CHALMERS

Developing Multimedia Training for robot operators

Master of Science Thesis in the Master Degree Program Learning and Leadership

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Gothenburg, Sweden, 2013

Master Thesis 2013:144

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Cover:
[The Metso Spout Robot]
Göteborg, Sweden 2013

Master Thesis 2013:144
ISSN: 1651-4769

Acknowledgements

I would like to thank Metso Power AB in Gothenburg, with personnel, for giving me the opportunity to carry out my master thesis on a welcoming and supporting department of the company.

Special thanks to my supervisors from Metso, Johan Olsson and Ola Herstad for a supporting environment and good feedback.

Lastly, I wish to thank my supervisor from the Chalmers University of Technology, Tom Adawi, for all the help during this project which included deep discussions and much laughter.

Jonathan Gren, Gothenburg May 20, 2013

Abstract

The aim of this project was to develop a multimedia training for robot operators. One problem was that the operators had various prior knowledge with robots and therefore felt unsecure when operating the robot. This has lead to unnecessary damage on the robot which made Metso consider making a Multimedia Training to deal with these problems. In order to carry out the scripts that were supposed to serve as a basis for the training, the technology surrounding the robot as well as different learning theories had to be studied. The project resulted in a finished multimedia training that was implemented in Metso Web Academy together with the rest of the trainings for Metso's products. The training is supposed to be used to educate current operators as well as presenting the product for potential customers.

Keywords: multimedia training, robot, pulp mill, learning theory.

Table of Contents

1. Introduction

This chapter will introduce the background and the aim of the project as well as the delimitations.

1.1 Background

Metso Power AB is a company that designs and produces recovery boilers for the pulp production industry. A recovery boiler is used to burn the residue black liquor in the production of pulp; the remains from the burning process are called *smelt*. The smelt flows through *spouts* to a tank, where it is dissolved to be used in the process once again; hence the name *recovery boiler*.

The spouts are water cooled to withstand the high temperature of the smelt which can reach temperatures of 1000°C. The temperature difference between the smelt and the water freezes part of the smelt, which prevents a continuous flow through the spout. The frozen smelt must be removed and this is done on most of Metso's facilities by humans using a three-meter long rod. The high temperature combined with the amount of force needed to clean the spout makes this a very unpleasant working environment. Therefore Metso has developed the *Metso Spout Robot* which is an industrial robot mounted near the spouts. The robot is equipped with a rod similar to the ones used by hand. Today Metso Spout Robots are active on five facilities worldwide.

The Metso Spout Robot moves in a pre-programmed sequence to clean the spouts. Problems occur when the robot stops for one reason or another. Sometimes the operators must operate the robot manually to its home position to be able to restart the sequence from the control room. There can be time gaps of several weeks between the occasions when the operators have to operate the robot manually. Hence the operators forget how the robot works and how to operate the robot in a safe way. This has led to damage on the robot and its working tool.

Metso is using an expert from the company to educate the operators. This has not been enough due to the time gaps between the occasions when the robot has to be operated manually. Therefore Metso wants to develop an E-learning module that helps the operators to understand how to operate the robot in a safe way and what actions to take when the robot stops. This training is to be used as a complement to the regular education.

1.2 Aim of the project

The aim of this master thesis project is to develop learning modules that make the operators more comfortable with how to operate the robot and teach them how a robot works. Metso already has E-learning modules for their major products in their learning platform, the *Metso Web Academy* (MWA). Metso calls these learning modules Interactive Multimedia Training (IMT). One of the restrictions in the development of the learning modules for the Metso Spout Robot is that they have to be in the same format as the existing IMTs and be available through the MWA.

Metso Power is preparing for a higher demand for the Metso Spout Robot in the future. An IMT is considered to be a good way to promote the robot to potential customers. Because of this, Metso wants the initial part of the IMT to be more directed to a broader audience without too much technical information.

As a takeoff in this project, three questions were formulated to be answered during the project:

- What are the weaknesses with the current teaching material?
- In what way can theory be helpful in presenting the new training material?
- What affects learning in a multimedia setting?

The solution with the spout robot differs between the five facilities where it is active but the basis is the same and also what actions to take when the robot stops. This project will focus on creating a general IMT on how the Metso Spout Robot works. The primary focus is to deliver the basis for the IMT production, which includes scripts, media and course map. The deliverable will be complete scripts containing text and associated media (pictures and animations).

2. Technology background

This chapter aims to provide the reader with the technology background needed in the construction of a multimedia training for the Metso Spout Robot.

2.1 Pulp mill

In the *pulp mill*, wood chips are processed to pulp for paper production. (A picture describing the pulp mill can be seen in figure 1). The process starts with wood chips getting cooked in a digester to produce pulp. The pulp is then washed and screened for later use in the production of paper. In the cooking stage one residue is separated, the black liquor. The black liquor is sent to the recovery cycle so that this residue can be used later in the process again. In the recovery cycle the black liquor goes through a evaporation plant which purpose is to increase the dryness of the liquor. The black liquor is then burned in the recovery boiler to create power for other processes in the mill. The chemical remains from the burning, the smelt, flows through smelt spouts to a dissolving tank where it is mixed with weak liquor. It is then called green liquor due to its color. In the white liquor plant, the green liquor is converted to white liquor, which is the kind of liquor that once again can be used in the digester, hence the name the *recovery cycle*.

2.2 Recovery boiler

The *recovery boiler* works both as a chemical reactor and a steam boiler. In the recovery boiler, the active chemicals that have been charged in the digester are recovered. The energy in the combustible components of the liquor is used to produce steam in the boiler for other mill processes. Black liquor from the evaporation plant is sprayed into the recovery boiler, where the correct supply of air and liquor results in optimum furnace performance for combustion and maximum recovery of chemicals. The final chemical reactions take place in the bottom of the boiler (see Figure 2). The smelt flows from the furnace floor through smelt spouts to the dissolving tank. The number of spouts can vary from site to site but the most common is to use four spouts on each recovery boiler. In the dissolving tank, smelt is mixed with weak liquor. The green liquor is pumped from the dissolving tank to the recausticizing plant for further recovery of chemicals.

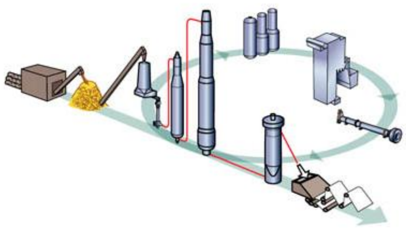

Figure 1 - In the pulp mill, wood chips (left) are processed to pulp for paper production (right)

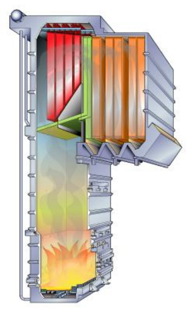

Figure 2 - The final chemical reactions take place in the bottom of the boiler

2.3 Metso spout robot

The *Metso spout robot* cleans frozen smelt in the smelt spouts (see Figure 3). Smelt from the recovery boiler flows through smelt spouts on its way to the dissolving tank. Since the smelt can reach temperatures up to 1000°C, the spouts must be water cooled to withstand the high temperature. Due to the temperature difference between the hot smelt and the cold spout, part of the smelt will freeze, which prevents a continuous flow through the spout. The smelt is removed by the Metso Spout Robot, which is an industrial robot with six axes. An additional axis has been implemented in terms of a linear unit on which the robot is mounted. This gives the robot seven degrees of freedom.

The robot moves to the desirable spout and starts the pre-programmed sequence. The robot uses its tool, the rod, to clean in and around the spout and working itself from the lower hood area up through the spout to the inlet. When all spouts are done, the robot returns to its home position and waits for the sequence to start again or for the operator to order it to clean once again.

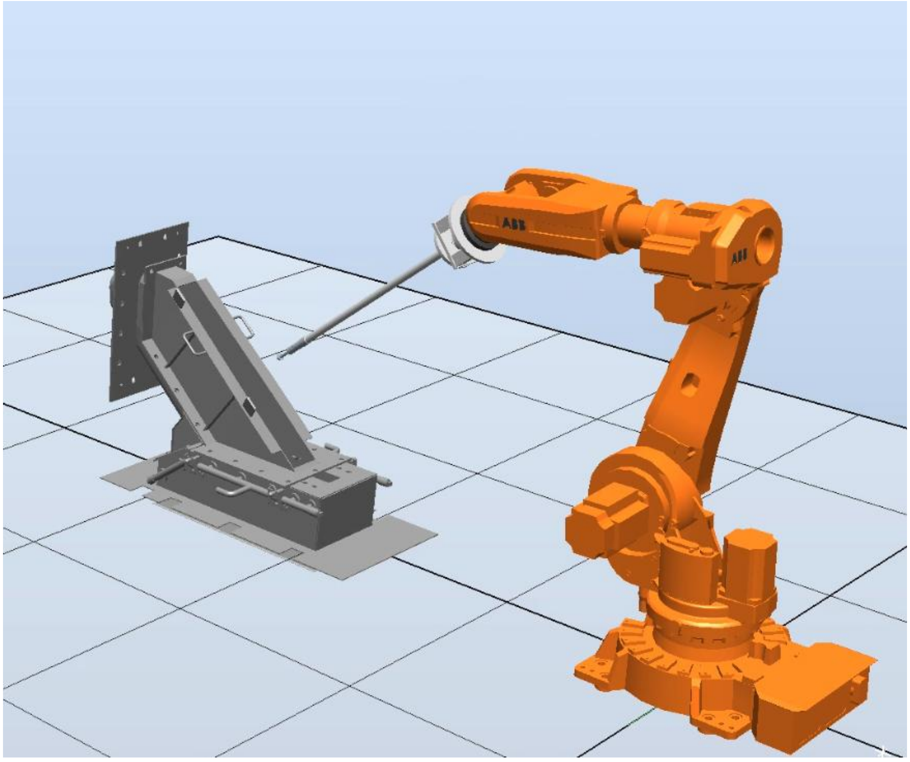

Figure 3 – Capture from the animation that were created in the robot software

2.4 ABB RobotStudio

In order to create pedagogical animations, *ABB RobotStudio* was used. This is a software that allows you to create realistic animations of different types of ABB robots. The software allows import of CAD files from programmes such as SolidWorks and CATIA. There is a couple of pre-defined robots and equipment that can be imported from the ABB library. To use all of the imported parts one has to build it into a system and create a Virtual Controller, which should represent a real robot controller, which also is called a pendant. In order to make the robot move, instructions had to be defined. These instructions contained the target, the movement style and the speed of the robot movement. All the instructions together made up the path in which the robot should move.

2.5 Metso Web Academy

Metso provides training for all their major products, and they call these *Interactive Multimedia Trainings* (IMT's). The training modules are available through Metso's own training platform, the *Metso Web Academy* (MWA). When one starts one of the modules the "topic outline" appears, where the goals and what course material that is available are presented. When clicking on the "course material" a table of content appears and the learner can choose which chapter to start with. Each chapter is built as a SCORM object, which is a standard for how to navigate and communicate using web-based e-learning (Rustici software).

The SCORM window (see Figure 4) consists of four areas:

1. The *content area* is used for presenting the content of the chapter in form of links, where the user chooses what content to go through. When one link is used, it turns grey to represent that the part has been handled but this does not prevent the user from clicking it again.

2. The *media area* presents animations and pictures that are used in the chapter. The animation starts automatically when a link has been clicked in the content area.

3. The *text area* presents exactly what the narrator says, but in writing. This helps the user to understand if they have problems with the language. This area can also present a caption if there is only a picture in the media area.

4. The *media controller* is a tool for navigation through the course material. It is possible to jump forward and backward in animations, zoom in on pictures, pause and play animations. Under the course module "Review" another functionality is added that makes the media controller replace the text area and becomes an interactive area for answering questions.

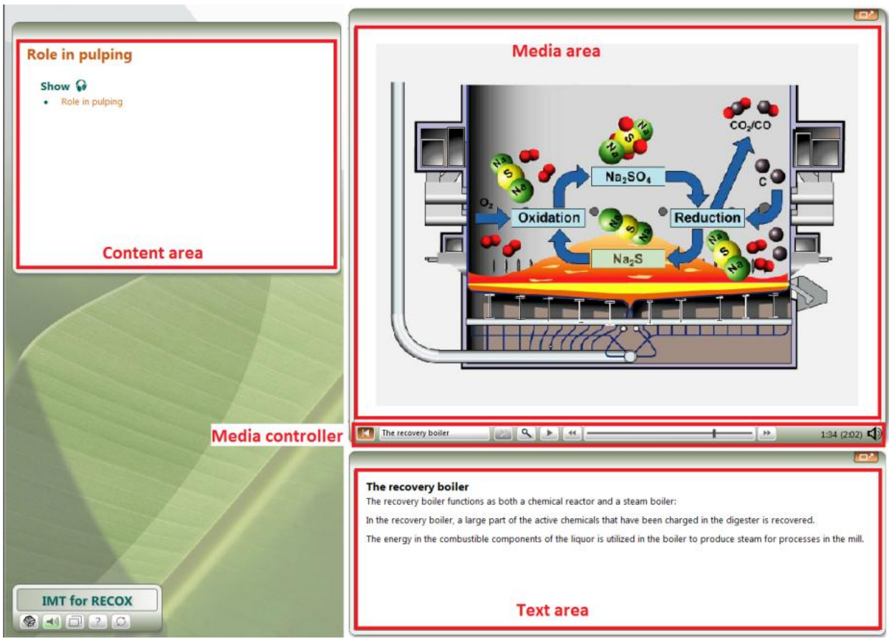

Figure 4 - The screen in which all Metso's trainings is carried out

2.6 Scripts

The *scripts* for the Metso learning modules are written in Excel using a script template. The existing templates had to be revised in the beginning of the script production since they had not been used for a while and were out of date. Scripts are used since Metso does not create the learning modules – this is done by another company, Maincon. The material with all text, pictures and animations is sent to Maincon in a specified format.

The table of contents page (Figure 5) defines which chapter the script is about and the different subchapter it holds. This also holds information about who the author is and when the document was created.

Figure 5 – Table of contents

The pink color in figure 6 indicates that this is a template for a sequential player with both narration and animation or picture. The column between the text and the media, “Events”, holds the file name and where it is located for the external company to find it.

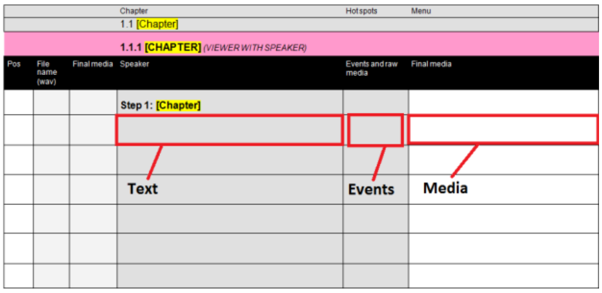

Figure 6 – Sequential player

The blue color in figure 7 indicates that it is a viewer with text and images. This is similar to the sequential player except it does not hold a column for the location of the audio file.

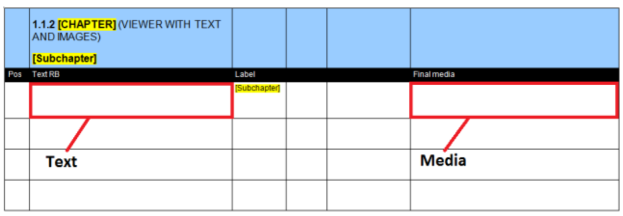

Figure 7 – Viewer with text and images

3. Theoretical background

This chapter presents theoretical concepts and principles that can be used in the construction of a multimedia training for the operators. In particular, it describes Richard Mayer's *cognitive theory of multimedia learning*. This chapter also includes a discussion of *advance organizers* and *learning objectives* as well as different types of pictures and language that can be used.

3.1 Advance organizers

David Ausubel's research on how humans learn has been used in this thesis. Ausubel argues that new knowledge must be organized into the learner's previous knowledge (Ausubel, 1968). Therefore the learner must be prepared for the new knowledge. Ausubel calls this an *advance organizer,* more commonly known as preparing for learning. One example is an introductory text, which is used to prepare the learner for what the chapter will deal with and to give the learner a chance to make connections between previous knowledge and the new knowledge presented (Ausubel, 1968).

3.2 Learning objectives

Diana Laurillard has written the book *Rethinking University Teaching* which, as the name reveals, aims at giving university teachers a different perspective and new ideas on how to improve teaching and learning. The purpose of using *learning objectives* is to make clear to the students to what they are supposed to learn from the material. Learning objectives also let the students know when they have reached the goals (Laurillard, 1993).

The word "understand" should be avoided when writing learning objectives since this word can have several meanings (Biggs, 1999) and is often overused when people write learning objectives. Instead "understand" can easily be replaced with an active verb from Bloom's taxonomy for learning objectives (Bloom, 1956). A good learning objective defines what the student should be able to do with the new knowledge (Laurillard, 1993). This is an example of a badly defined learning objective: *"After this lecture, you should understand the three laws of Newton"*. This does not say anything about what you should be able to do with the new knowledge. According to Laurillard you do not know what to learn when facing a learning objective like this. Then it is better to formulate the objective in accordance to Bloom: "*After this lecture, you should be able to explain and apply which of Newton's three laws to use when facing a problem and argue for this choice in your working group*".

3.3 Cognitive theory of multimedia learning

Multimedia is media using a combination of words and pictures (Mayer, 2001). Words can be presented as text or spoken words. Pictures can be presented as illustrations, graphs, images, animations and video. Multimedia learning is also called *dual-channel learning,* since Mayer's assumptions state that humans have two information processing systems, one for the auditory- and one for the visual information.

Students who are taught using well-organized multimedia presentations perform better on *transfer tests* and *retention tests* than students who receive the same information in plain text (Mayer, 2001). Well-organized multimedia presentations draw on Mayer's five design principles described later in this chapter. The transfer test is designed to test understanding and the ability to apply the knowledge in new situations, while the retention test is designed to test how much the students remember and recognize from the presented material. The transfer test and the retention test can be seen as measuring two different levels of learning, understanding versus remembering.

3.3.1 Dual-channel assumption

Mayer's *dual-channel assumption* is the assumption that we have two different channels to take in information and then process that information. It all starts when getting exposed to pictures and words through a multimedia presentation (left side of figure 8). The boxes represent different memory storages. *Sensory memory* allows for pictures and printed text to be held as images for a short time and for spoken words to be held as sound for a short time. The arrow from "words" to "ears" represents spoken words while the arrow from "words" to "eyes" represents written words. The words and images are then processed in the *working memory*. The right box of the figure represents the long-term memory, where the information is stored when we have made connections with prior knowledge. It is not until then we have made the information to knowledge.

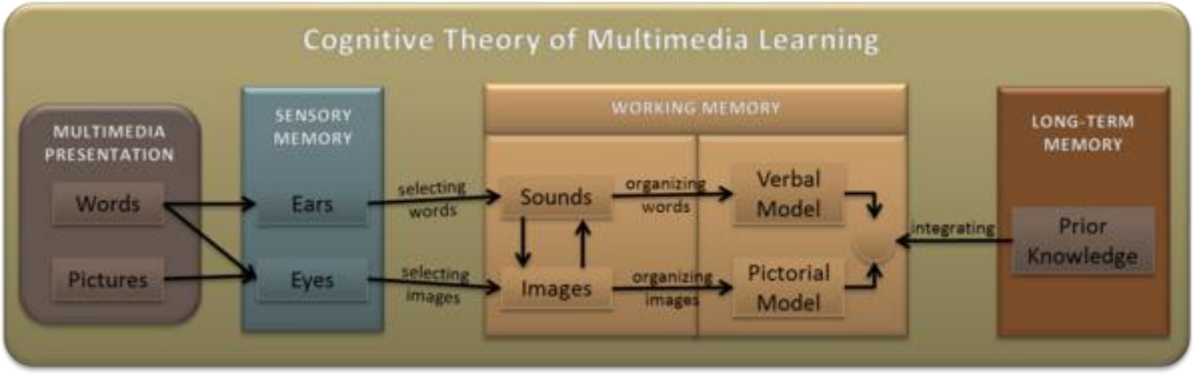

Figure 8 - Mayer's cognitive theory of multimedia learning where words and pictures are processed in different channels.

3.3.2 Limited capacity assumption

"Humans are limited in the amount of information that they can process in each channel at one time" (Mayer, 2001: 44). The *limited capacity assumption* proposes that there is a limit to how much information one can hold and process in the working memory. If we are exposed to illustrations or animations, the working memory can only hold a few images in memory and words are no exception. The cognitive capacity between individuals can vary and one way to test the cognitive capacity is to do a digit span test. Read a series of digits at a rate of one digit a second and then repeat. The longest streak without any error is the memory span. The memory span for adults is usually 7 ± 2 digits. (Miller, 1956). However one can use techniques to get around this problem by remembering chunks of digits and therefore remembers more digits, but instead it comes down to remembering 7 ± 2 chunks instead of digits.

3.3.3 Mayer's principles

Temporal contiguity principle

The *temporal contiguity principle* states that "students learn better when corresponding words and pictures are presented simultaneously rather than successively" (Mayer, 2001: 96). Students that are presented with narration and animation at the same time perform better on transfer tests as well as retention test than students that have pauses between narration and animation. This is due to the problem of keeping information in the working memory. In three of five retention tests and eight of eight transfer tests, learners performed better when corresponding words and pictures were presented simultaneously rather than successively (Mayer, 2001).

Spatial contiguity principle

The *spatial contiguity principle* states that "students learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen" (Mayer, 2001: 81). When students do not have to search the page or screen for information they seem to learn better since it is easier to keep the information in the working memory if the information is presented side by side. Mayer suggests that one way to get around this problem is to integrate the text into the pictures instead of having all the text on one page and all the illustrations on another page, for example, which unfortunately is a common mistake. In two of two retention tests and five of five transfer tests, learners performed better when corresponding picture and text were placed near each other rather than far away from each other (Mayer, 2001).

Coherence principle

The *coherence principle* states that "students learn better when extraneous material is excluded rather than included" (Mayer, 2001: 113). Simplicity is a key when using multimedia presentations, since too much information inhibits learning. Mayer advocates a "less-is-more" approach, which means that one should strive to simplify the presentation and get rid of all unnecessary information. If too much information is presented the information channels are overloaded. This is why one should only present the most relevant information in a multimedia presentation. In eleven of eleven retention tests and eleven of eleven transfer tests, learners performed better when extraneous material was excluded (Mayer, 2001).

Modality principle

The *modality principle* states that "students learn better from animation and narration than from animation and on-screen text" (Mayer, 2001: 134). The animation and the printed text will be taken in by the eyes and therefore compete for the visual resources, before the text is processed in the auditory channel and the animation in the visual channel. One example is a PowerPoint presentation when the presenter speaks to the written text in the presentation. When animation and narration is presented simultaneously the animation is taken in by the eyes and processed in the visual channel while the narration is taken in by the ears and processed in the auditory channel. This prevents animation and narration from competing for the same resources, which is the case in a PowerPoint where the spoken words and the written words compete for the same. In four of four retention tests and four of four transfer tests, learners performed better when presented with animation and narration rather than animation and on-screen text (Mayer, 2001).

Redundancy principle

The *redundancy principle* states that "students learn better from animation and narration than from animation, narration and text" (Mayer, 2001: 147). This principle, like the modality principle, focuses on where the information is taken in and where it is processed. The problem with adding text to an animation and narration is that it is almost impossible for the audience not to read the text. The text will compete with the animation in the visual channel at first and then be processed together with the narration in the auditory channel, which will lead to overload in the auditory channel. In two of two retention tests and two of two transfer tests, learners performed better when presented by animation and narration rather than animation, narration and on-screen text (Mayer, 2001).

3.7 Pictures - types

Depending on the context one can choose to use different types of pictures. Mayer (2001) categorizes pictures into four different types in his book *Multimedia Learning*. This can help in choosing which picture to use in a specific situation. The four types of pictures described by Mayer are:

1. *Decorative* - Illustrations that will interest or entertain the reader but does not add anything to the text. For example, "a picture of a group of children playing in a park for a lesson on physics principles" (Mayer, 2001: 77)
2. *Representational* - Illustration of a single element that has a clear connection to the text. For example, "a picture of the space shuttle with the heading *the space shuttle*" (Mayer, 2001: 77)
3. *Organizational* - Illustration that shows connections and relations between elements, an example can be a map or the main parts of a human brain.
4. *Explanative* - Illustration of how a specific system works like a series of pictures explaining how a specific product works.

3.8 Words - types

Max Atkinson is a former speechwriter for American presidents and advisor to the former leader of the Liberal Democrats, Paddy Ashdown. Atkinson has written the book *Lend me your ears* which helps presenters to inspire their audience with exemplary use of PowerPoint and body language. This book also advocates the use of the *active voice* in a speech or in any presentation. Atkinson pays attention to the small things that easily can be forgotten. Two such small things to take notice of in a presentation are the use of abbreviations and repetitions.

It is a big difference between writing a text that is only going to be read and writing a text for a speech (Atkinson, 2004). A way of testing the difference is to read out loud a text that only was supposed to be read. This can sound extremely strange and rigid. Just by adding abbreviations the text will be easier to listen to. The other thing is the use of repetitions; this can look wrong and complicate the reading of a text but it can be a really powerful tool in a speech. Just compare listening to Martin Luther King's famous "I have a dream" speech with reading the same speech; it will be perceived as complicated to read due to all the repetitions.

It is better to use the active voice instead of the passive voice when writing a speech since the active voice is more pleasant to listen to (Atkinson, 2004). Atkinson uses three words to describe a good speech: simplicity, brevity and clarity. When writing a speech one should try to simplify as far as possible since the audience does not have time to pause and think about what the spoken word means, which is different from reading a text.

4. *Methods*

This chapter describes the methods used within the different phases of this project. Figure 9 shows a schematic picture of the phases and the methods.

4.1 Pre-study

To identify the problems and possible solutions a pre-study was conducted. This was done in two steps. Firstly, to get a grip of the robot, the environment and the robots functions had to be studied. The robot, the pulp mill and the recovery cycle were studied. Robot manuals, existing IMTs in MWA and robot videos from the different sites were also studied in this step.

To really understand the problems with the robot, the second step included informal conversations with the operators of the robot on site. At the visit to Södra Cell Mörrum, these informal conversations were held with the operators to identify the problems with operating the robot and to get practical perspectives on the problems. The purpose of the informal conversations was not only to understand what the operators' thoughts about an online training but also to get a grip of possible problems they encountered when operating the Metso Spout Robot.

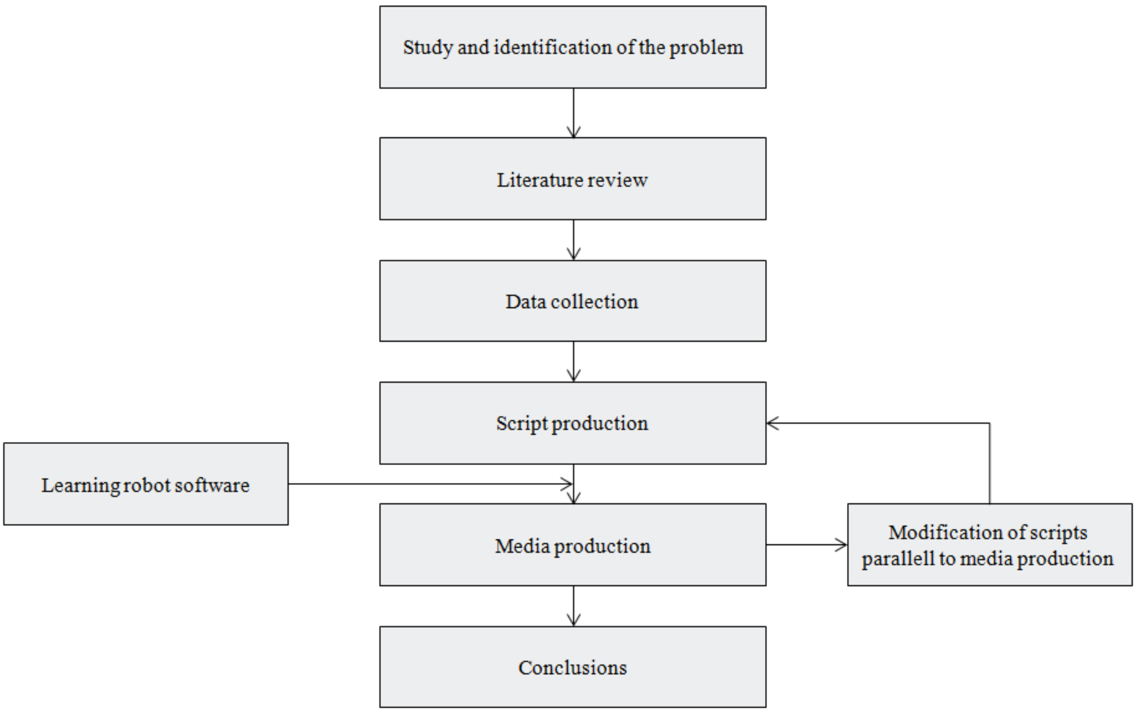

Figure 9 - Schematic picture of the phases and the methods

4.2 Literature review

When most of the technology needed was covered, the reading of literature about learning and education started. Most of the books used in this project were recommended by the supervisor from the University. This part was done to get ideas on how to present multimedia, what pictures to use and what language to use when writing both speaker scripts and ordinary scripts. The literature was used to get ideas on what to consider when creating the scripts and to back up the scripts that had already been written.

4.3 Script production

Metso always creates course maps in the beginning of the script production. Such a course map was created to estimate how many chapters that were needed and how many sequential players that should be included since this was the most expensive part to produce.

The script production and literature review was done in parallel but when all the necessary reading was over the script production intensified. The scripts were written in an Excel format, using a template that had to be created in the beginning of the script production. To synchronize the text with the pictures and animations, the work with the text and the media production had to be done in parallel.

4.4 Media production

The robot animations were done in ABB RobotStudio where all animations from linear movement to the specific spout rodding sequence could be programmed. Learning to use RobotStudio was learning-by-doing since no one at Metso was familiar with the software. Both animations from RobotStudio, robot videos and other pictures were included in the media production. The pictures were taken from the spout robot project, older trainings and from the internet. For example, when the comparison between the human arm and the robotic arm is made, pictures from the Internet had to be used since Metso lacked this kind of pictures.

5. *Results*

This chapter will exemplify parts of the multimedia training developed in this project to show how the theory and the informal conversations have been used to present the technology in a pedagogical way. I have chosen half a dozen examples in a variation to give a good representation on the training as a whole. All the scripts that were produced during this project can be found in appendix A.

The informal conversations helped to understand some of the problems that the operators had been facing. Many of the operators had no experience of robots and thought it would be good to learn how a robot in general works. Because of this chapter 3 “How a robot works” was included in the training. They also thought that the current teaching material was hard to understand and incorrect and therefore requested a chapter that dealt with what actions to take when the robot stops. This is why chapter 5 “Manual operation” was included in the training. The chapter named “25” lists four different actions to take when the robot stops.

After going through the current teaching material my conclusion was that not enough effort and consideration had been spent on the layout and how the information would be received by the operators. This was confirmed during my informal conversations with the operators on site. The expectation of this training was to skip the approach of telling exactly how the operators would behave in every situation, which was how the current material looked like. Instead, the training sought to educate the operators in an expectation that they would learn how to operate the robot and learn what actions to take when the robot stops and not be forced to look through the material every time. To achieve this goal the training dealt with things like how a robot in general works, safety issues and describing the specific spout sequence.

5.1 Advance organizers

An *advance organizer*, or an introductory text, was used in the beginning of the chapters that did not have learning objectives to prepare the learner for the content of the chapter. I chose to not have any learning objectives in the first two chapters since they were supposed to be used not only as a training for the operators but also as presenting material for potential customers. The advance organizer was used in a hope that the learner would start to make connections between old knowledge and the new knowledge. One example from the scripts is the sentence: *“This chapter will introduce you to the recovery boiler´s purpose and function in the pulp mill”*

5.2 Learning objectives

In the remaining chapters of the multimedia training, *learning objectives* were used instead of advance organizers in the beginning of the chapters. The main purpose of learning objectives is to let the learners know what is expected of them so that they know when they have reached the goals. Learning objectives and advance organizers serve the same purpose: to prepare the learner for the content. I have deliberately chosen not to use the word “understand” in the learning objectives since this word can have several meanings and does not really say anything about how you should be able to use the new knowledge. To get around this problem, the word “understand” is broken down into appropriate and active verbs like: summarize, provide examples, and recognize. These active verbs were selected from *Bloom’s taxonomy* of learning objectives (Bloom, 1956). These are two examples of learning objectives from the scripts: *“Provide examples of why coordinate systems are necessary when* *working with a robot”* and *“Summarize and give examples of the different steps in the normal robot operation sequence”*.

5.3 Mayer’s principles

Mayer’s five research based principles for designing multimedia presentations were used in producing the scripts and the media.

5.3.1 Temporal contiguity principle

The *temporal contiguity principle* was used to ensure that the corresponding narration and animation was presented simultaneously instead of successively. For example, the narrator describes a part in the process where smelt flows through spouts to a dissolving tank and at the same time the media area shows an animation of smelt flowing through a smelt spout (Figure 10).

♪♫ *“The smelt flows from the furnace floor through smelt spouts to the dissolving tank”* ♫

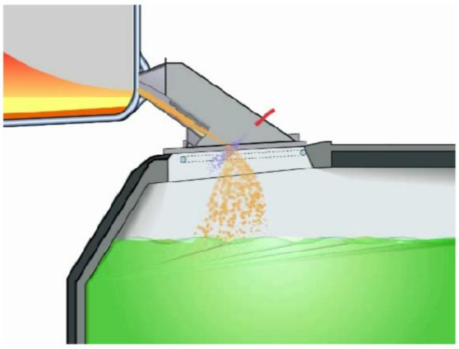

Figure 10 - An example of implementing the temporal contiguity principle

5.3.2 Spatial contiguity principle

The *spatial contiguity principle* was already used in the Metso Web Academy, but I do not know if this was done on purpose or by coincidence. The layout was not something I had control over in the scripts since this was done by the external company implementing the scripts, but I could choose to place text in the pictures that explained the pictures rather than to have it in the text area. My recommendation is that Metso keeps this layout since there are pedagogical benefits in presenting words and pictures near each other. This is what it looks like in Metso’s current trainings (Figure 11):

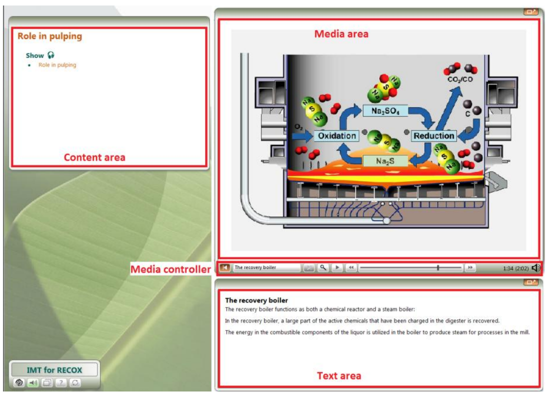

Figure 11 - An example of implementing the spatial contiguity principle

5.3.3 Modality principle

The scripts were to be presented in two different ways: Sequential player which includes narration and an animation and Text/picture which only included a picture and a text string. My recommendation, in line with the *modality principle,* is that all chapters should be sequential player since narration and animation gives a better understanding than text and picture. The sequential player was expensive to create and the budget only allowed four of these. The four hardest to explain only by text were prioritized:

- Recovery boiler
- Spout robot
- Movement
- Task: Rodding

The other parts of the chapters were presented as text and pictures.

5.3.4 Redundancy principle

The scripts to the sequential player were written so that the narrator could read the text and record it to the animation while the scripts to the text and picture were written as a text to be read by the operators. Metso have chosen to print the speaker script in the text area during the sequential player since this has been requested by the customers in earlier trainings. My recommendation, however, based on Mayer's work, is that Metso sticks to the *redundancy principle* and only uses narration to the animations.

5.3.5 Coherence principle

The *coherence principle* was used as a guiding principle when writing the scripts and reflecting on how much information to include in each chapter. There is extremely much information that could be included in some of the chapters but I had to think of how much information that was necessary for the operators to be able to understand. An example is the first chapter on the recovery boiler which now briefly summarizes its purpose and function. This is not the most essential part in the training but it is necessary to understand the context and in what environment the robot works in order to understand the problems it can cause. The recovery boiler is much more complex and interesting than what is explained in this training; that is why Metso has a training on only the recovery boiler that is far bigger than this relatively small training.

5.4 Simplicity

I have tried, as advocated by Atkinson, to simplify the training as far as possible. This shows in different ways, most in easy understandable language and the simplifications of words and pictures. One example of this is the revamping of the word "utilized" to the word "used", which I think is more easily understood. The word "utilized" was taken from the old scripts of the recovery boiler which I had to rewrite.

5.5 Pictures - types

When working with the scripts, the text was first written and then the media was produced in form of animations and pictures. A way of determining what kind of pictures to use were to use Mayer's categorization of pictures. For example, when the Metso Spout Robot had to be described with the available equipment, an *organizational picture* (Figure 12) was chosen since this would clarify what the equipment looked like and its purpose. If a picture of a random robot would have been used the picture would have lost its purpose, namely to show the robot with its available equipment. There were, however, parts of the scripts where it did not matter much which type of picture that was used. For example, in chapter 23.5 where the importance of coordinate systems is described. Here, the picture does not add anything to the information more than being nice and representing the text - this kind of picture is called a *representative* picture.

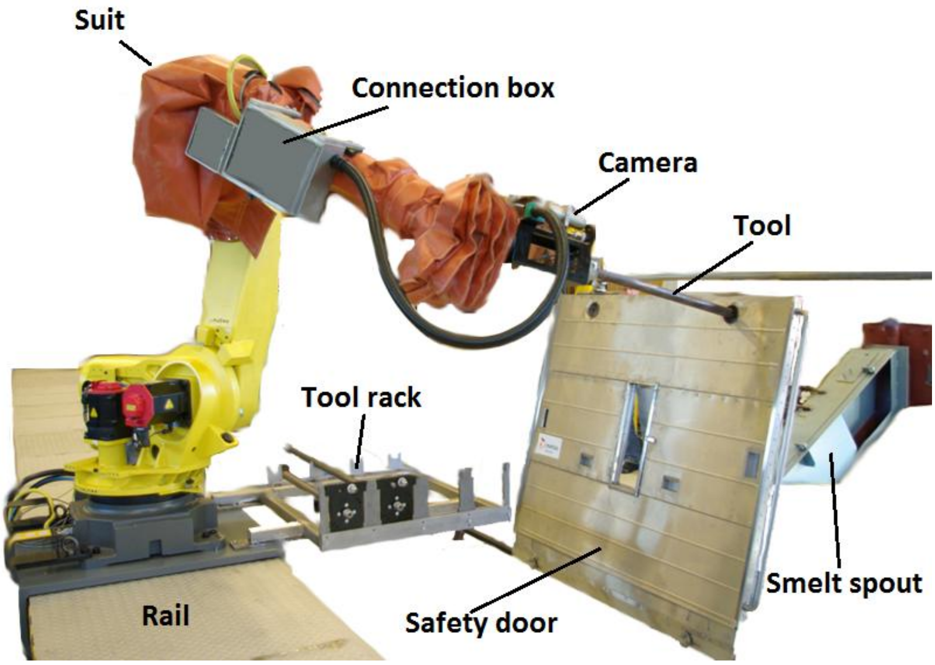

Figure 12 - Organizational picture showing the available equipment of the spout robot

5.6 Words - types

I chose to use a more active voice when writing the scripts, since the passive voice is more suitable for a report or a thesis. Some parts of the scripts are speaker scripts which mean that a narrator will narrate the text and thus the active voice is more suitable than the passive voice. The active voice has been used throughout but a concrete example from the scripts is the following: *"The robot opens the spout hatch and checks that the hatch is open".* If this sentence had been written using a passive voice it could have read: *"The spout hatch is opened by the robot which then checks if the hatch is open".*

6. Discussion

Metso call their learning modules ”*Interactive Multimedia Trainings*”. I chose to call my work Multimedia Training since I think most of the trainings, including this one, lack the *interactivity*. Laurillard defines *interactivity* as: *“Used to differentiate computer-based learning from other methods by virtue of the computer’s capacity to be programmed to change its behavior according to the learner’s input”* (Laurillard, 1993: 268). The Metso IMT’s clearly lack this kind of *interactivity* since the learner does not have the possibility to change anything in the learning modules to get another outcome.

The aim of this project was clear from the beginning, to create the basis (text and media) for a learning module. This learning module was to be implemented in the MWA and therefore had a predetermined format. I think it is hard to create an interactive learning module in the current format and it is probably too expensive to start with a new format, since this is set by the external company Maincon. It is important to remember that these learning modules only serve as a complement to the teacher-led education.

If Metso is interested in making this or other learning modules more *interactive* I suggest, in accordance to Laurillard (1993), that they use some kind of *simulation* since this is a form of interactivity. Interactivities aim is to let the student act to achieve the task goal (Laurillard, 1993) which also is in accordance to Mayer’s active processing assumption that states that from going from a passive receiver of information we have to make sense of the information and this can be done by acting and see that the outcome changes as we act. Mayer also states that it is not enough to only act to process the information in an active way, we also have to make sense of the material but I think that acting and see that the outcome changes is a good way to achieve this.

One example of how a simulation could be used in this learning module would be to use software like ABB RobotStudio. This software can be used to build a system with the robot and the surrounding environment and operate the robot with an on-screen virtual controller. It is also possible to connect a real robot pendant to the virtual system to be able to operate the robot exactly as in a real situation. A programmer can create different tricky situations in the software for the operator to solve, for example a robot that is stuck with the tool in the spout and a beam behind the robot which complicates the operation. The operator is then able to train on operating the robot when in a less stressful situation.

All the operators requested more training in operating the robot and therefore I recommend a form of simulation like the one described above to achieve this. This is probably expensive to do but I think this is exactly what the operators want and need as well as that it would make the multimedia training more interactive.

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Rustici software, www.scorm.com 26/4-2013.

Appendix A

Revision	0		Internal
Project name			Jonathan Gren
Doc. ID	P00149604		February 12, 2013
Project ID	890003		
Subject	Script		

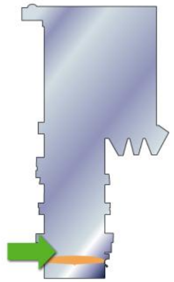
2.1 Recovery boiler

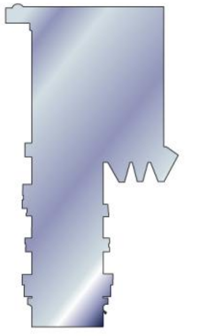
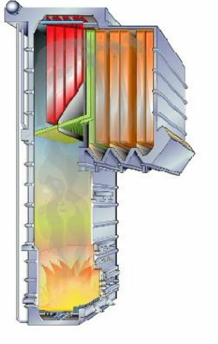
Contents

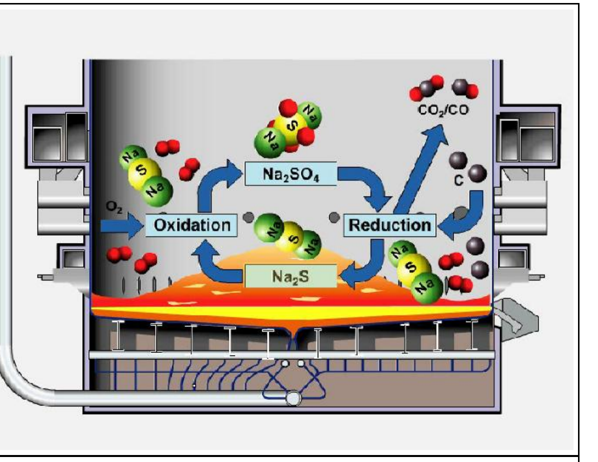
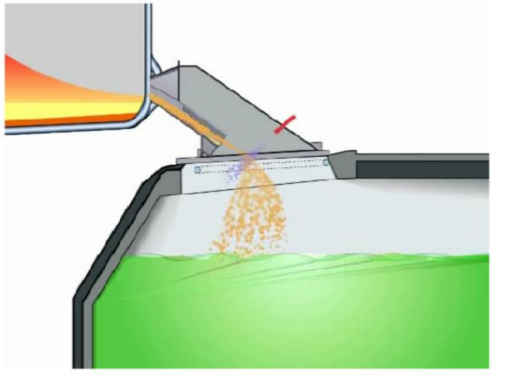
Prepared by	Reason for issue	Checked by	Approved by
Jonathan Gren			

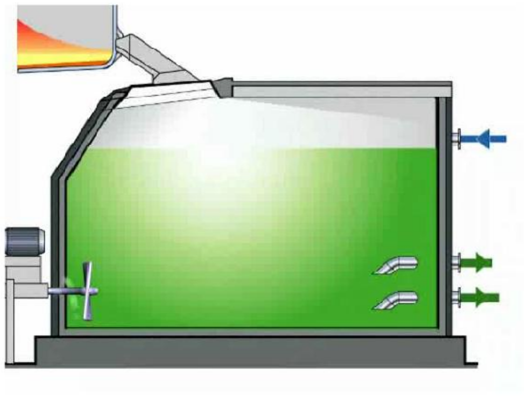
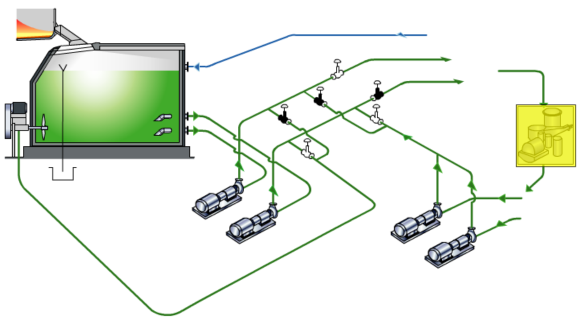
SEMasterGLB-00003 rev 2 / 17 Sep 2010

			Chapter	Hot spots	Menu
			2.1 Recovery boiler		
			2.1.1 RECOVERY BOILER*(VIEWER WITH SPEAKER)*		
Pos	File name (wav)	Final media	Speaker	Events and raw media	Final media
			Step 1: Introduction		
			This chapter will introduce you to the recovery boiler's purpose and function in the pulp mill.	P-K-0021-01 Show text: - Chemical reactor - Steam boiler - Recovery boiler	Chemical reactor + Steam boiler = Recovery boiler 
			Step 2: Purpose		

			The recovery boiler works as both a chemical reactor and a steam boiler to produce energy and recover chemicals.	P-K-0021-01 Show text: - Chemical reactor - Steam boiler - Recovery boiler	Chemical reactor + Steam boiler = Recovery boiler 
			In the recovery boiler, the active chemicals which have been charged in the digester are recovered.	Recox/Role in pulping/Recovery boiler 1:40 – 1:52	

			The rest of the energy in the combustible components of the liquor is used in the boiler to produce steam for other mill processes.	Recox/Role in pulping/Recovery boiler 1:52 – 2:02	
			Step 3: Function		
			Black liquor from the evaporation plant is sprayed into the recovery boiler. Correct supply of air and liquor results in optimum furnace performance for combustion and maximum recovery of chemicals.	Recox/Systems/ Combustion air/purpose 0:06 – 0:22 (Texten följer stegen i animationen)	

			The final chemical reactions take place in the bottom of the boiler. The recovered chemicals are gathered on the furnace floor in the form of smelt.	Recox/Role in pulping/Recovery boiler 1:34 – 1:40	
			The smelt flows from the furnace floor through smelt spouts to the dissolving tank.	Recox/green liquor/function 0:35 – 0:42	

			In the dissolving tank, the smelt is mixed with weak liquor. This results in a slurry, which is called green liquor.	Recox/green liquor/function 0:43 – 0:50	
			The green liquor is pumped from the dissolving tank to the re-causticizing plant for recovery of purified chemicals.	Recox/green liquor/function 0:50 – 0:57	

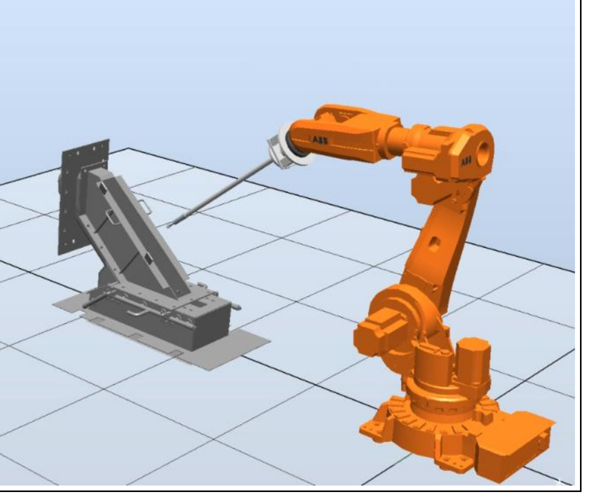
Revision	0		Internal
Project name			Jonathan Gren
Doc. ID	P00149604		February 13, 2013
Project ID	890003		
Subject	Script		

2.2 Spout robot

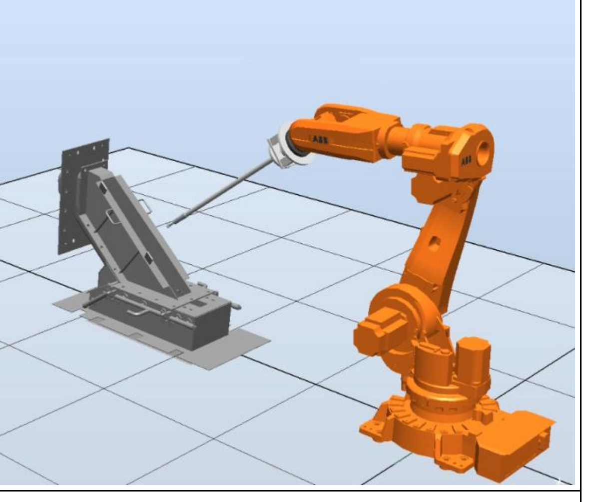
Contents

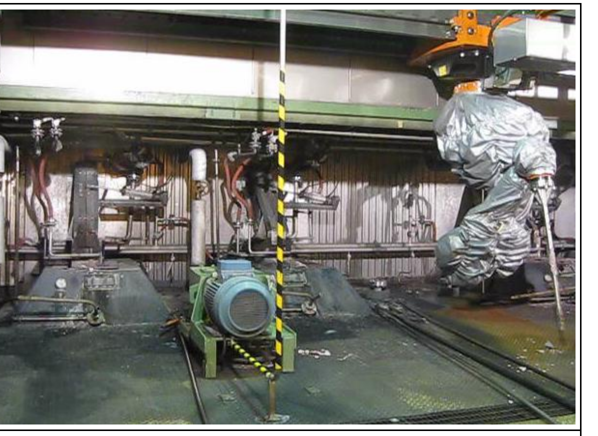
Prepared by	Reason for issue	Checked by	Approved by
Jonathan Gren			

SEMasterGLB-00003 rev 2 / 17 Sep 2010

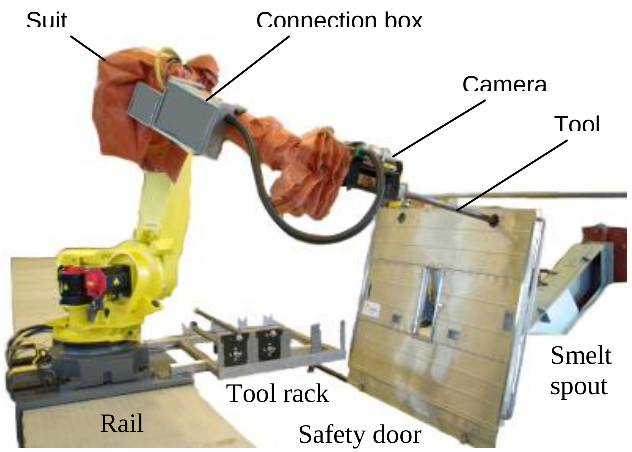
			Chapter	Hot spots	Menu
			2.2 Spout robot		
			2.2.1 SPOUT ROBOT *(VIEWER WITH SPEAKER)*		
Pos	File name (wav)	Final media	Speaker	Events and raw media	Final media
			Step 1: Introduction		
			This chapter will introduce you to the work done by the robot in and around the smelt spouts.	P-K-0022-01	

			Step 2: Purpose		
			Smelt from the recovery boiler flows through smelt spouts on its way into the dissolving tank. To withstand the high smelt temperature, up to 1000 °C, the spouts must be water-cooled.	Recox/green liquor/function 0:19 – 0:25	
			The temperature difference between the hot smelt and the cooler spouts is enough to freeze part of the smelt in the spouts, preventing a continuous flow.	M-K-0022-02.flv	

			The frozen smelt must be removed, which until now has been done by specialists with a rod.	M-K-0022-03.flv (fd manual_rodding_utan_robot.flv) Sudda ut företagsnamnet på jackan	
			To minimize the risks of working in the hazardous environment in and around the spouts, Metso has developed the Metso Spout Robot.	P-K-0022-01	
			Step 3: Function		

			The robot begins the automatic cleaning sequence from its home position and moves to open the spout hatch.	M-K-0022-04.flv	
			The robot can now start to remove the frozen smelt. It moves in pre-defined pattern to remove smelt deposits in the spout, the spout inlet and the lower hood area.	M-K-0022-05.flv	

			When the work in the spout is finished, the robot closes the hatch and repeats its work on the remaining spouts. When all spouts are cleaned, the robot returns to its home position and waits , waiting for the sequence to start again, or for a start order from the operator.	M-K-0022-06.flv	

	2.2.2 METSO SPOUT ROBOT (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	The main parts available in the Metso spout robot installation are: • Connection box • Camera • Rail • Tool rack • Tool • Smelt spout • Safety door	Metso Spout Robot		P-K-0022-07 Show pointers - Connection box - Camera - Rail - Tool rack - Tool - Smelt spout - Safety door	

LO K-0023 IMT for robot, How a robot works			1/14
Revision	0	Internal	
Project name		Jonathan Gren	
Doc. ID	P00149604	February 26, 2013	
Project ID	890003		
Subject	Script		

23 How a robot works

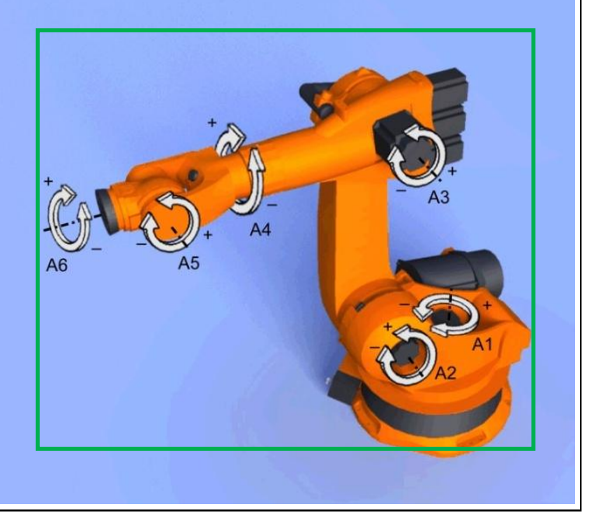
Contents

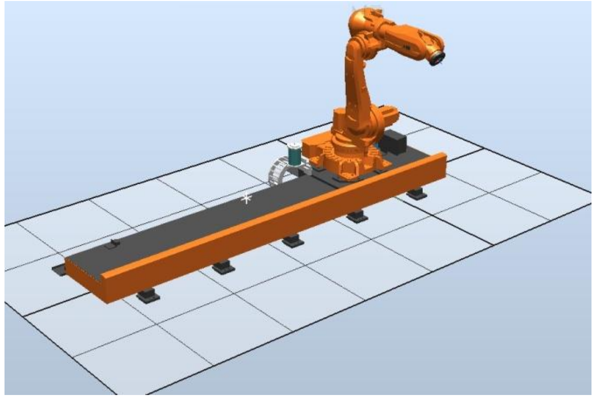
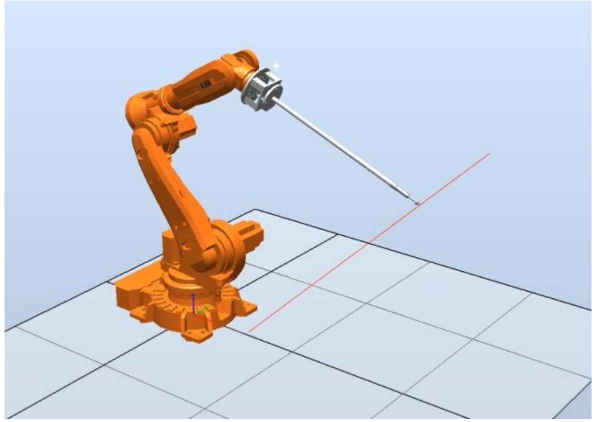
Prepared by	Reason for issue	Checked by	Approved by
Jonathan Gren			

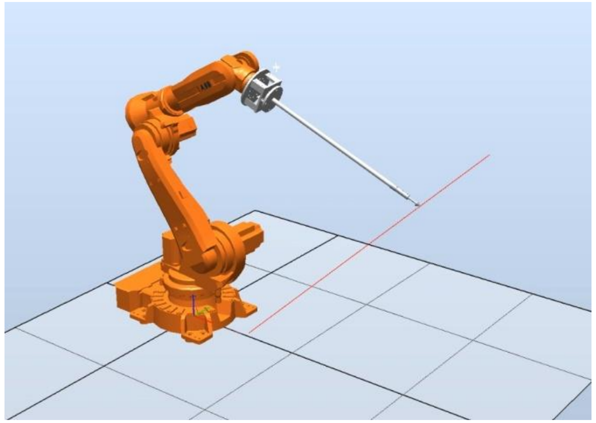
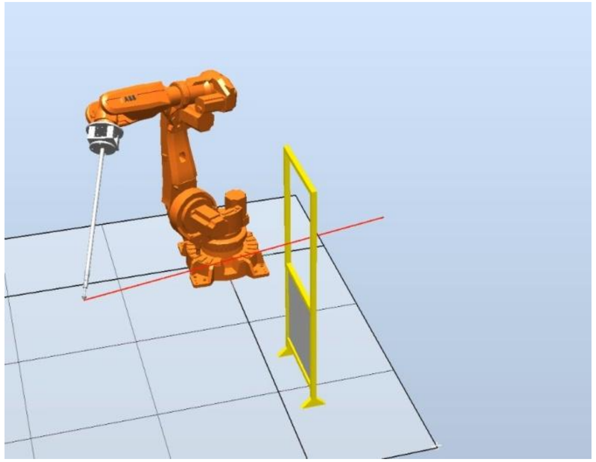
SEMasterGLB-00003 rev 2 / 17 Sep 2010

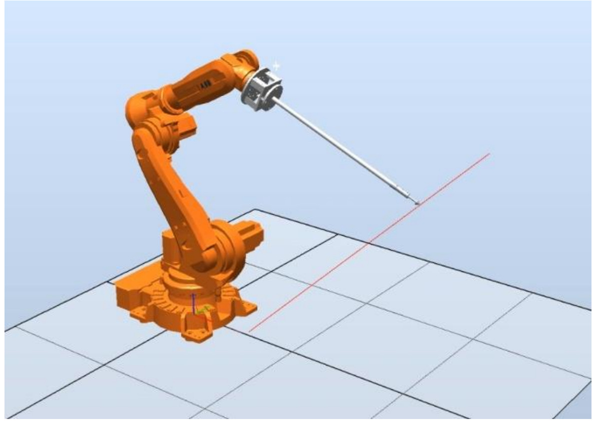
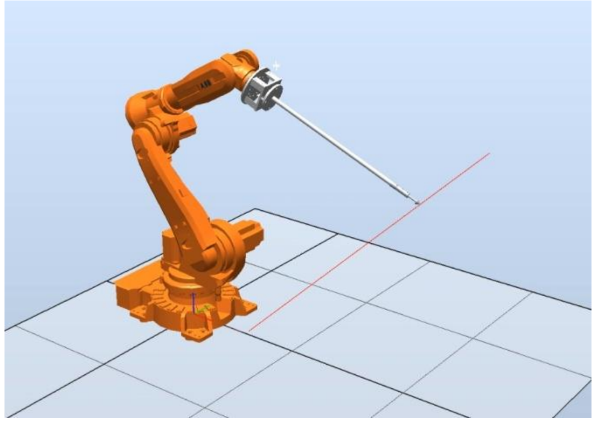
	2.3.1 LEARNING OBJECTIVES (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	After this chapter you should be able to: -See the resemblance between the human arm and the robotic arm and by this understand how a robot is able to move. -Visualize in your head the different movement styles when you come across them next time. -Provide examples of why 3D-coordinate systems are necessary when working with a robot.	Learning objectives		P-K-0023-01 Show text - Learning objectives	

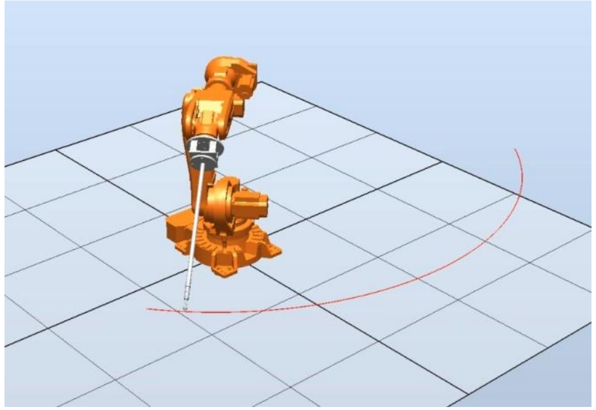
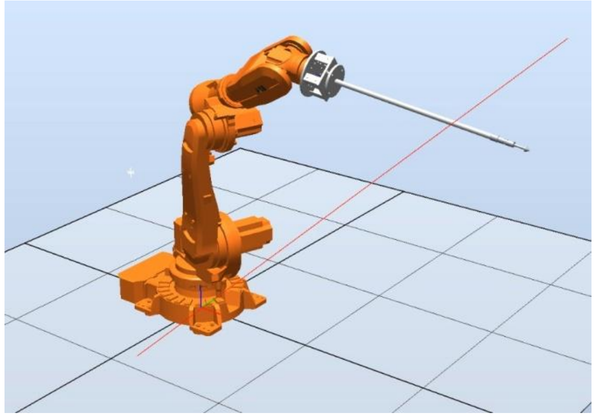
	2.3.2 ROBOT (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	An industrial robot has a close resemblance with a human arm. For instance, it has: • A shoulder • An elbow • A wrist			P-K-0023-02	
	There are even more similarities. The human arm and the robotic arm share the same purpose, which is to move its working tool from place to place. While the human arm's working tool is a hand, the robotic arm can use a variety of tools.			P-K-0023-02	

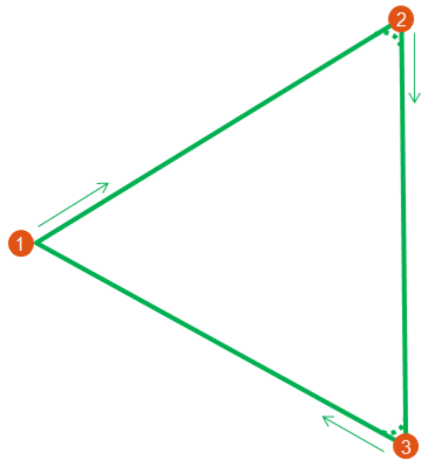
			Chapter	Hot spots	Menu
			2.3 How a robot works		
			2.3.3 MOVEMENT*(VIEWER WITH SPEAKER)*		
Pos	File name (wav)	Final media	Speaker	Events and raw media	Final media
			Step 1: Axes		
			An industrial robot is typically built around six axes, which together give the robot six degrees of freedom. This means that the robot can move in six different directions since it rests on an immobile foot. The human arm has additional degrees of freedom. A human is also able to move its body, which can be seen as an external axis.	P-K-0023-03 Zooma in lite eftersom så att det inte blir en stillbild.	

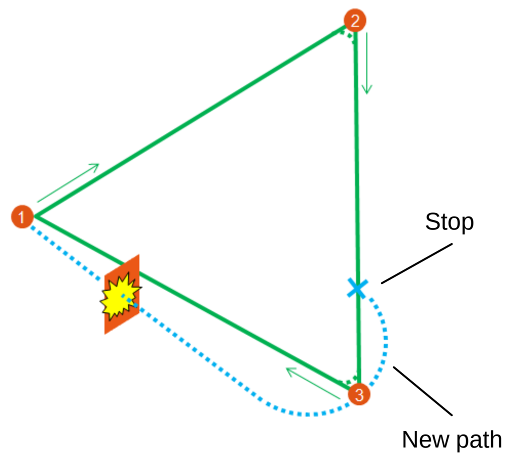
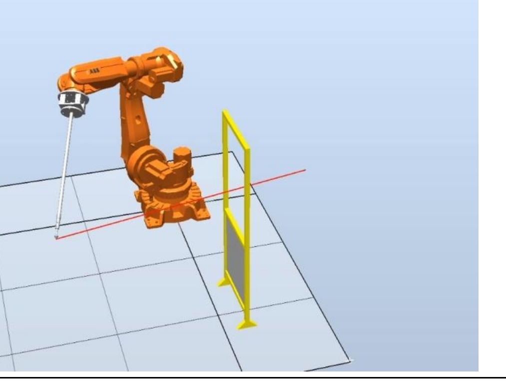
			A robot can also use an external axis to add another degree of freedom. One example of an external axis is the rail.	P-K-0023-04	
			Step 2: Movement		
			A robot does exactly what you tell it to do, and nothing else.	Stillbild (startbild från nästafilm) från " M-K-0023-05"	

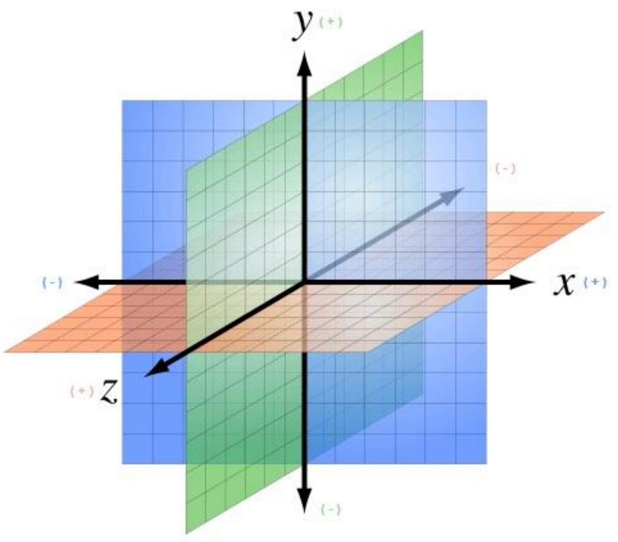
			If you tell the robot to move from A to B, it will follow your instruction. However, the robot will not be aware of any unspecified equipment in the robot cell.	M-K-0023-05	
			So if the operator does not pay attention to the path the robot is taking, there might be a collision. You must pay attention to the entire robot. Not only the tool can collide, the rear of the robot may also cause a collision.	M-K-0023-06 0:03 – 0:08	

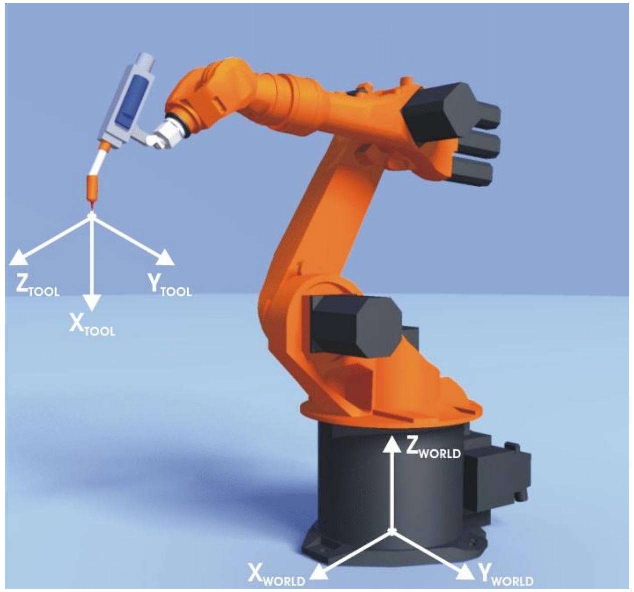
			The robot moves in three different motion styles.	Stillbild från "M-K-0023-05"	
			• Linear motion, which means that the center point of the tool moves in a straight line between two points. This includes movement along all axes.	M-K-0023-05	

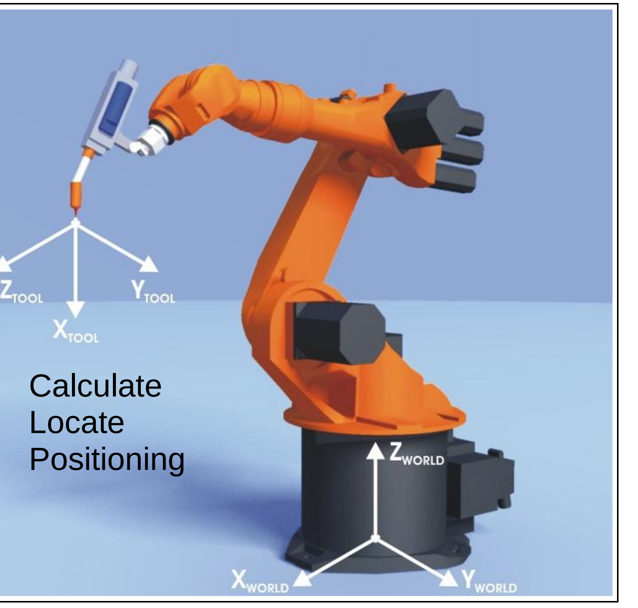
			• Circular motion. To be able to calculate a circle, the robot needs three points.	M-K-0023-07	
			• Point to point motion is the fastest way to move between two points, but not necessarily the shortest. It´s impossible to predict which path the robot will take when doing a point to point motion. Which of these motion styles the robot uses, depends on how the robot is programmed.	M-K-0023-08	

			Everytime a robot starts a sequence, it knows all the targets in the sequence, but not which path to take between them. The robot must calculate the path connecting these targets.	P-K-0023-09	

			If the robot stops between two targets it has to make a new calculation, starting in the current position. The new path will be different from the path first calculated, which may lead to a collision.	P-K-0023-10	
			It is important to remember that the robot is not aware of any other equipment around it.	M-K-0023-06	

	2.3.5 COORDINATE SYSTEMS (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	The global three-dimensional coordinate system describes the location of all the targets in the robots' working area.			P-K-0023-11	

	A coordinate system helps the robot programmer to position the working tool. To make it simpler to program and operate, the robot usually needs several coordinate systems.			P-K-0023-12	

	Three-dimensional coordinate systems helps • To calculate the robots' movements, • To locate where objects are situated and • The programmer to position the working tool.			P-K-0023-12 Texten i textrutan ska läggas in i bilden, till vänster om roboten under verktyget. Show text - Calculate - Locate - Positioning	

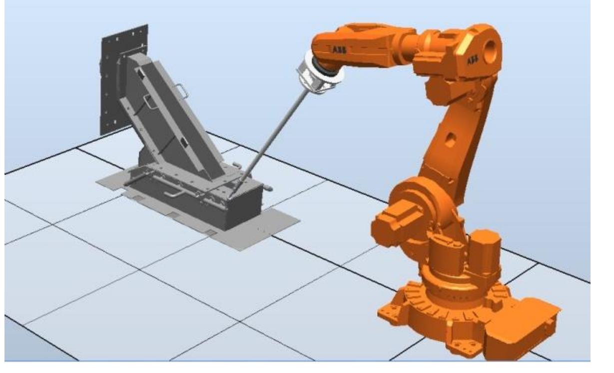
	2.3.6 SAFETY (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	If you have instructed the robot to move from A to B, it will do so. Depending on where the robot is located, it can move very fast. Remember that the robot will not mind if there is something, or someone, in the way.			P-K-0023-13	

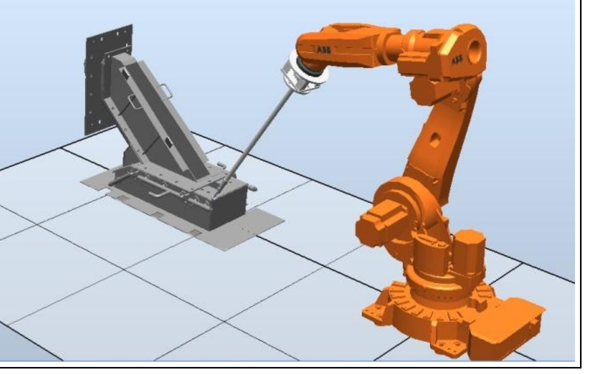
2.4 Normal operation

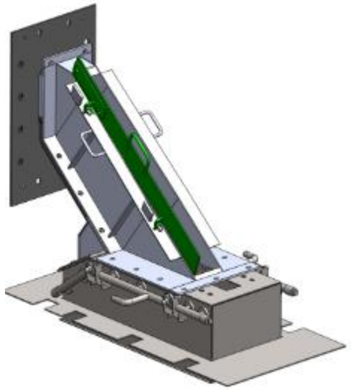
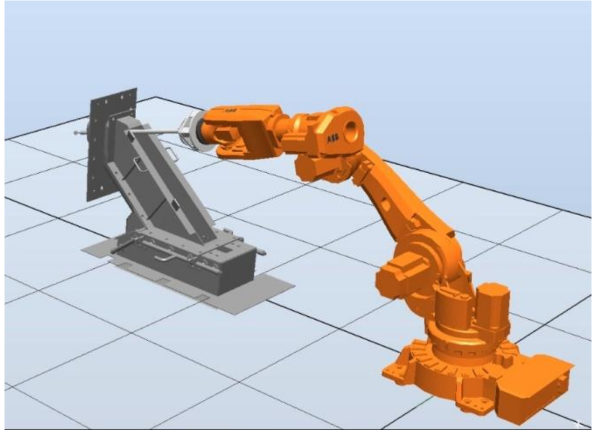
Contents

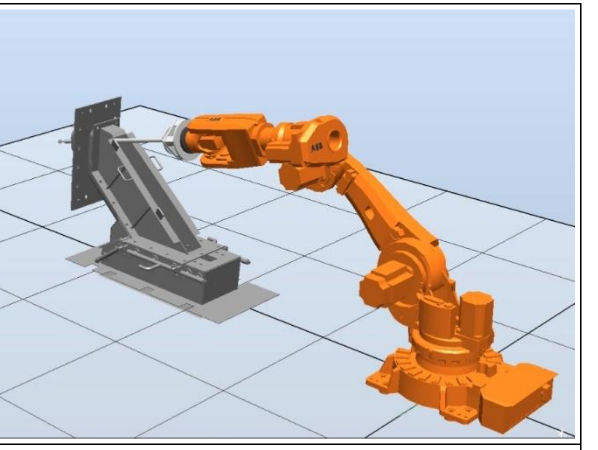
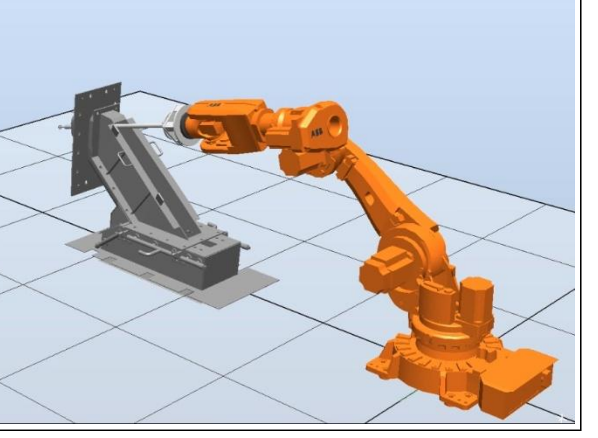
Prepared by	Reason for issue	Checked by	Approved by
Jonathan Gren			

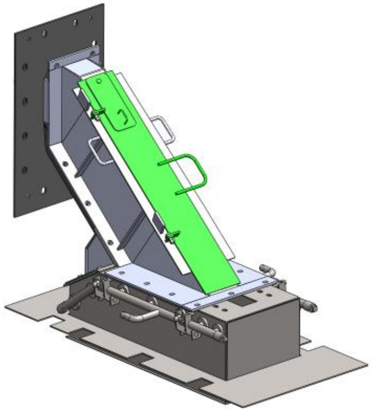
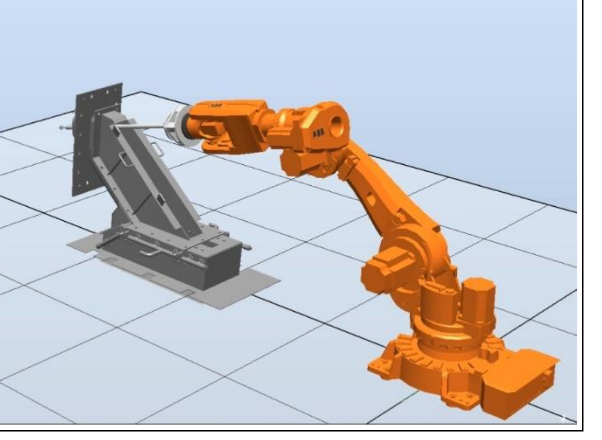
	2.4.1 LEARNING OBJECTIVES (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	After this chapter you should be able to: -Summarize and give examples of the different steps in the normal robot operation sequence. -Remember that the robot works in a continuously changing environment and therefore name the reasons why the robot sometimes performs a calibration sequence.	Learning objectives		P-K-0023-01 Show text - Learning objectives	 Learning objectives

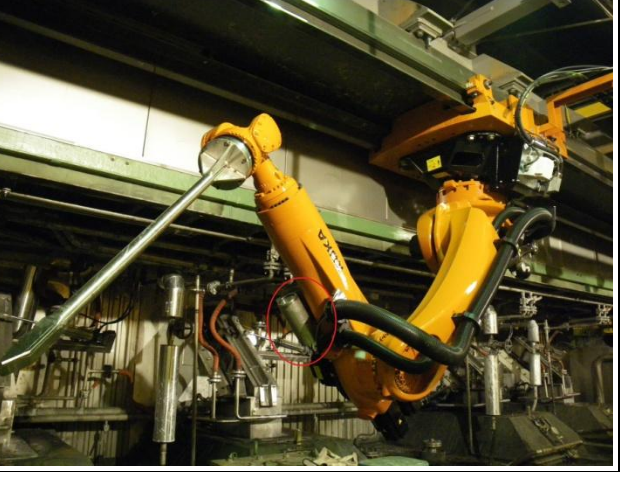
	2.4.2 CALIBRATION (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	The robot moves in a pre-programmed sequence and is quite sensitive for deviations. Therefore the robot will do a calibration if: • The tool is damaged • The spout has moved • The boiler has moved In this calibration, the robot checks if the tool is damaged and if the spouts or the boiler have moved out of position.	Calibration		P-K-0024-01	

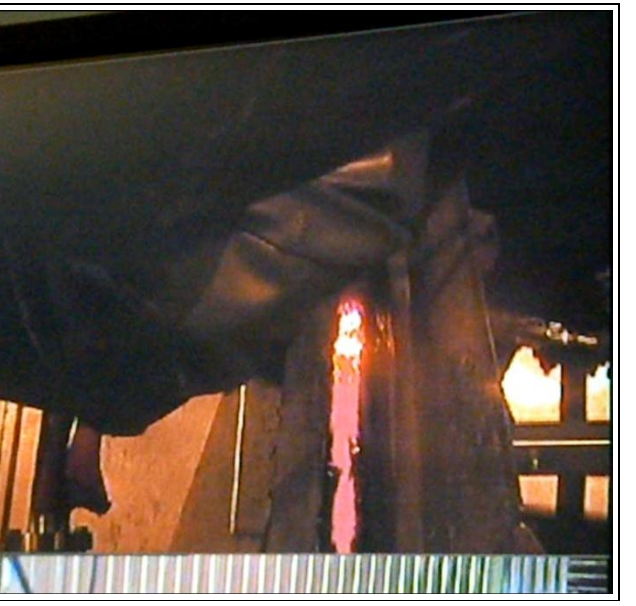
			Chapter	Hot spots	Menu
			2.4 Normal operation		
			2.4.3 TASK: RODDING *(VIEWER WITH SPEAKER)*		
Pos	File name (wav)	Final media	Speaker	Events and raw media	Final media
			Step 1: Rodding		
			The robot starts by checking the current position of the spout to ensure that the spout is located in the right place. If the spout has moved, the robot will perform a calibration sequence.	P-K-0024-01	

			The robot opens the spout hatch and checks that the hatch is open.	P-K-0024-02	
			The robot then starts rodding, in this case by cleaning the shatter jet nozzle and continuing in the lower hood to remove smelt from the walls inside the hood.	M-K-0024-03 0:00 – 0:10	

			The robot then cleans the spout walls and works itself upwards through the spout.	M-K-0024-03 0:10 – 0:17	
			When the robot has cleaned the spout, from the lower hood to the inlet, it removes smelt that is stuck in the inlet, to ensure an open passage for the smelt.	M-K-0024-03 0:17 – 0:27	

			The robot finishes by closing the hatch. The procedure is repeated for the remaining spouts.	P-K-0024-04	
			Finally the robot returns to its home position, and waits for the sequence to start again or for a remote order.	M-K-0024-03 0:27 – 0:30	

	2.4.4 TASK: INSPECTION (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	The inspection sequence uses a camera, placed on the robot, to study details on active spouts and selected positions in the robots' working area.	Task: Inspection		P-K-0024-05	

	The picture shows the screen from the operators' point of view, when the robot is performing an inspection sequence. In the inspection sequence, the robot moves in a pre-programmed sequence. The sequence can be paused for a closer inspection, but not reversed. During the inspection, the operator can deselect the other spouts and start the sequence once again.			P-K-0024-06	

	2.4.5 SAFETY (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	Do not stand close to the robot or the spout when the robot is working. When the tool is in the smelt, there is a risk of smelt splashes on the spout deck.	Safety		M-K-0024-07	

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Project ID	890003	
Subject	Script	

2.5 Manual operation

Contents

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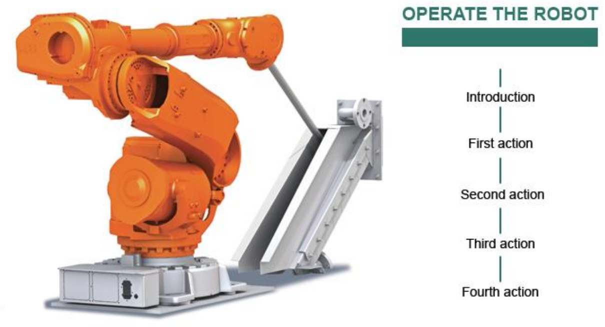
	2.5.1 LEARNING OBJECTIVES (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	After this chapter you should be able to: -Operate the robot in a safe way. -Recognize the important functions on the pendant. -Use the instructions to operate the robot and feel confident about what to do if the robot stops.	Learning objectives		P-K-0025-04	

	2.5.2 PENDANT (VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	All robot brands have their own pendant but they all have some things in common: - An emergency stop and - A dead-man feature	Pendant		P-K-0025-01	

	The emergency stop is recognized as a big red button. Pushing this button will immediately stop the robot.			P-K-0025-01 Show pointer: - Emergency stop	

	The dead-man feature is a safety precaution in the form of buttons. When operating the robot from the pendant the dead-man feature always has to be correctly pressed. If the button is released or pressed to hard, the robot will stop immediately.			P-K-0025-02 Show pointer: - Dead-man feature	

	2.5.3 OPERATE THE ROBOT(VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	Introduction			P-K-0025-03 Detta avsnitt ska läggas upp som CYMIC boiler/Operations/Operation. Rubrikerna nedan ska vara klickbara rubriker.	
	This sequence will guide you through the necessary actions when the robot stops. Click the headlines in the picture to read more.				
	First action				

	If the robot stops when you have tested the emergency stop or when it stops due to an unknown cause. • Look at the screen to see if everything looks correct • Acknowledge on the screen • Restart the sequence The robot will then continue the sequence from where it stopped.				
	Second action				
	If you are unable to start the robot by the first action, there is probably something else that made the robot stop. • Go to the spout deck. • Reset the alarms and the safety enclosure in the robot cell. • Acknowledge all errors on the pendant. The robot can now be activated from the control room. It will continue the sequence from where it stopped.				
	Third action				

	If none of the mentioned actions works, you will have to operate the robot in manual mode. The following is an example of the not unusual but most difficult situation where the robot stops. **The robot has stopped with the tool in the smelt** • Enter the spout deck and select the tool cordinate system on the pendant. • Using the pendant, carefully pull out the robot tool a few centimeters so that the tool is out of the smelt. • Press the "forward-button" until the robot finds a known position. This is necessary for the robot to be able to resume the sequence. • Acknowledge all errors on the pendant. The robot can now be activated from the control room and will continue the sequence from the known position.				
	Fourth action				
	Sometimes the robot is unable to resume the sequence, despite that the known position has been found. To help the robot return to its home position.: • Start the Assisted Return Program. • Define in which spout the robot is located. • The sequence can then be re-started from the beginning.				

	2.5.4 SAFETY(VIEWER WITH TEXT AND IMAGES)				
Pos	Text RB	Label			Final media
	When you operate the robot manually it might be necessary to move inside the robot cell. In this case you must be careful and keep track of both the robot and the smelt spout. Always remember: - Smelt can splash from the boiler or the spout - The robot does not know where you are, keep out of the way of the robot - Robots can be unpredictable, you never know what the next movement will look like	Safety		P-K-0023-13