of the project's main parts is the module, this is where everything is going to be assembled. The module includes the camera, scale and some type of conveyor to transport he products that are being manufactured. The module is also going to be able to sort the products that is qualified by the quality check and the products what is not fulfilling the criteria. The qualified or the bad product is then sorted by help of the high-pressure air connected with some kind of arm removing the bad quality products to the side while the qualified products move along the conveyor band.

Something the customer wants is the opportunity to be able to extend the module or at least make it to handle even bigger products being produced in the future.

The maximum length being produced at the moment is 900mm long, but the customer wants to ensure it is possible to handle pieces up to 1500mm pieces.

9.1 Camera shelter

The camera module will need some sort of camera shelter to protect the camera(s) from unwanted movements and other factors that could have some impact on the camera when it is operating.

The camera shelter will at the same work as protection from dust and things getting in touch with the cameras that could eventually move or put the camera in an incorrect placement from where it has been calibrated to operate. Another very important thing that the camera shelter is doing is to protect the camera from unwanted lights that could disturb the camera and affect the outcome of the quality check.

The accessibility to the camera is important to be easy, because if something would disturb or affect the camera or lens it has to be easily reachable and be resettled so the production can continue normally without any longer stops.

10 Camera options

The amount of different camera manufactures is large in the industrial business, in this chapter I have been looking closer on three different manufactures. These three companies all offer smart vision systems and other smart camera solutions that could suit this project.

10.1 Cognex In-Sight 7050

The camera that is going to be used in this project and module is a Cognex In-Sight 7050. Why the choice of camera became Cognex and the In-Sight 7050 model, one of the main reasons is that the customer already has two of these camera types up and running in the production hall. But the cameras do not have any necessary function where they are placed so it would be an excellent opportunity to use the cameras at L27 instead.

The model In-Sight 7050 belongs to one of the tougher models in the Cognex 7000-series of cameras.

Figure 10. Image of the Cognex IS 7050. (Cognex IS-7050, u.d.) (Cognex, 2022)

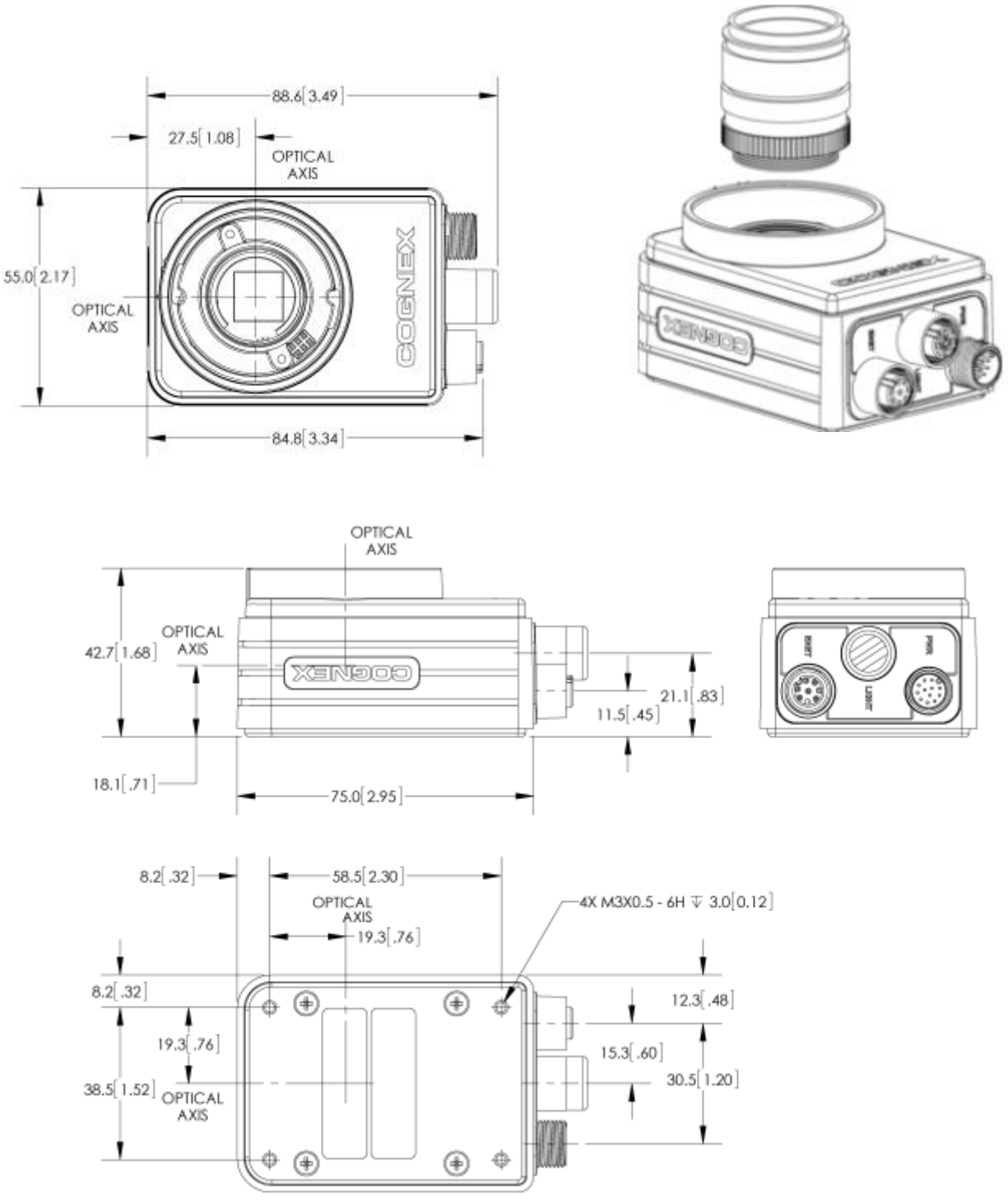

Figure 11. Images of the camera with measurements and how to eventually fit it on different places. (Cognex Data Document, 2021) (Cognex, 2022)

10.1.1 Cognex In-Sight 7050 Technical data

Down below is a chart of the technical data.

Specifications	Cognex In-Sight 7050
Minimum Firmware requirement	In-Sight Version 4.9.0
Job/Program Memory	512MB non-volatile flash memory; Unlimited storage via remote network devie
Image Processing Memory	256MB SDRAM
Sensor Type	1/1.8-inch CMOS
Sensor Properties	5.3mm diagonal, 5.3 x 5.3µm sq. Pixels
Maximum Resolution (Pixles)	800 x 600
Electronic Shutter Speed	16µs to 950 ms
Acquisition	Rapid reset, progressiv scan, full-fram intergration
Bit Depth	256 grey levels (8 bits/pixel)
Frames Per Second	102 full frames per second
Lens Type	M12 or C-Mount
Trigger	1 opto-isolated, acquisition trigger input. Remote software commands via Ethernet and RS-232C
Discrete Inputs	3 general-purpose inputs when connected to breakout cabl
Discrete Outputs	4 high-speed outputs when connected to breakout cable
Status LEDs	Network link and activity, power and 2 user-configurable
Internal LED Ring Light	Red, Green, Blue, White, IR (M12 lens configuration only)

Network Communication	Ethernet port, 10/100 base with auto MDI/MDIX. IEEE 802.3 TCP/IP PROTOCOL
Serial Communication	RS-232C: 4800 to 115,200 baud rates
Power Consumption	24VDC ± 10%, 2.0 amp.
Material	Aluminum housing
Finish	Painted
Mounting	Four M3 threaded mounting hoels (1/4 - 20, M6 and flathead mounting holes also available)
Lens Cover View Port Material	Clear, hard-coated optical grade acrylic precision sheet with scratch-resistance coating on sides
M12 Lens Configuration Dimenssions	55mm (2.17in) x 84.8mm (3.34in) x 55mm (2.17in)
Weight	220g with lens cover and typical M12 lens installed
Operating Temperature	0°C to 45°C
Storage Temperature	-30°C to 80°C
Humidity	90%, non-condesning (Operating and Storage)
Protection (IP)	IP67 with lens cover properly installed
Regulatory Compliance	CE, FCC, KCC, TÜV SÜD NRTL, EU RoHS

Figure 12. Datasheet Cognex In-Sight 7050. (Cognex, 2022)

10.2 Opto Engineering

Opto engineering has many camera options, but their selection does not really meet the demands what I am looking for this project.

Their cameras are not designed to perform image processing, because it is usually in charge of different software libraries. Opto engineering offers a much more flexible solution where you have the possibility to optimize all the integration and analysis to the wanted needs.

I have been in contact with opto engineering regarding their selection of cameras, after some research and discussions with them I realized that their models are not something that I am looking for now.

Their options would need a separate programmer that could code programs and software for the cameras depending on the needs. Opto is offering several different software libraries also but changes and optimizing still would have been needed to do for the final program. In this case that would mean that the customer would need a “in house” programmer that would master these skills or some external supplier that could provide these services.

Also Opto engineering does not have any importer or services located in Finland.

10.3 Basler

Basler is a leading international camera manufacturer that is providing customers in automation, medicine and traffic and many more industries with cameras and accessories. Their headquarter is located in Germany.

Basler is imported and is being marketed by OEM in Finland, with its headquarter in Turku. The good thing with both importer and marketer in Finland is that services and easy access to knowledge and help are near if needed.

I have had contact with Basler and I was forwarded to OEM and after some discussions and thinking I was offered following from their selection of cameras and accessories. A positive thing with Basler products is that they are offering all from cameras to complete software's depending on what the customer need.

The requirements were to be able to do a control check on a product up to 950mm long and 150mm wide. This camera model can work with products up to 1500mm long and 200mm wide.

- Resolution approximate 5MP or higher global shutter camera to see the 1-3mm sized flaws.
- Density check possible with backlight, must be at least as big as the product. If the whole product is wanted to be seen in one frame.

AREA SCAN

Item	Product code	Description	Price
Area scan camera	aca2500-60um	Ace 2590x2048 / 60fps USB3 mono	860.00 €
lens	C11-0824-12M	OPTIC C FIX 08MM 12P 1/1" Basler Prem	252.00 €
cable	2000033239	Kaapeli USB 3 Micro B screw lock-A 3m	27.00 €
software license	DAXWINPU	Matrox DAX Win Developer (USB+DVD)	3,555.00 €
Runtime license	MXRT M 0 0 0 0 0 0 0 0 00	MIL 10/X Machine Vision package. Includes Image Processing, Blob Analysis, Bead Inspection, Pattern Matching (NGC-based), Measurement and Calibration modules.	310.00 €
Light for 1500x200mm area			
	BL4008-WHI24	Back-Lit Backlight, 40" x 8", White, Dual 24v	3,400 €
			8,404.00 €

Figure 13. Picture: Potential Offer and all the items needed for the camera setup, from email conversation with supplier.

For this project Basler recommend the camera model: Ace 2590x2048 / 60fps USB3 mono.

The offer also contains other accessories needed to run the camera, such as software license and runtime license. If more cameras than just one are needed it is enough to just purchase the runtime license.

Lights for the backlight for the product are also listed.

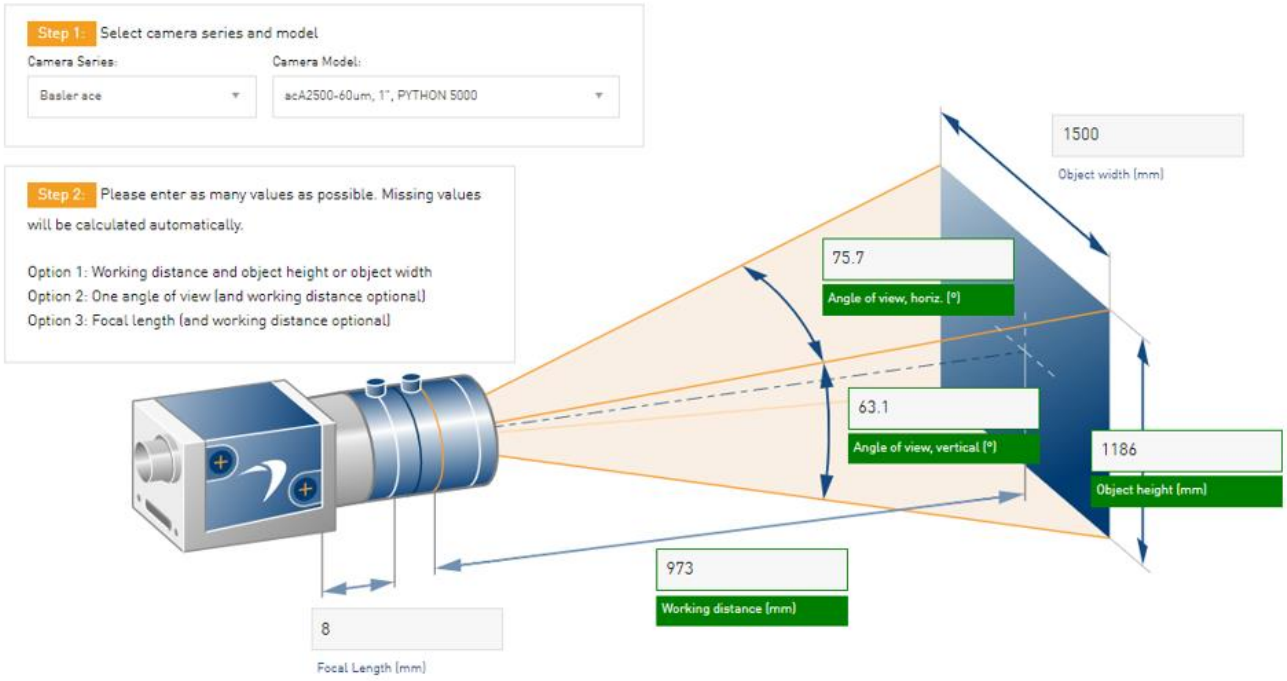

Figure 14. Picture: Illustration of Basler camera optical calculations with measurements.

With the working distance between camera and product, in this case 973mm from the product it would be able to check a product sized 1500x1186mm with an 8mm lens.

The field of view might also be changed to smaller if focal length and lens is changed.

10.4 Camera accessories / Optics

Other optics needed for the best performances are lights, that are very bright and placed so they are focusing on the product that is being produced and checked by the camera. Without proper light a product with defects could easily slip through the camera check.

Another very important thing is that the camera is well hidden or placed in a camera shelter that protects the camera from non-wanted movements or shadows that may appear from other actions around the production line as a person moving by or a truck.

10.5 Utility

The utility of the camera, as well as the scale combined with the camera in the module will make huge improvements. The quality will increase to even a higher level than it is at the moment, which means that with the new module every single piece produced at the line is going through a quality check. This will be a very huge difference, as the company only being able to do quality checks at the moment manually by a person that is picking e.g.10 random pieces and controlling them individually visually and with a scale and a calipers.

10.6 Camera positioning

The positioning of the camera is one of the main questions, should the camera be positioned before or after the scale? Or maybe they should be positioned so they both are active at the same time.

The placement of the camera is a very interesting question, because the camera is going to co-operate with a scale. So should the camera be in front of the scale, after or at the same place as the scale?

In this case the camera would be best if placed together with the scale so they both would be active and operate at the same time.

Eventually the camera could also be placed just before the scale because the importance of the weight is much more important, if the piece is to light the piece will be considered immediately not passed in the quality check.

10.7 Camera Angles

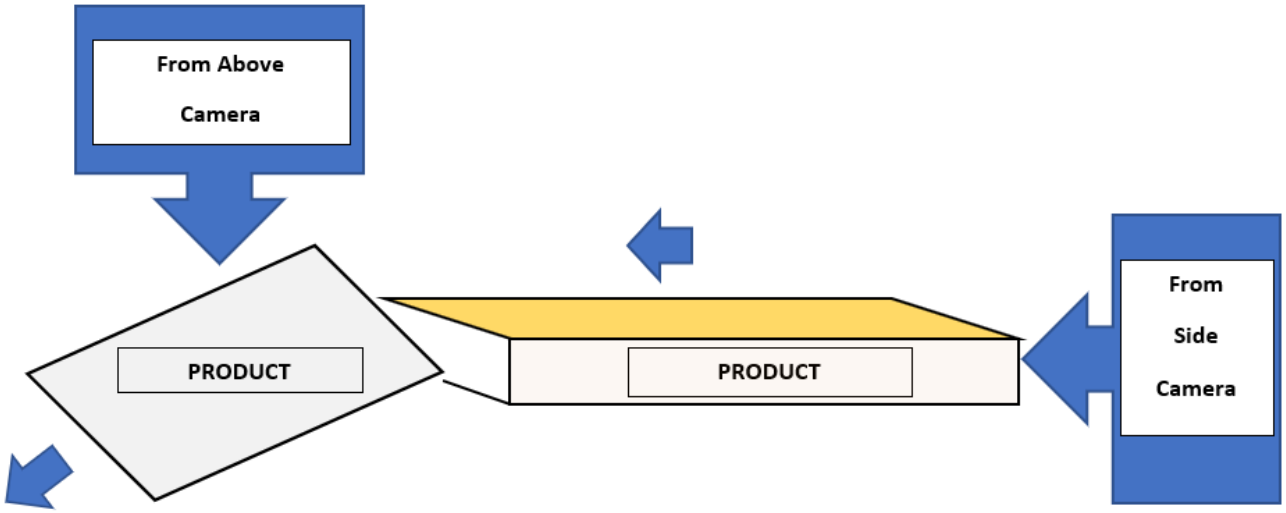

Figure 15. Illustration on camera placements and camera angles.

The placement of the cameras is very important, when using two different cameras the area of what is possible to check increases a lot more than just using one camera. It is possible to only use one camera as well, but the same area and quality will not be the same as using two.

The advantage of using several cameras is that the quality check can be done both from the top, controlling that the product is shaped correctly and is containing the right amount of ventilation holes when they are produced. It is also possible to check the thickness of the product when one camera will be positioned on the side measuring the thickness of the pieces passing by. All these camera checks will be done at the same time when using two separate cameras in the quality check.

10.8 Image analysis

When the camera has captured an image, they are going to be processed, the image process is being done usually by the camera system. The processing is made by a smart camera system that is made especially for the demand that is required for the wanted outcome.

The process is divided in steps, the first step is to add a filter that will make the image clearer and highlight the contrast in the details of the image. The following step is the extraction from the digital image and processing it in an external computer system where the software is reading the image codes and texts.

In the third and final step the image is compared to the wanted product, the comparison is done with wanted values and limits that have been set for the product.

With these following steps the product is considered passed or not passed in the image analysis.

10.8.1 Camera Features

- Blob tools
- Edge & Inspect Edge tools
- Flaw detection tools
- Geometry tools
- Histogram tools
- ID tools
- Image filtering tools
- Optical character recognition tools
- Pattern matching tools

- Color pattern matching tools
- Color tools

All these points listed above are different tools used for image analysis.

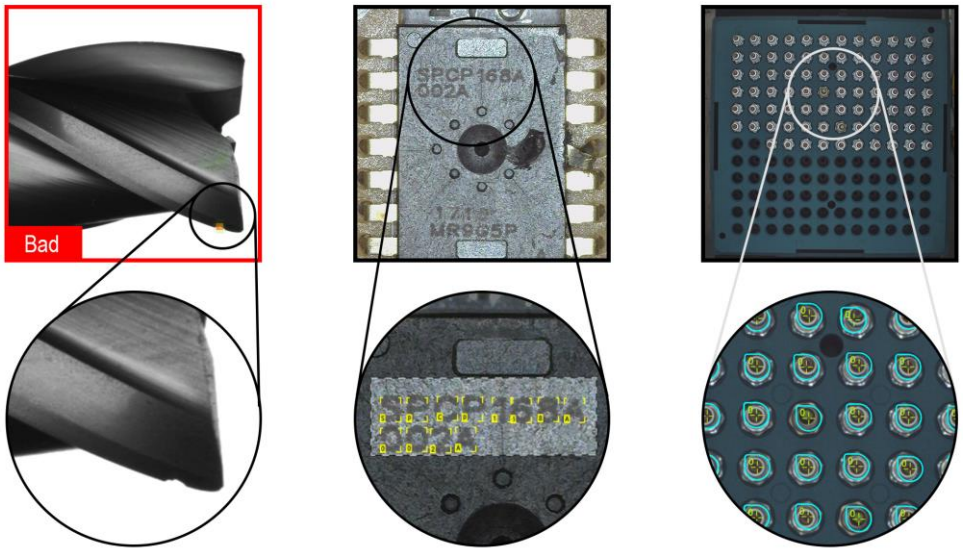

Figure 16. Image of showing different image analysis methods done by Cognex.

10.8.2 Software

The software is the key to usability, it should be easy to use and to understand without reading the whole instruction manual. The software will be locked from outsiders or people without permission, but just with some password or something easy maneuvered. It should

also be easy to do changes, if you have to add a new product with other specifications than the elders' ones that already exist.

10.8.3 Interfaces

Interface is something hugely important, especially when there are many different operators at the same production line and new products might have to be added to the system as well. It should be smooth both for the users' eyes and easily maneuvered.

Without a user-friendly interface, the set time during the switch of products may cause very long and unnecessary stop times, all due to complicated interfaces. As well as when the production line is operated by different workers in different shifts.

11 Maintainability

Maintainability is something that is very important, it should be easy to access different articles if changes or maintenance must be done. Both cameras should be accessible without the need of tools and work, the camera lenses have to be easily reachable because the amount of dust might be relatively high due to the large production hall and other production lines.

It is also very important that maintenances can be done by all the staff/personnel who operates the production line. So, in order to make everything as easy as possible, the

documentation of the whole module / construction is a very useful document about everything regarding the module.

11.1 Spare parts

Spare parts are another extremely important question, without access to spare parts the whole production line could in the worst scenario cause big problems for the production, customer and the company due to long stops in the production.

The availability for the spare parts for the camera and the scale is very important, just because if something is broken or need to be replaced it has to be easily accessed so the production will not suffer from longer standby.

12 Results

The result of this project was good, a lot of experience has been gained during this process. The theoretical goal I had in my mind when beginning this project is quite close to the final result, of course the outcome is something different, but the principle was close.

The main goal of this project was to develop a quality check for a production line that already is up and running at the factory, the quality check is divided into two separate projects, this project was focusing on the camera part and the other is focusing on the scale part.

I am very satisfied with the result of this thesis, there have been a lot of challenging times during the project but with help from the Edupower team and the customer everything has been solved and many good discussions have been held.

Even though the result is only a theoretical development it is fully possible to execute it and build it on the production line.

13 Conclusion / Discussion

This thesis has been very rewarding and instructive, I have learned a lot of different things that I will carry with me in the future and surely will benefit from.

I have learned a whole new way of thinking when it comes to lean production, I am very grateful to have had the chance to be part of a very talented team who has given me advice along the way of the project.

The whole project has included all from interesting meetings to very tricky problems that have needed to be solved along the way.

But in the end, I have to state that the cooperation between the Edupower team and the customer has been really good and very easy to communicate when needed.

14 Future development

As with every project and all production lines there is always possibility to develop something and make something even better and smarter. Something that has been discussed with the customer about different features that could be added later if wanted was some different options. For example, to get the best result with the minimum of waste production the camera should be able to indicate where the “bad spot” on the produced piece is, then calculate where to cut it off, then again reset and calculate to get the right length on the produced piece.

With this kind of feature the waste of material and time could be even lower, the smarter the quality check is the better it will work.

Future developments could also bring something more, but that is going to be focused on when everything is set up and running with the basics first.

15 Reflections

This chapter includes my own reflections about the whole process and project, a short summary, step-by-step description is also presented.

15.1 Task introduction

This thesis was made on commission by Edupower ltd to a customer of theirs. The whole process of this project all from the start has been interesting, rewarding and a learning journey.

It all started with a meeting with Edupowers customer at their place, we looked around in the facilities and we especially put our focus on the L27, what kind of products was produced and for what kind of purpose.

That day we got a guided tour through the factory from the technical development manager himself, it was for sure a very exciting tour and much information to take in.

When we stood at the L27 we were introduce to the product, something very useful and revolutionary, this product is something that may be used in so many different areas and the future developments with this product has just begun.

Now when we were introduced to the product, we started to look at the production line, unfortunately the production line was not running that day, so we were not able to see the whole process in action. Instead, we were told how the line is working but we were promised that as soon they get the line up and running again, they would call us to come and have a look.

On the first visit to the customer, it occurred an unlimited amount of questions about almost everything about the production line, the upcoming project and development.

We got a very clear assignment of what the task was and what kind of features they want for the production line.

Luckily, we are doing this development together with help from a very knowledgeable team and together with a classmate who is focusing on the scale part.

15.2 Planning and research phase

Now when the task was set, we knew what the customer wanted it was time to start brainstorming ideas on how to start and what and how we are going to solve this task with this requirement.

This project is something that I have never seen before, therefore it is very exciting but at the same it is very agitating.

Just a couple of days after the first visit to the customer of Edupower we got called and the production line (L27) was now up and running, so we went over to the factory and checked how the whole process is working when it is active and producing.

Already at the place we started to list different opportunities and ideas of how we could start this project. The beginning was challenging because this was something new and no one of us had ever seen anything close to this project.

The vision came relatively fast from how we wanted to create the module, we had a very clear vision of how the cameras and scale would operate and how we wanted to be able to sort approved and rejected products in the end of the production line.

15.3 The main part

When several different meetings and ideas were being flipped with the customer and the Edupower team, the next step was to get something down on paper and to build up the project.

The beginning was a little bit confusing but with the knowledge and support from my supervisors the puzzle pieces started to find their places. Something that took a lot of time was to be in contact with the different camera suppliers, there was just weeks what went to communicate with them and try to find something from their selection of cameras and smart solutions that could be suitable for this purpose.

But after a few weeks with a lot more information and knowledge about different machine vision systems I finally had gathered the information, I needed for my next step in the project with L27.

15.4 Project essentials

This whole project may look simple and easy, but the process has been really demanding, a lot of small factors and things that have to work, especially together.

Another very important factor is how are we going to get the most value for the money with this project. Next is the purpose of the whole project, how to get everything out of the purpose and see that it is done right.

The environment where the module is going to be is also very interesting and exciting, one good thing is that the L27 is the last production line in the lineup at the factory, which also means that L27 is a little more undisturbed and protected from unwanted vibrations, traffic and other unnecessary motion that could have an impact on the camera or the scale.

15.5 Problems during the project

Problems are something that just is meant to be solved, one major problem during this project has been the coronavirus pandemic. There have been many things that could have been different without this limiting our lives.

I was luckily able to visit the customer's factory and the production line 27 whenever I wanted the three first months of the project and get to see everything by person, I was doing weekly visits to the factory where I was able to talk to the employees, operators and managers. In my opinion it was very important to get to see how everything is being manufactured in person.

In the middle of December 2021, the coronavirus pandemic was taking shape and getting more aggressive in Ostrobothnia, therefore all outside visitors' access to the factory were limited to avoid getting the pandemic in to the company which was obvious.

Fortunately, I already had the information needed and a lot of memories and pictures and movie snaps from the L27 that could be useful during the progress of the project. So, in the end I was not that affected by the restrictions to be able to visit the factory.

15.6 Summary

When looking back on this project the final result is something I had a small vision about but still something much more and a lot different.

During the time working on this project is have gathered so much valuable knowledge, all from lean production to making contacts in the business world. As well as writing this whole thesis in a language that is not my mother tongue, it has been a journey filled with problems that have been solved and finally I have been able to complete this project.

The whole project would never been finished without all the clever ideas being discussed during all the meetings with my supervisors. I have gained so much valuable knowledge I am going to carry with me in the future.

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