MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS
Academy for Innovation, Design and Technology

SANDVIK

TREE FOR LEG

PROJECT, PRODUCTION- MAINTENANCE AND QUALITY MANAGEMENT
4.5 credits, advanced level

Byungwook Cheong
Oguzhan Eren
Joakim Svartström
Erica Visti

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Principals: Sandvik AB
Mentor: Antti Salonen

ABSTRACT

Today's world companies try to improve their facilities and workstations in order to receive more efficient results. In our case, Sandvik, one of the world's leading companies in its area, asked for an improvement in their blaster workstation. The task was to improve a workstation and develop a solution in order to receive a more efficient workstation for both the operators and the manager. We were asked to draft and design a better solution, three concepts of a tree used for the blaster machine were presented because the current tree was not sufficiently blasting the inside of the component properly and it was difficult to place components on the tree. Therefore, three concepts were designed for three weeks in CAD programs and presented to the manager of the company. One of the ideas was applicable for the tree and they decided to build a prototype of the design. The prototype consisted of three similar ideas with some little changes in one of the trees; thus allowing us to see which one was the best. As a result one of the designs, with three circles and three pegs, was chosen and the company will probably use the concept in their workstation.

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1 INTRODUCTION

This project is a course element in KPP206, Production- Maintenance and Quality Management, at Mälardalen University in Eskilstuna. The project is a group work and intends 4.5 credits at advanced level.

1.1 PROJECT SPECIFICATION

It's becoming more and more important for companies to constantly keep an optimized production to maintain competitiveness and profitability. There are saving opportunities for companies if the right equipment is available. Companies with production should continually review its manufacturing in all aspects to lower the use of resources and reducing costs. But more important the operators working at the station must have an environment where they can work ergonomically and be safe. The task in this project is to improve a workstation at Sandvik. This will be a combination of us as "consultants" with new eyes looking over the fabrication and a close cooperation with the experienced operators with a lot of knowledge of the processes. This job describes the development of a tree for hanging legs.

2 PURPOSE AND GOAL (EXPECTED OUTCOMES)

The purpose with this course is to gain a comprehensive understanding of production, maintenance and quality in industrial activity. Besides this the purpose is:

- Improve the existing workstation
- Develop products/solutions that satisfy demands from both operators and management
- Design with ergonomics in mind

The goal with the project is to develop a concept ready to launch in nine weeks.

3 PROJECT BOUNDARIES (DELIMITATIONS)

There are three tasks in the solving of the lifting tool – the actual tool, the design of the "tree" and a solution for a more stable "tree". The main focus will be the development of a suitable "tree" to place the parts called "leg" before going into the sand blaster machine. The developed tree has been inspired by the size $12^{1}/_{4}$" with a batch size of 15.

4 SANDVIK AB

Initially a general description of the company and the task will be presented.

4.1 COMPANY DESCRIPTION

Sandvik Group is a high-technology engineering group specializing in tooling, materials technology, mining and construction. Sandvik is also a globalized company and their business activities are spread out across 130 countries all around the world. In 2012, they had around 49.000 employees and their sales were approximately 99.000 MSEK that year. Sandvik Mining, Sandvik Coromant, Sandvik Materials Technology, Sandvik Construction and Sandvik Venture are the companies within the Sandvik Group. In our project, we focus specifically on Sandvik Mining in Eskilstuna.[1]

4.1.1 SANDVIK MINING

Sandvik Mining is one of the leading global suppliers of equipment, tools, service and technical solutions for the mining industry. Their head office is in Amsterdam but their offices spread out all around the world. The company is service-oriented and globalized thus service technicians, which are located strategically, can work for customers all around the world. They focus on products which include rock drilling, rock cutting, rock crushing, loading and hauling. Sandvik Mining had about 14.000 employees and annual sales about 37.800 MSEK in 2012.[2]

Picture 1, Sandvik has offices all around the world.

4.1.2 THE TASK BEFORE DELIMITATIONS

As mentioned there are three tasks in the solving of the lifting tool. The concerned parts are the lifting tool (hook), the design of the tree and a solution for a more stable tree. The hook is mostly used to lift the legs in contrast to the roll which is mostly lifted by hand. An ideal tool would satisfy both parts, but that might be hard to achieve. The tree has shortcomings when it comes to blasting the best way which is described below. Also the tree is somewhat unstable since it is hanging and isn't embedded at the bottom. This complicates hanging of the parts since the tree is wiggling and spinning. An initial analysis will be done to see what to focus on to satisfy the stated purpose.

[1] http://www.sandvik.com/en/about-sandvik/ 2013-04-24
[2] http://mining.sandvik.com/ 2013-04-28

5 CURRENT STATE OF PROCESSES

The following chapter describes the current situation at Sandvik and requests to improve the workstation.

5.1.1 DESCRIPTION OF THE PROBLEMS AND CURRENT EQUIPMENT

The existing workstation at start is a station without ergonomics. Sandvik use a lifting tool which isn't efficient enough. The picture below shows the current tool. After heating treatment the leg and the roll are attached to the tree and then into the blaster machine.

Picture 2, Current lifting tool.

The same hole is used to lift the objects and for attachment to the tree, also the object becomes horizontally when it should be set vertically. This means that the operator have to lift the part preliminary and then attach it to the tree. With the current solution, it's difficult to both get the items onto the lifting tool and hang them on the trees. Operator Jouni says that the biggest problem is the difficulties getting the part from the pallet to the tree.

Picture 3, Tree with hanging leg.

Another problem is that when hanging like this the item is furthest away from the sand blaster when blasting the inside of the part. Since the inside is the most important part to blaster a different position could benefit the final quality. The best result is given when the head of the leg is placed outwards. Approximately one tree a month needs to go through the blaster machine an additional time.[3]

[3] Interview with operator Jouni Kaipio at Sandvik Köping, 130412, 30429.

5.2 PROCESS DESCRIPTION AND PRODUCTS

This part describes both the process from the parts coming to Sandvik from Bodycote and the logistics at the workstation.

5.2.1 PRODUCTS

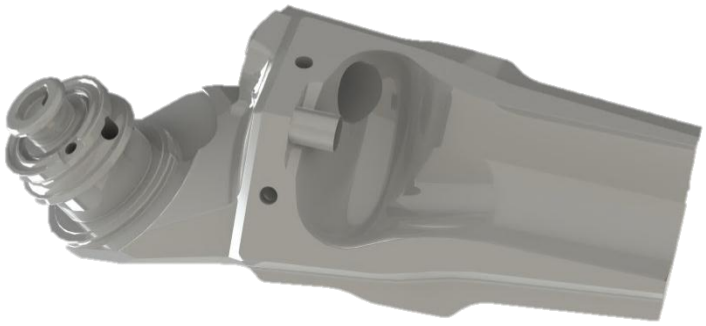
The products leg and roll form the final product called crown. After the sand blaster station the parts are being passed to processing with assembly and weld. The blaster quality isn't measured in any way but ocular and the parts don't have tight tolerances.

Picture 4, To the left: legs before blaster. To the right: rolls after blaster.

After evaluating the workstation it's decided to focus on what seems to be the biggest problem: the tree for hanging of the legs.

5.2.1.1 LEG

The leg is produced in seven different sizes, from $7^{7}/_{8}$" to 16" where the most common one is $12^{1}/_{4}$".



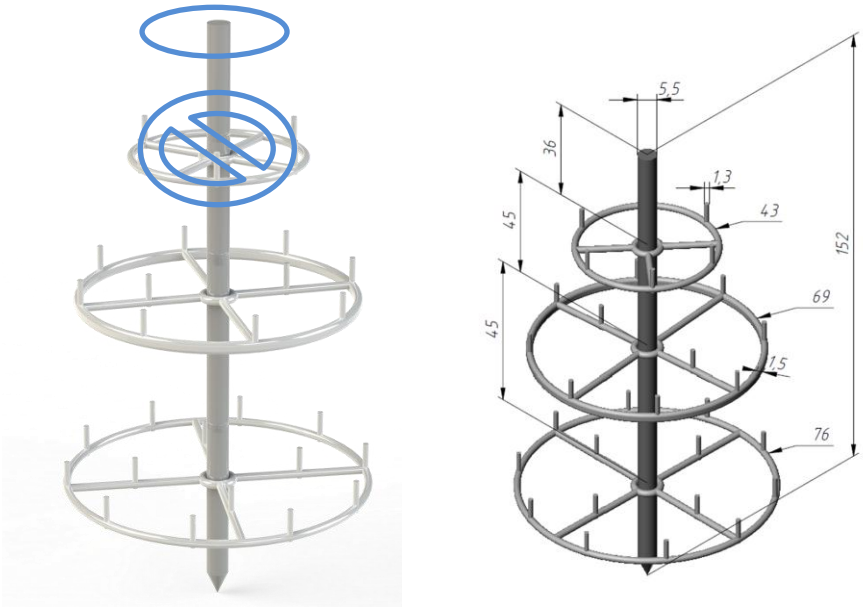
Picture 5, CAD of a leg from Sandvik. [4]

A desire from Sandvik was to adjust the tree so that the seven sizes could fit in three different trees. Although since the part is a gradiation the same thing can be done with the trees. One tree can then be scaled to fit all ranges.[5]

[4] CAD-part from Sandvik, not to be used in other context then in this report to Antti Salonen and Sandvik.
[5] Interview with Johan Tjernell and the operators at Sandvik Köping, 130521.

5.2.1.2 TREE

The top hook on the tree is bought and therefore suggestions will be drawn without that part. The operator Jouni also mention that parts hanged on the top circle doesn't have the same quality as the ones being hanged on the middle or lower circles, therefore he prefers to not use the top one. Also the top circle is placed so high up that it gives the operator a bad working environment. All parts in one batch needs to fit in the tree.



Picture 6, CAD-picture and drawing of the existing tree made by the group.

The drawing above shows spatial limitations to some extent. Although when hanging the legs the part itself "builds" over 10 centimeters on one side. With a new concept there are possibilities to increase the diameter of the circles making it possible to fit more parts.

Picture 7, Possible increase of the trees circle diameter.

This might benefit the operators work situation since it might make it possible to lower the top circle and adjust the distance between the circles. The best way to decide which distance to have between the circles might be by testing.

5.2.2 PROCESS MAPPING (MATERIAL HANDLING AND LOGISTICS)

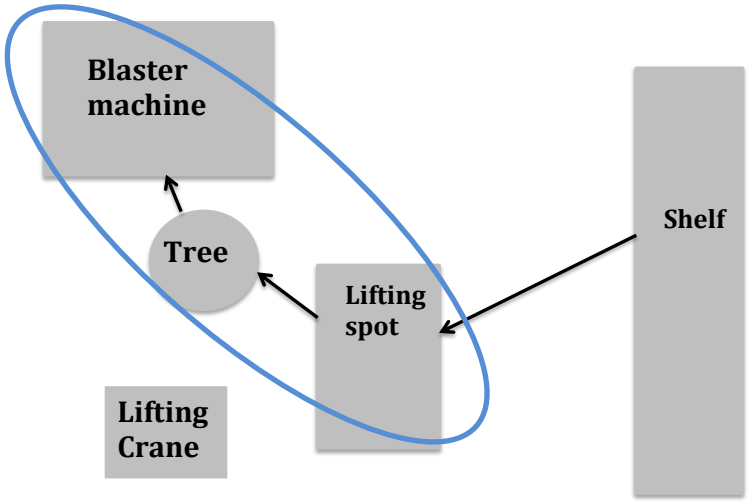
When the parts arrive to the workstation they have been at Bodycote for heating treatment. Bodycote use similar tools as Sandvik but the heating treatment are being done in baskets and the operators don't feel that the existing system with hook and telpher is a problem.[6]

Picture 8, Sandviks working partners in the process.

That Bodycote is satisfied with the present solution with hook and telpher might indicate that the tree is a bigger problem than the lifting tool.

5.2.3 PLANT LAYOUT

Summarily the workstation has the following plant layout:



Picture 9, Plant layout of the current workstation.

This might change since the plant layout is being under change as well. Therefore anything regarding the layout must be discussed with personnel in charge of this. An inventory is located in accession to the workstation. Marked stations are the ones directly linked to the task.

[6] Telephone interview with Bodycote's heating department, 021-15 67 00, 130419.

5.3 MANNING AND CAPACITY

David Jentsch claimed that: "You can't improve what you don't measure"[7] and besides that it's said: "What isn't measured can't be controlled".[8] In this project the possible factors to measure are time, quality and health. By measuring these aspects it's easier to evaluate if the suggested solution is capable to improve the numbers. Since it's hard to measure health and ergonomics the main measurements will be time and quality.

Working hours: 8 hours/day
Numbers of operators: 1
Distribution of sizes blasted in 2012:

Table 1, Distribution of sizes that were blasted.

Ben											
Storlek	**6 3/4"**	**7 7/8"**	**8 1/2"**	**9"**	**9 7/8"**	**10 5/8"**	**11"**	**12 1/4"**	**13 3/4"**	**15"**	**16"**
Ben OA	1038	4389		6733	5492	1624	209	8158	1756	263	258
Ben QX		468			1302	2313		1401	643	4	512
Summa	**1038**	**4857**	**0**	**6733**	**6794**	**3937**	**209**	**9559**	**2399**	**267**	**770**

QX= Charger
OA = Open Air (regular)[9]

The ideal would be to do a long time study to see if these numbers could be improved with a new tree. To enable this the bottleneck mentioned below needs to be solved.

5.4 TIME STUDY

Capacity of most systems is constrained by a bottleneck. The cycle time of the process with existing tree is the following:

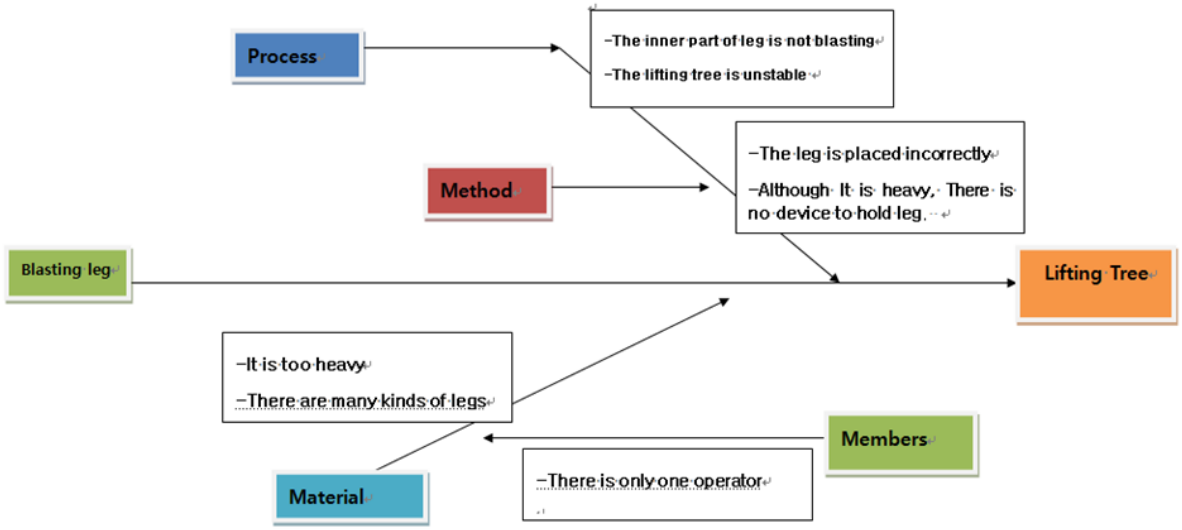
Time to hang leg by hand: ≈ 1 minute (regardless of size)
Time to hang leg with lifting tool: ≈ 2-3 minutes (regardless of size)
Time in the sand blaster machine: ≈ 15 minutes (during this time the operator uncouples the finished parts and makes a new suspension ready for the machine)[10]

The bottleneck in this process is the blaster, a better hanging of the leg could enable a shorter time in the blaster. Improvement of the bottleneck would be ideal.

[7] Lecture with David Jentsch, MDH Eskilstuna, 130419.
[8] Lecture with Antti Salonen, MDH Eskilstuna, 130426.
[9] Interview with Fredrik Persson, Sandvik, 130429.
[10] Interview with operator Jouni Kaipio at Sandvik Köping, 130412, 30429.

5.5 ROOT CAUSE ANALYSIS

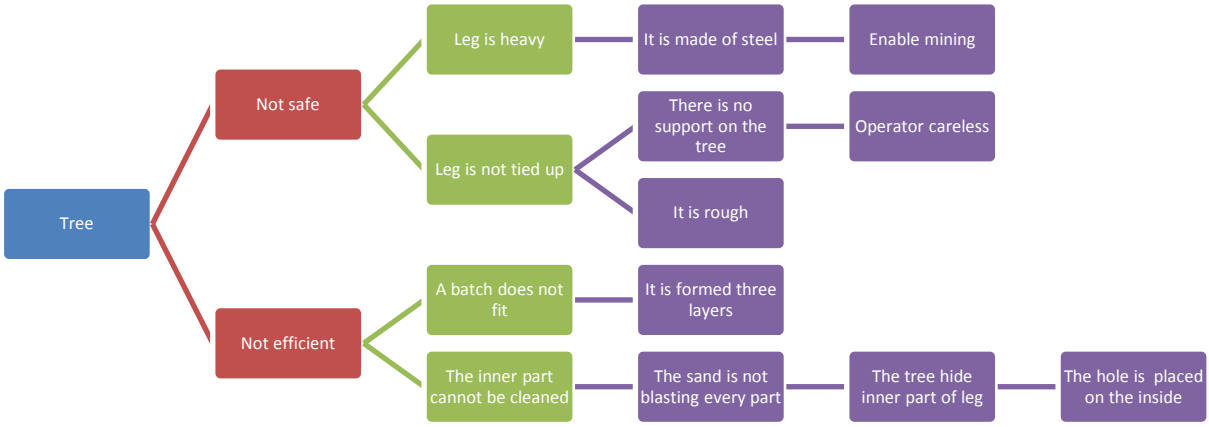
The root cause analysis is a central method when solving a problem. One of the tools in Root cause analysis is Ishikawa diagram (Fishbone diagram). Ishikawa is a diagram that shows the cause of a certain event.



Picture 10, Ishikawa diagram to define the cause.

5.6 THE 5 WHY:

The 5 why is a system to find the main problem. You ask for the cause "why did that happen" and get a cause for the cause then you ask it again.[11]

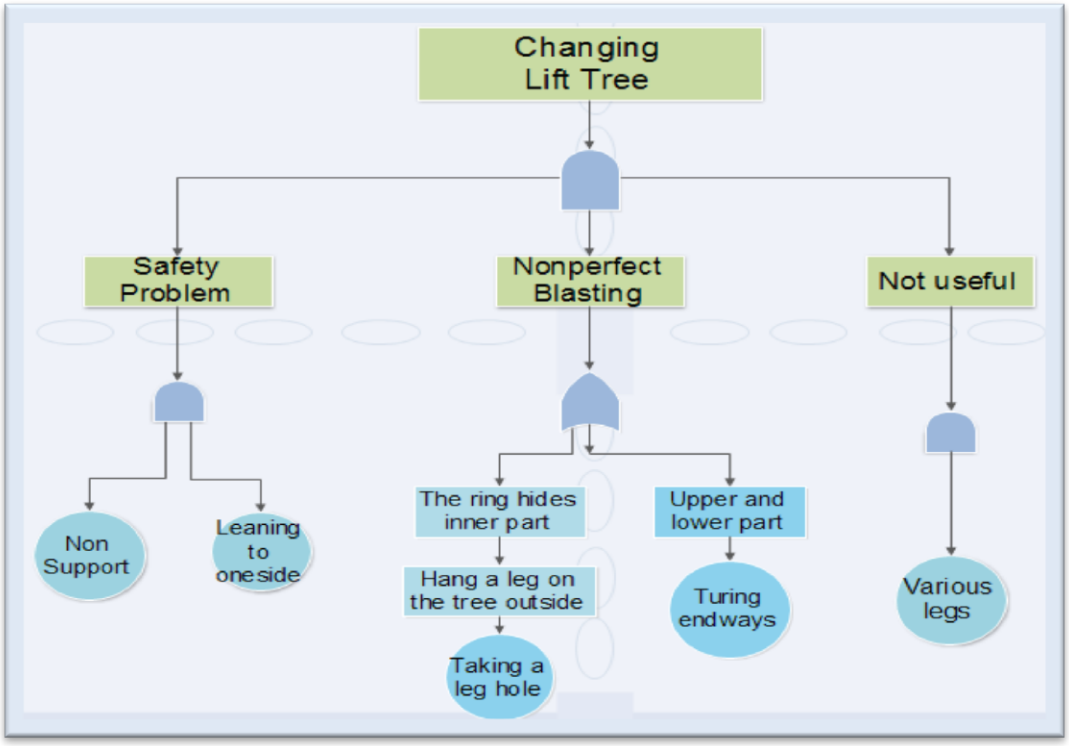


Picture 11, 5 Why to define the cause.

[11] Lecture with Antti Salonen, MDH Eskilstuna, 130507.

5.7 FTA, FAULT TREE ANALYSIS

FTA is a deductive technique, providing a method for determining cause of the particular accident event.



Picture 12, FTA to define the cause.

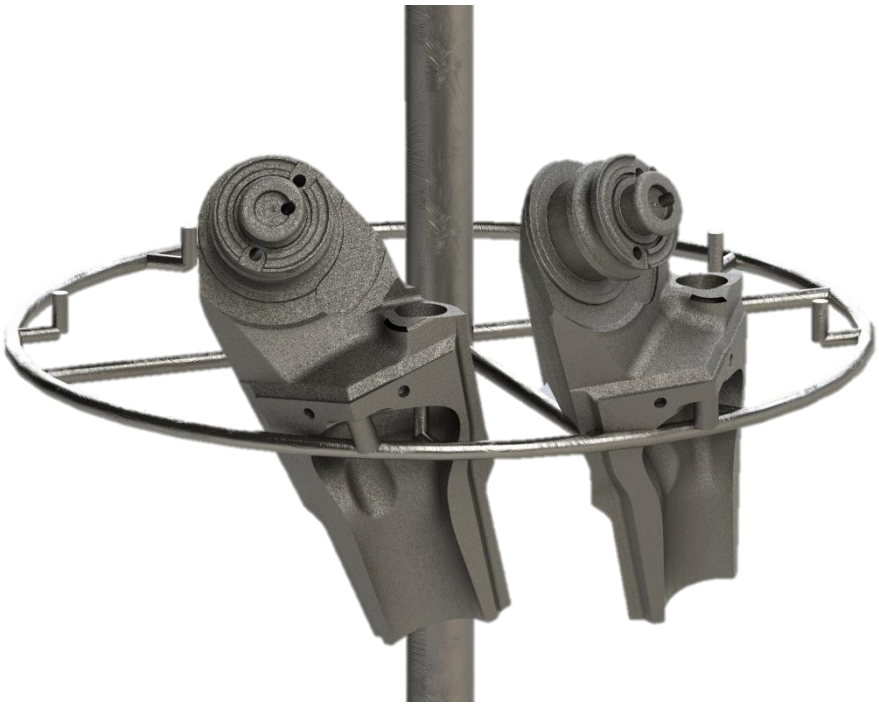
As a result of the methods, the group found causes from the original tree and tried to connect cause and effect. There is no support on the tree. It causes an unsafe situation and when hanging the inside part of the leg on the original tree it causes incomplete blasting. Upper and lower cutters weren't cleaned perfectly on account of hanged tree endways. Although they have a variety of legs, they keep a leg each tree. Through analysis, the group figured out essential requisites about new tree which facilitates to blast holes, cutters and inside part clean and lay properly on the tree.

6 SUGGESTED IMPROVEMENTS (CONCEPTS)

Three main concepts with some variations were created and presented in the third factory visit at Sandvik. The idea and purpose of designing these concepts were blasting the inside of the components better and an enhanced work environment for the operators. The following concepts brainstormed by the group and made in SolidWorks were presented to Sandvik.

6.1 "REVERSED TREE"

One easy solution to improve the quality of the sand blasting is to simply place the pegs on the inside of the circle instead, see picture below.



Picture 13, Concept 1 - Reversed tree.

The idea with placing the pegs inside of the ring instead of outside of the ring was the component to be hanged inside of the ring, and being blasted better. Benefits with this solution are that it's only small modifications compared to the existing concept and that it will blaster the parts better on the inside. Although this solution wouldn't improve the operators work environment and there is a risk that the chain from the telpher would hit the frame when hanging. There is a problem in terms of handling the part with the lifting tool. Placing the pegs inside was making it harder to handle components with lifting tools. Therefore, Sandvik choose not to continue with this concept.

6.2 "PARALLEL CIRCLES AND PEGS"

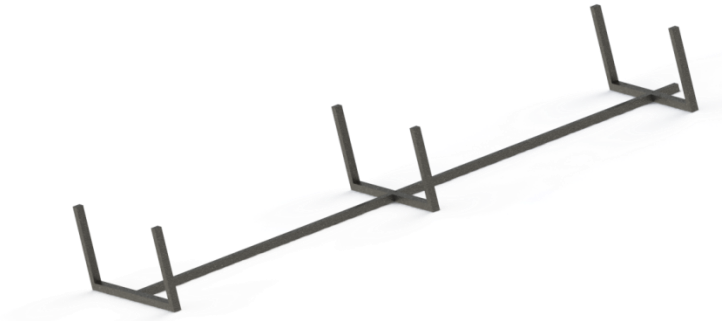
Concept number two consists of two rings in the tree and instead laying the components on the tree with some support. Thus, the inside of the components are going to be blasted better. Also, in this concept, it's easy to handle and place the components on tree because placing the components instead of hanging from hole is easier, faster and does not require any ability.

Picture 14, Concept 2- Parallel circles and pegs.

Sandvik liked the thought of laying the part down. However there was a small problem in this concept as well. For lower levels, the rings are obstacle to handle the parts by taking them out. Therefore, it was decided to make some little changes on the tree.

6.3 "BASKET"

The third concept is inspired by Bodycote's method with baskets. This concept is to be applied on a tree and the leg will be lying in the basket.



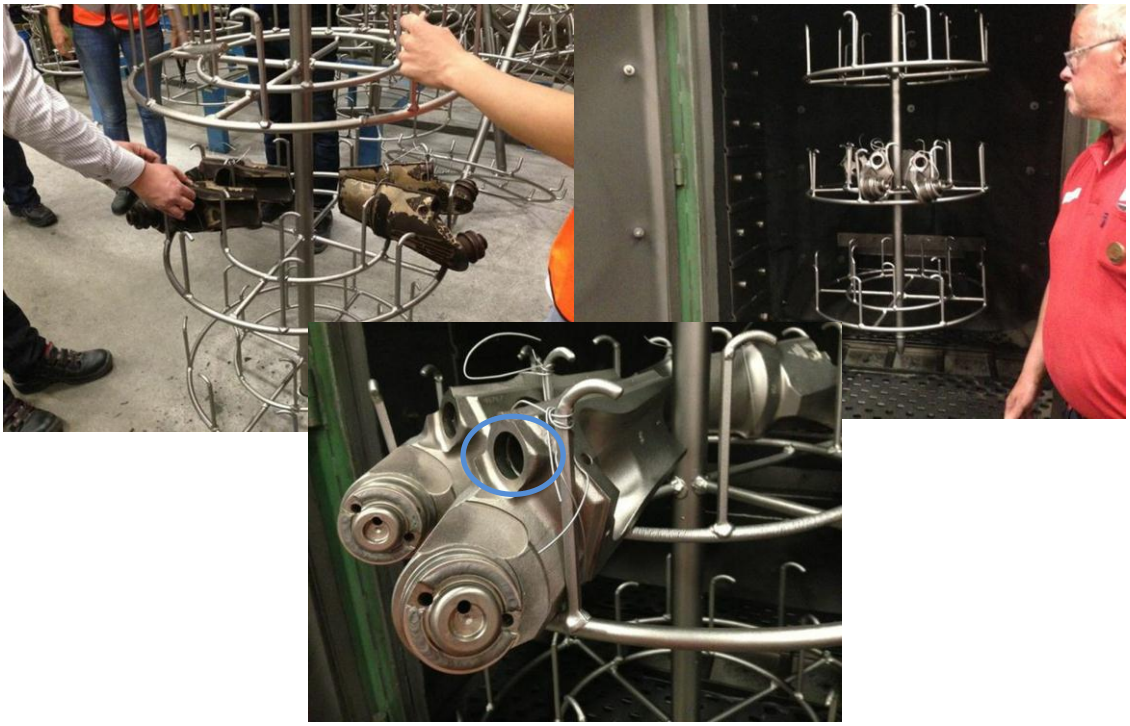
Picture 15, Concept 3 – Basket.

Sandvik found both concept two and three interesting and decided to make a prototype.[12]

[12] Interview with Johan Tjernell and the operators at Sandvik Köping, 130521.

7 IMPLEMENTATION

After deciding to go with the concept of lying the leg down instead of hanging it a test was done in the blaster machine to see if the result were sufficient.



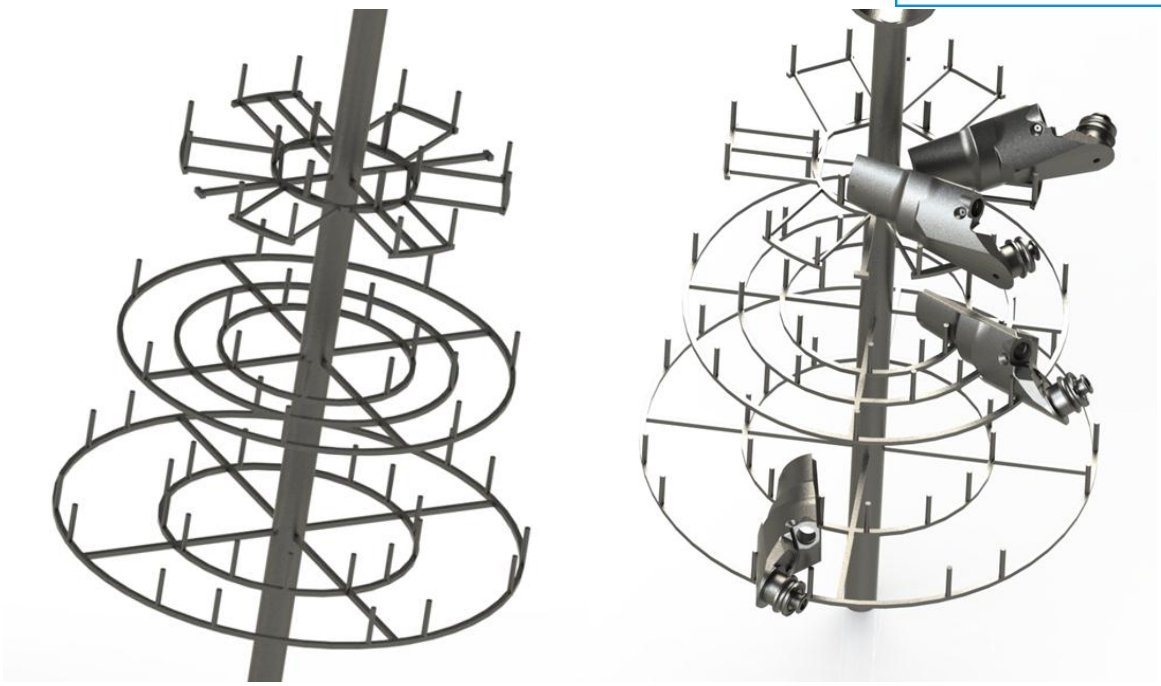
Picture 16, Test of quality of the blaster with the leg lying down.

7.1 ECONOMY, COST AND INVESTMENTS

The quotation of the prototype made by Weldor was approximately 30.000 SEK. In this price all changes made in the workstation, including a new plant layout and "tree-park" is included. The investment will hopefully result in a more ergonomic workstation for the operators and better distribution for Sandvik.

7.2 THE PROTOTYPE

After some trial of blasting and measurement, it was decided that three different concept in one tree is going to be made as a prototype. All the levels in the tree represent different concepts. First level is like a flower and there are some spaces in the ring. These spaces were made because of that lifting tool cannot handle the component without any space in the upper level. The shape of the lifting tool isn't suitable to handle the parts otherwise it hits each other with upper ring. Therefore, flower shape makes it possible for the chain from the telpher to reach each level. The second level consists of three rings with three poles and the third level consists of two rings with four poles. This is because, the size of the components are different from each other, according to the size, two rings or three rings is going to prevent it from falling down in blaster machine. The prototype represents three different ideas in one tree.



Picture 17, CAD of the prototype with three different concepts.

When you implement a change you need to coordinate it[13]. Therefore the operators will be informed of the new concept, which is highly inspired by Jouni's requests.

7.3 TESTING OF THE PROTOTYPE

The following pictures shows the result of the prototype made by Weldor.

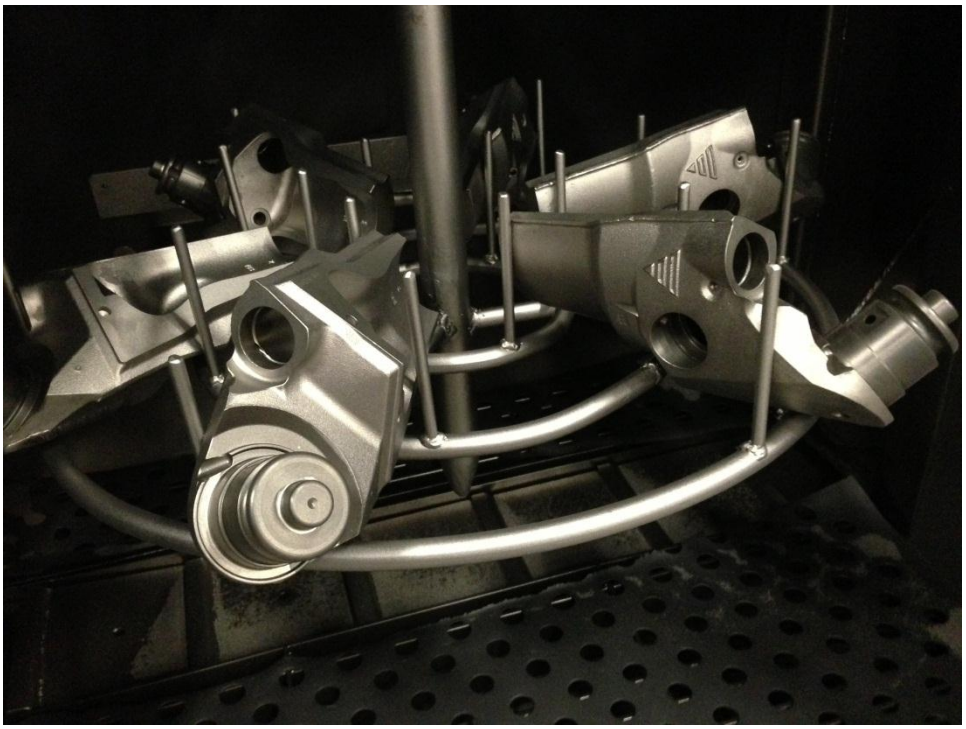
Picture 18, The prototype made by Weldor.

[13] Lecture with David Jentsch, MDH Eskilstuna, 130419.

Level number one consisting of "flower pedals" will not be used since the tree covered the weld, which is one of the most important parts to blaster.

Picture 19, Jouni testing level number one.

Level number two consisting of three circles and three pegs was successful in testing. The time in the blaster machine was eight minutes, adding two minutes for a secure result. This will decrease the current time of the machine which is ≈ 15 minutes to ≈ 10 minutes. The concept will therefore solve some of the problems with the bottleneck, saving five valuable minutes in the machine.



Picture 20, Level two consisting of three circles and three pegs

(Note that the concept of two circles and four pegs hasn't been tested in this prototype since Weldor decided to go with only two levels.)

There will be modifications done to the prototype to achieve the best results possible. Sandviks request about making trees so that the seven sizes could fit in three different trees was solved by analyzing the prototype and suggest the following measurements[14]:

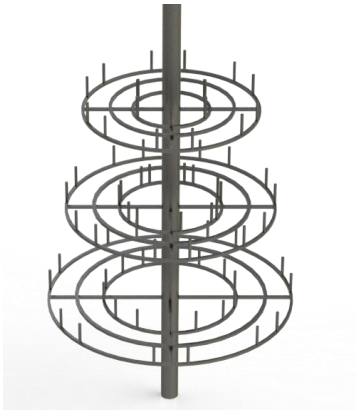


Table 2, Measurements [mm] of radiuses for the tree to fit all seven sizes of legs.

Upper circle	370-240-120
Middle circle	440-310-190
Lower circle	500-370-250

These measurements fulfill the request from Sandvik to fit all seven sizes in only three trees.

7.4 QUALITY

An ocular control showed that the result was approved. Sometimes the parts have dirt gathered in the upper holes (see marking) that is harder to remove. This condition has not been tested, but is also quite rare. The blaster quality can therefore be seen as unchanged, which is a good thing. Due to this measurement the concept has passed.

7.5 THE TIME ASPECT

With the current tree, operator Jouni uses his hands instead of the lifting tool. With the leg lying down it's easier to fill the tree, but the time to fill it is a little bit longer then with the current tree using the lifting tool. If you compare filling the existing tree and the new tree with the lifting tool it takes longer to fill the existing tree. Note that in the start-up phase of a new concept it's always unaccustomed for the operator, so the time might improve slightly. Due to this measurement the concept has passed. Most important though is that the time in the blaster machine can be shortened with up to five minutes, which is a wonderful result since that is the bottleneck. This has the potential to improve distribution and income for Sandvik. Due to this measurement the concept has passed.

7.6 ERGONOMICS AND HEALTH

Instead of using the same hole to lift the object and for attachment to the tree the operators only need to use the hole for the lifting tool. This encourage using of the lifting tool which makes it easier and gentler for the body getting the part from the pallet to the tree. Jouni has been a big part of this and he was satisfied with the prototype, since he experienced that the new tree makes his work less heavy. Due to this measurement the concept has passed.

[14] Interview with Johan Tjernell and Jouni at Sandvik Köping, 130528.

8 CONCLUSIONS AND ANALYSIS

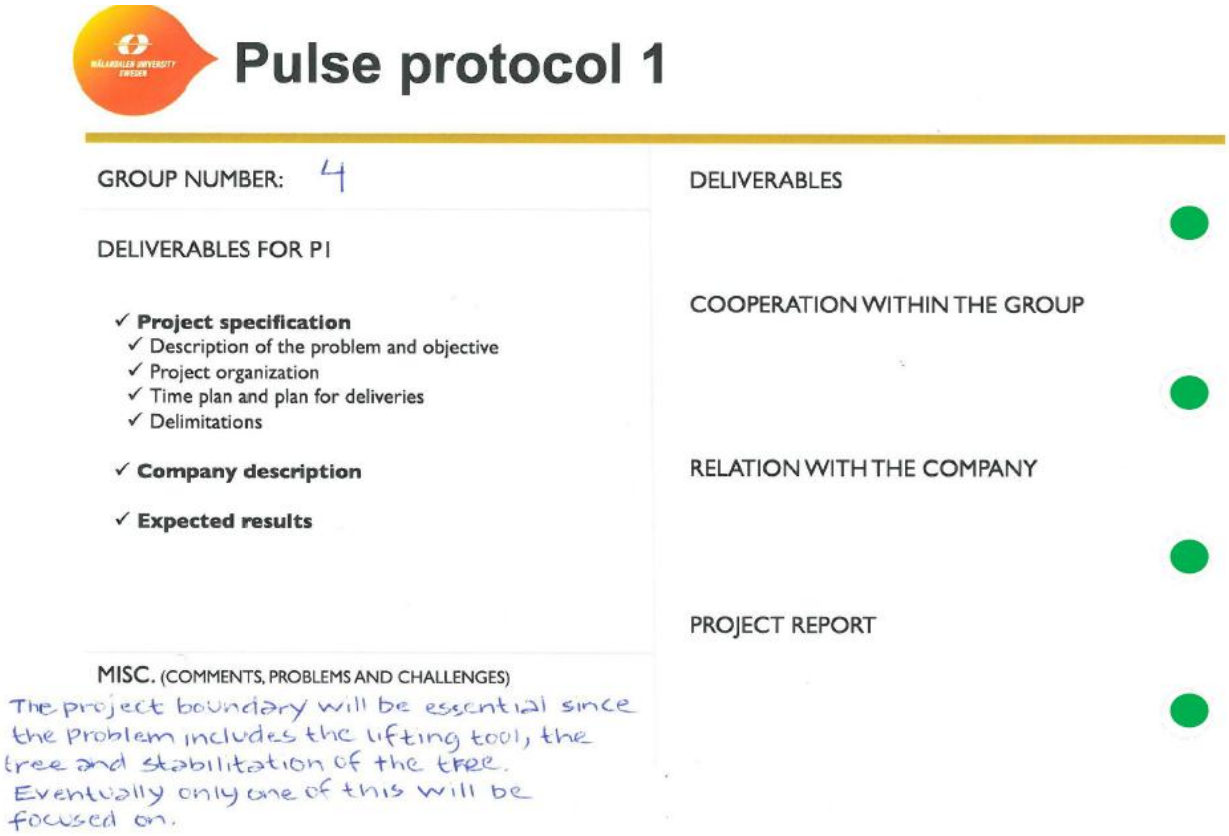
Three concepts were designed for Sandvik's workstation. These concepts were designed in order to make the workstation better and more efficient. One of the ideas handling the leg lying down was chosen by Sandvik who made a prototype of the idea. In the prototype three different levels on the tree were tested in order to see which one works the best. The three designs were based on the same idea with slight variations. Therefore, Sandvik decided to make a prototype with three different levels instead of making three prototypes. However, the idea behind the different levels was laying down the components instead of hanging because it allows blasting of the components inside better. Also, hanging components on the tree requires short diameter for the ring in order to fit into blaster machine. However, laying down the components on tree enables to use bigger ring, thus more components can fit into a tree.

In addition, another reason behind our design was to improve the operators work environment. Since these components are heavy, it's difficult to handle them without lifting tool and it can cause injures. Laying down the components makes it easier to use the lifting tools compared to hanging them. Thus, operators do not have to afford too much energy to place components into the tree. Furthermore, our aim was developing an idea and launching the concept in nine weeks. We developed and presented the concept to Sandvik within nine weeks but Sandvik might need more time to test the prototype and decide whether it works for them or not, although the tests of the prototype showed optimistic results.

The group is satisfied to have accomplished the task with respect to a relevant delimitation using methods like Root cause analysis and FTA, and a concept fulfilling the measurements. It's also pleasing that both the operators and management seems satisfied with the solution.

9 ATTACHMENTS

9.1 PULSE PROTOCOLS



Pulse protocol 1

GROUP NUMBER: 4

DELIVERABLES FOR P1

- ✓ **Project specification**
  - ✓ Description of the problem and objective
  - ✓ Project organization
  - ✓ Time plan and plan for deliveries
  - ✓ Delimitations
- ✓ **Company description**
- ✓ **Expected results**

MISC. (COMMENTS, PROBLEMS AND CHALLENGES)

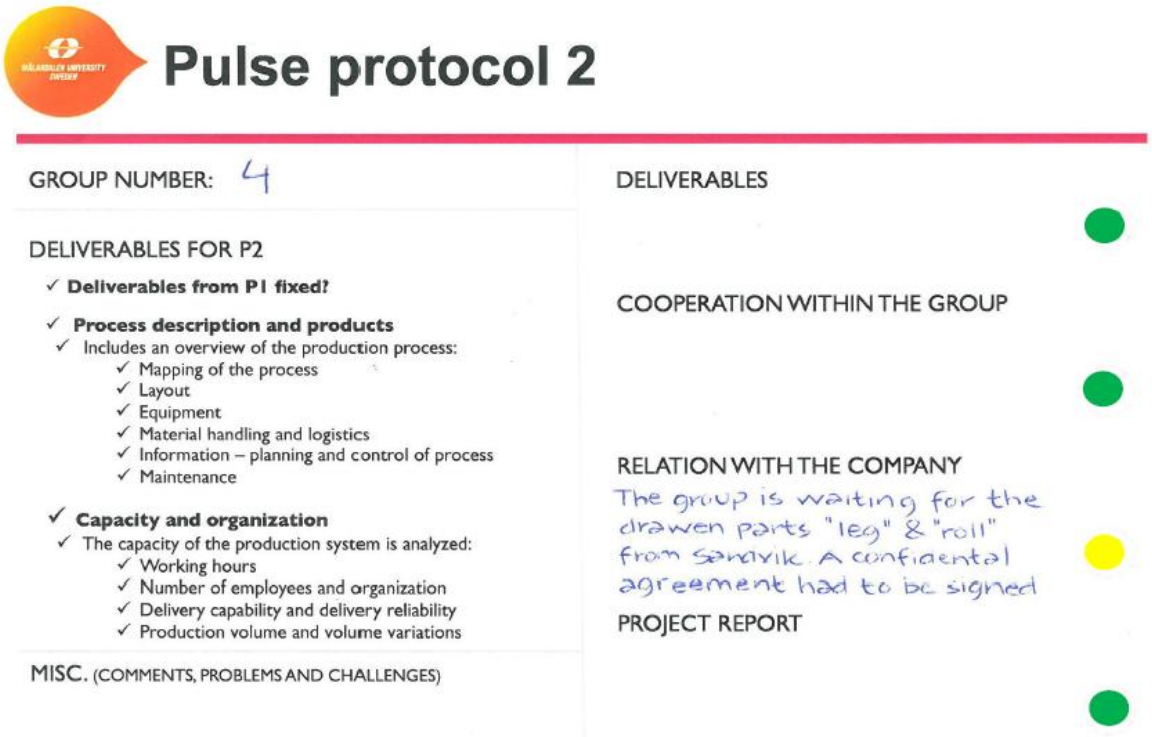
The project boundary will be essential since the problem includes the lifting tool, the tree and stabilitation of the tree. Eventually only one of this will be focused on.

DELIVERABLES

COOPERATION WITHIN THE GROUP

RELATION WITH THE COMPANY

PROJECT REPORT



Pulse protocol 2

GROUP NUMBER: 4

DELIVERABLES FOR P2

- ✓ **Deliverables from P1 fixed?**
- ✓ **Process description and products**
  - ✓ Includes an overview of the production process:
    - ✓ Mapping of the process
    - ✓ Layout
    - ✓ Equipment
    - ✓ Material handling and logistics
    - ✓ Information – planning and control of process
    - ✓ Maintenance
- ✓ **Capacity and organization**
  - ✓ The capacity of the production system is analyzed:
    - ✓ Working hours
    - ✓ Number of employees and organization
    - ✓ Delivery capability and delivery reliability
    - ✓ Production volume and volume variations

MISC. (COMMENTS, PROBLEMS AND CHALLENGES)

DELIVERABLES

COOPERATION WITHIN THE GROUP

RELATION WITH THE COMPANY

The group is waiting for the drawen parts "leg" & "roll" from Sandvik. A confidental agreement had to be signed

PROJECT REPORT

PULSE PROTOCOL – P3

GROUP NUMBER: 4

DELIVERABLES FOR P3

- ✓ **Deliverables from P2 fixed?**
- ✓ **Time study and clarification of problem**
- ✓ **Data is analysed according to one or more of the following parameters/costs:**
  - ✓ *Cycle times and bottlenecks*
  - ✓ *Losses – adjustments and cassation*
  - ✓ *Change overs*
  - ✓ *Reconfiguring times and maintenance*
  - ✓ *Overall equipment efficiency OEE*
  - ✓ *Estimation of disturbance costs and economic potential of improvements*
  - ✓ *General problem consequences*

MISC. (COMMENTS, PROBLEMS AND CHALLENGES)

The group went to Sandvik 130429, for the next meeting the task is to present concepts. This to have time to make the prototype. The ideal would maybe to wait until after the root-analysis, but shortage of time make that impossible.

DELIVERABLES

COOPERATION WITHIN THE GROUP

RELATION WITH THE COMPANY

Sandvik had some problems with their computer, but the group have received the most important part "leg" but are still missing the "roll".

PROJECT REPORT

PULSE PROTOCOL – P4

GROUP NUMBER:

DELIVERABLES FOR P4

- ✓ **Deliverables from P3 fixed?**
- ✓ **Analysis of problem:**
  - ✓ Disturbances and losses
  - ✓ Effect on capacity
  - ✓ Economy, cost and investments as well as revenues
  - ✓ Use 5 Why, FTA, 7QC

MISC. (COMMENTS, PROBLEMS AND CHALLENGES)

Some of the deliverables from P4 will not be in the report. For example "economy, cost and investments as well as revenues" will only be mentioned.

DELIVERABLES

COOPERATION WITHIN THE GROUP

RELATION WITH THE COMPANY

The group will go to Sandvik on 130521 to present three different concepts.

PROJECT REPORT

10 REFERENCES

10.1 INTERVIEWS

Interview with operator Jouni Kaipio at Sandvik Köping, 130412, 130429.
Interview with Fredrik Persson at Sandvik, 130429.
Interview with Johan Tjernell and the operators at Sandvik Köping, 130521.
Telephone interview with Bodycote's heating department, 021-15 67 00, 130419.

10.2 LECTURES

Lecture with David Jentsch, MDH Eskilstuna, 130419.
Lecture with Antti Salonen, MDH Eskilstuna, 130426, 130507

10.3 INTERNET

http://www.sandvik.com/en/about-sandvik/ 2013-04-24
http://mining.sandvik.com/ 2013-04-28
http://www.weldor.se/ 2013-05-28