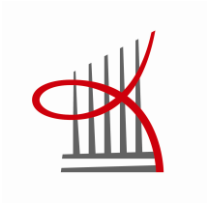

DRILL RIG TECHNICAL TRAINING CURRICULUM

Mikko Manninen

Bachelor's Thesis
September 2013
Degree programme in
mechanical engineering
Aviation engineering

TAMPEREEN AMMATTIKORKEAKOULU
Tampere University of Applied Sciences

TIIVISTELMÄ

Tampereen ammattikorkeakoulu
Kone- ja tuotanto tekniikka
Lentokonetekniikka

MIKKO MANNINEN:
Poralaitteen teknisen koulutuksen modulaarinen opetussuunnitelma

Opinnäytetyö 16 sivua, joista liitteitä 87 sivua
Kesäkuu 2013

Tämän opinnäytetyön aiheena on Sandvikin DPi -sarjan poralaitteiden teknisen koulutuksen modulaarisen opetussuunnitelman laatiminen. Työn tavoitteena oli saada opetussuunnitelman varsinaisen teknisen koulutuksen osuus laajennettua ajantasaiseksi ja kattavaksi modulaariseksi kokonaisuudeksi. Opetussuunnitelma myös käännettiin kokonaisuudessaan englanniksi, jolloin se on paremmin työn tilaajan hyödynnettävissä.

Työssä esitellään lyhyesti DPi -sarjan poralaitteita. Lisäksi työssä käydään läpi syitä, jotka synnyttivät tarpeen opetussuunnitelmalle, sekä itse opetussuunnitelman rakennetta ja sisältöä. Opetussuunnitelman tietosisältöä koostettiin Sandvikin koulutusmateriaalista, Sandvikin teknisen koulutuksen opetuksesta ja lukuisista asiantuntijahaastatteluista.

Asiasanat: poralaite, modulaarinen, tekninen koulutus, opetussuunnitelma

ABSTRACT

Tampereen ammattikorkeakoulu
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MIKKO MANNINEN:
Drill rig technical training curriculum

Bachelor's thesis 16 pages, appendices 87 pages
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The topic of this thesis is the drafting of the Sandvik DPi -series drill rigs' modular technical training curriculum. The object of this work is to broaden the actual technical training part of the curriculum into an up to date and comprehensive modular body. The curriculum was also translated into English to enable better usability to the employer.

The thesis includes a brief presentation of the DPi -series drill rigs. In addition it incorporates the reasons behind the need for a technical training curriculum in Sandvik and the structuring and contents of the curriculum. The information content is compiled from official Sandvik training material, Sandvik technical training teachings and numerous expert interviews.

Key words: drill rig, technical training, modular, curriculum

TABLE OF CONTENTS

1 INTRODUCTION

Surface tophammer drill rigs are complex machines that are continually being developed to incorporate the latest technologies, so that customers are able to ever more efficiently and more safely drill holes into rock. The scope of technological advancement in the last 100 years is massive: from hand held pneumatic drills to ultramodern remotely operated electrohydraulic drill rigs. Yet the most valuable drill rigs to customers still are those that exhibit the least downtime, thus emphasizing the importance of proper maintenance.

This continuous advancement of technology has required manufacturers to develop ways to train operators in the proper usage of the new technologies, as well as more importantly, to train the technical staff properly to ensure products meet their expected lifetimes. Drilling rock is, even in the best circumstances, challenging and demands utmost performance from man and machine. Spare parts and services sales are a continuously growing important and lucrative business for drill rig manufacturers.

The main idea behind the technical training curriculum is to create such a comprehensive structure of teaching that it can be easily and effectively implemented in all Sandvik service organizations the world over. This essentially unifies the competence requirements of all the organizations, guaranteeing quality maintenance services to all customers regardless of their location. In addition the modular structure enables cross-referencing between different models and faster drafting of future curriculums.

2 DPI –SERIES DRILL RIGS

2.1 Top hammer percussive drilling

A basic percussive drilling system can be categorized into four main components: rock drill piston, shank adapter, rods/tubes and drill bit. The rock drill piston is the main actuator in the system, converting the original energy form (hydraulic, pneumatic, electrical, etc) into mechanical energy. The shank adaptor conveys the impact energy of the piston (and possible rotational torque) through the rod(s) or tube(s) to the drill bit. The drill bit utilizes the energy of the system to attack rock abrasively so as to create a hole. (Sandvik Tamrock 1999, 63)

In tophammer drilling, the piston in the rock drill hits the shank adapter which consequently transmits the mechanical energy to the rod(s) or tube(s) and drill bit. The structure of this system requires the rock drill to be at one end of the drill string and the drill bit to be at the opposite end. Typically this is achieved (in vertical hole drilling) so that the rock drill is positioned on top of the drill strings, hence the name tophammer drilling. (Sandvik Tamrock 1999, 64)

Four drilling parameters determine the performance of percussive drilling at any given moment. These parameters are percussion power, feed force, bit rotation speed and flushing (see figure 1). To achieve maximum efficiency of drilling, these parameters must be uniquely balanced. (Sandvik Tamrock 1999, 64)

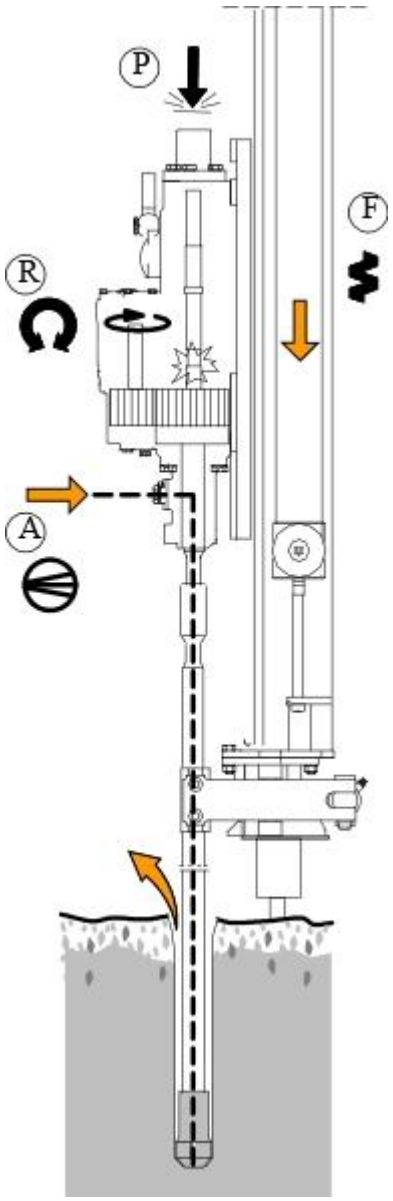

Figure 1 The main parameters of top hammer drilling are percussion (P), rotation (R), feed (F) and flushing (A). (Sandvik training material)

Percussion power is the impact energy and frequency output generated by the rock drill, which is directed through the drill string to the rock face. Feed force ensures proper contact between the rock drill and shank adapter, as well as between the drill bit and rock face. Bit rotation indexes the bit to keep it attacking 'fresh' rock continuously. To remove the rock cuttings at the bottom of the hole, flushing is needed. (Sandvik Tamrock 1999, 64-68)

A modern tophammer drill rig consists of a hydraulic rock drill on a feed. The feed force is transmitted to the rock drill cradle either by chain or cylinder. Flushing flow is directed through the shank adapter, drill string and drill bit to the bottom of the hole. The overpressure supplied by the flushing forces air (and cuttings) out of the hole by

way of the small spaces between the drill string and hole wall. It is then collected into a dust collection system to minimize harmful dust emissions.

2.2 Brief history of Sandvik (Tamrock)

The current Sandvik fleet of tophammer drill rigs are a continuation of Tamrock –era products. The catalogue consists of track drill rigs as well as rubber tyred drill rigs encompassing a broad area of hole dimensions from the smallest 22 mm capable DC –series to the largest 152 mm capable DPi –series. Non-cabin, remotely-operated rigs are also on offer. (Sandvik Construction website)

The first hand-held pneumatic rock drills were manufactured in Tampere in 1953 by the predecessor of Tamrock: the rock drill unit of Tampella. The Tamrock –name was first branded in 1969. Early products were mainly hand-held pneumatic rock drills which incorporated revolutionary designs at the time. (Sandvik Mining website)

The first hydraulic drills were manufactured and sold in the mid 1970's. Decades of growth followed, finally ending in the bankruptcy of sister company Tampella. This event paved the way for Sandvik Ab to acquire majority ownership in Tamrock in 1997. Nowadays the company is divided into Sandvik Mining and Sandvik Construction by customer sales areas. (Sandvik Mining website)

2.3 Sandvik DPi

The Sandvik DPi –series is a series of electrohydraulic track drill rigs (see figure 2) designed to drill holes in the range of 89-159 mm in diameter. They are a continuation of the successful Tamrock Pantera –series. The most significant development being that it is equipped with an intelligent, bus-controlled operating system.

Figure 2 Sandvik DP1500i drill rig. (Sandvik Construction website)

The DPi is available in three models (based on the installed rock drill: 900, 1100 and 1500) and can be equipped with a variety of optional equipment (for example rock drill stabilizer, one hole drilling automatics, hydraulic winch, etc.). Multiple engine variants are available to choose from, covering European emissions requirements from Stage IIIA to Stage IV (the corresponding US levels being from Tier 3 to Tier 4F). Future models are currently in the works and they will feature among other things an upgraded user interface and a completely redesigned electrical system.

3 TECHNICAL TRAINING CURRICULUM

3.1 Background

The Sandvik aftermarket business concept relies heavily on the quality of spare parts and services it is able to supply to customers. Encouraging customers to utilize official Sandvik technical services is not an easy task, especially in markets where cheap labour forces are abundant. This is a complex problem originating from various causes and requiring various measures to increase Sandvik profitability.

One of the main points of the Sandvik policy is to ensure global service quality at a high standard. This is one of the main factors driving the creating of a modular technical training curriculum. The target being that all service staff will be trained to the same standard regardless of market area and will be able to supply services at Sandvik standards.

The modular structure of the technical training curriculum allows common topics to be used in various drill rig model specific curriculums. Even more importantly though, the modular structuring enables courses to be tailored according to the competences and needs of the attendees. This results in better training courses that greatly benefit technician competence growth.

3.2 Curriculum theory

Oxford dictionaries defines a curriculum as “the subjects comprising a course of study in school or college”. In broader terms a curriculum is a teaching plan that incorporates the main aspects of the teaching at hand. It is an excellent tool for teachers when doing pre-course planning and supports course time management planning.

Typically curriculums aren’t limited to include only the course subjects. They also normally define the examination and grading methods, connect course material to appropriate sections and suggest alternative teaching methods.

3.3 Sandvik technical training

Sandvik technical training courses are mainly designed as drill rig model specific. The target being that the attendee is able to independently troubleshoot and service drill rigs. Alternatively he or she is able to train technicians in his or her own organization to the same level. The curriculum content differs whether the trainees are Sandvik employees, Sandvik representatives or customer representatives.

Factory training courses are planned every six months and a bulletin is published to frontline organizations. Factory training courses last usually one week and utilize factory resources (such as drilling simulators, drill rigs, purpose-built training rooms and official Sandvik training material). Additionally training engineers can be flown out to frontline sites to hold training, if it is seen as financially more viable to do so.

Sandvik drill rigs are continuously being updated, upgraded and modified. However this requires equally continuous attention to updating official Sandvik training material. The training material is an important part of the training and all trainees are given the material at the end of the course for self-study and reference on the job. The material is crucial for explaining complex systems, for example as seen in figure 3 depicting the DPi CAN –bus system.

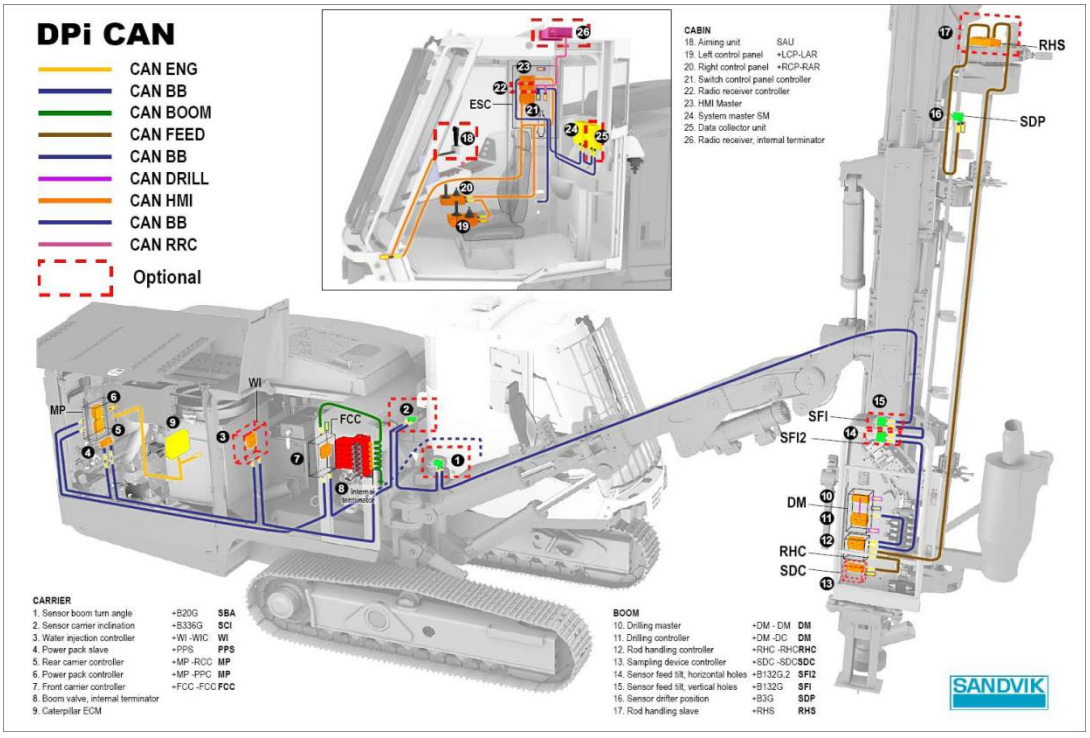

Figure 3 Overview of DPi CAN -bus system. (Sandvik training material)

Future plans for Sandvik training include developing a way to classify technician competence and experience. The modular technical curriculum will enable crossreferencing in this application. A large project will also be the updating of the DPi technical training material to include Tier 4 Final and all the older model contents once the Tier 4 Final – model is released next year.

3.4 Technical training curriculum

The DPi –series technical training curriculum has been developed to be as comprehensive and easily understandable as possible. It designed to be a support tool for the trainer to help structure and outline course content. One of the specialties of this curriculum is that it defines prerequisites between the modules, thus steering the training.

Currently the technical training curriculum is divided into twelve main modular topics (sections). These all contain their respective subcategories and subtopics in content. In addition the subtopics contain the aims, contents and implementation plans of their respective subjects.

The first topic “Introduction to rock excavation processes” contains basic information of all main rock excavation processes and basic rock type recognition. It is included in the curriculum to enable technicians to understand the rock excavation processes as a whole, to understand their significance in the chain of events and to be able to speak in industry terms with the customer(s).

The second main topic is “Safety and environmental issues of drill rig operation and maintenance”, which is a common and important subject for all drill rig operators and maintenance staff. “Introduction to the drill rig” is the third main topic and incorporates a basic understanding of the main systems of the drill rig. After the third topic the technician should be able to start Operators training.

The fourth main topic “Basic operation and the user interface of the drill rig” is designed to train the technician to understand how the rig works in normal conditions. The idea being that once the technician knows how the system should work, he or she will be able to more easily diagnose faults when they arise.

The next main topic “Hydraulic, pneumatic and electrical systems of the drill rig” depicts the main systems of the rig as independent entities. While the sixth main section “Main functional systems of the drill rig” is designed to build a comprehensive understanding of how all the systems work in unison to enable a function. The aim being that the technician understands the full chain of events from for example moving the joystick to the boom zoom cylinder actuating. The seventh main section “Optional systems of the drill rig” is developed in the same way, but only includes information on optional equipment so as to enable better utilization of the modular structure.

The content of the eighth topic “Drill rig scheduled maintenance” centers on the importance, actions of and needs of scheduled maintenance. “Drill rig documentation” (ninth main topic) is to contain issues related to the necessary documentations of the drill rig such as the Operators and maintenance manuals, as well as the spare parts documents. The tenth main topic “Drill rig lifetime support services” is to be concerned mainly with the contractual and drill rig lifetime issues.

Whereas the fourth main section centered around basic operation of the drill rig, the eleventh main topic “Drilling management and optimization in varying rock excavation circumstances” is designed to improve technician operating skills to an advanced level. He or she will be able to utilize the drill rig to the full extent of its’ capabilities, while understanding the main factors that limit and effect productivity, rock tool lifetime and drill rig downtime. The final module “Interpersonal skills on the frontlines” contains customer-relations skills and methods to finalize the technician competence.

Completing the curriculum fully will not guarantee a perfect service technician is trained every time. The concept of a perfect service technician is however now available and the curriculum gives the tools to evaluate trainees against that background, although somewhat purely on a theoretical basis. The modular structure enables training to be tailored specifically for individual technicians or for whole groups at a time and the resulting evaluations may be used to create a classification for technician competence and experience.

4 CONCLUSION

The drafting of the DPi –series technical training curriculum is a work in progress even after this thesis. However it is now closer to a usable state than ever before. The technical content of the curriculum is now up to date and the translation to English enables easier further development and implementation in the future.

The work required getting to understand the drill rig in its entirety. The amount of information that was handled during the course of this work is difficult to convey to a reader. Understanding just one subsystem perfectly would make a person a competent system expert, but to understand perfectly a multitude of systems working in unison without delay is something else.

In addition the DPi –series drill rig model family is ever-changing, especially with the upcoming launch of Tier 4 Final –models. This as such will require a major update to the current content. An interesting point to ponder is how future courses will be held, when the product lifetime comes to the point that there will be multiple versions of the same machine to be serviced by individual technicians.

Development of the modular structure is a challenge also, particularly how to incorporate the full spectrum of technician competences. The interconnectivity between drill rig model curriculums would ideally cover the full range of the current fleet as well as future models, without forgetting about discontinued models that still have large customer fleets. As with structured documentation, this too will create challenges over how it should be managed and implemented.

In conclusion it can be said that the curriculum is still on track to becoming an actual usable tool for trainers. The foundations have been set to unify the whole Sandvik training operations, but further development and work will be required. Drill rigs will always require regular maintenance and break down in one way or another, so a demand for competent maintenance personnel will continue to exist.

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- Ari Lähteenmäki (Documentation Engineer, Sandvik Mining)
- Jari Talasniemi (Technical and Field Support Manager, Sandvik Construction)
- Hannu Aalto (Service Engineer, Sandvik Construction)
- Mika Kotro (Training Manager, Sandvik Construction)
- Marko Sormunen (Documentation Manager, Sandvik Construction)
- Olli Järvensivu (Service Engineer (Drillmaster), Sandvik Construction)
- Sami Jartti (Service Engineer, Sandvik Mining)

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- Luke Yung (National Product Support, Sandvik Australia)
- Alexey Sesorov (BLM Surface Drill Rigs, Sandvik CIS)
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- Joey Accardo (Field Service Technician, Sandvik USA)
- Roar Nordrum (Service Manager, Sandvik Norway)
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APPENDICES

Appendix 1. DPi –series technical training curriculum