Tampere University of Applied Sciences
Degree programme in Chemical engineering
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Final Thesis

Selection of crusher type for on-line crushing of off-spec material

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Commissioned by	Yara Suomi Oy René Malmberg, Development Engineer, Master of Science in Technology

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Name of the thesis	Selection of crusher type for online-crushing of off-spec material
Number of pages	27
Graduation time	June 2011
Thesis supervisor	Anne Ojala
Commissioned by	Yara Suomi Oy

ABSTRACT

This final thesis was commissioned by Yara Suomi Oy and the aim of the work was to find a crusher for crushing off-spec material. Crushed material could be then fed several tons per hour straight to granulation stage. Off-spec material is a product that doesn't meet the specified or standard requirements of any type of fertilizer, but because it's good raw material, it's wanted to feed back to the process. It's already now possible to feed uncrushed off-spec material to the reactor stage, but only to a limited extent, so crushing the material would also free storage space from bunkers for other products.

Theory part of this work was about introducing different crusher types and terms related to size reduction of materials. In the essential work contacts were taken to different crusher suppliers. When the wanted specifications were presented, some of the suppliers withdrew immediately, telling the specifications were too strict to their crushers. Three suppliers were willing to do test runs with their crushers and one supplier also offered opportunity to come to see the test run. After before-granule size analyses were taken at Yaras laboratory, samples were sent to suppliers. When test runs where performed, suppliers sent samples back to Yaras laboratory and after-granule size analyses were taken. The result of this thesis came from comparing granule size analyses.

The result of this work was that none of the suppliers where able to crush off-spec material to desired specifications. However this research can be continued, because this thesis was only based on comparing analyses. If this research is continued, there are many different variables left for comparing different crushers, like price, the needed accessories, the maintenance interval, arranging smooth feed for test runs and so on.

Key words	Crushing, grinding, particle size analyze, size reduction, milling, crusher

Tampereen Ammattikorkeakoulu
Kemiantekniikan koulutusohjelma

Tekijä	Aleksi Puurunen
Työn nimi	Murskaintyypin valinta alirakeen hienonnukseen
Sivymäärä	27
Valmistumisaika	Kesäkuu 2011
Työn ohjaaja	Anne Ojala
Työn tilaaja	Yara Suomi Oy

TIIVISTELMÄ

Tämä opinnäytetyö tehtiin Yara Suomen toimeksiannosta tarkoituksena löytää sopiva murskain alirakeen jauhamiselle, jotta jauhettua aliraetta voidaan syöttää useita tonneja tunnissa lannoiteprosessin kiertoon. Alirae on lannoitetta, joka ei täytä minkään lajikkeen vaatimuksia, mutta on silti laadukasta raaka-ainetta, jota halutaan käyttää hyväksi prosessissa. Aliraetta voidaan syöttää reaktoreille pieniä määriä myös murskaamattomana, joten alirakeen murskaaminen vapauttaisi tilaa myös lannoitebunkkereihin.

Työn teoriaosuudessa on esitelty yleisesti erilaisia murskaimia ja murskaukseen liittyviä termejä. Varsinaisessa työssä otettiin yhteyttä eri murskainvalmistajiin, joille esitettiin Yaran asettamat vaatimukset murskatulle alirakeelle. Osa valmistajista kieltäytyi heti vedoten liian jyrkkiin vaatimuksiin, mutta kolme yritystä suostui ajamaan koeajoja murskaimillaan. Erään valmistajan koeajoa päästiin seuraamaan myös paikan päälle. Näytteistä otettiin raekokoanalyysit Yaran laboratoriossa ja lähetettiin valmistajille murskattavaksi. Kun valmistajat saivat koeajot suoritettua, he lähettivät näytteet takaisin Yaran laboratorioon, jossa niistä otettiin raekokoanalyysit. Analyysejä vertailtiin keskenään ja työn tulos syntyi niitä vertailemalla.

Työn tuloksena todettiin, että yksikään kolmesta valmistajasta ei pystynyt murskaamaan aliraetta asetettuihin vaatimuksiin. Tutkimusta pystyy kuitenkin helposti jatkamaan, koska tämä työ perustui ainoastaan raekokoanalyysien vertailuun. Jatkotutkimuksissa tulee vertailla laitteiden hintoja, huoltovälejä, vaadittavia lisälaitteita ja niin edelleen.

Avainsanat Murskaus, raekokoanalyysi, murskain, mylly

Foreword

Writing this thesis has been a real challenge, because English is not my native language and I have had only few courses in English. I also had never been doing business with companies, so at the starting point I was a bit afraid how I will do. However I feel that this work improved my language skills a lot and I also learned how take contacts in business world.

I would like to thank both my supervisors, Anne Ojala from TAMK and René Malmberg from Yara and of course greetings for whole Yaras workers with whom I had pleasure to work with for three summers. I would also like to give special thanks to Rauli Mäkitalo from Yara Harjavalta plant who gave me valuable guidance and tips for doing a research like this.

Tampere University of Applied Sciences

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1. Introduction

Yara Suomi Oy, formal known as Kemira GrowHow, is a subsidiary of Yara International ASA and one of the World leaders in manufacturing of fertilizers.

Yara Suomi Oy Uusikaupunki fertilizer plant is one of the most modern fertilizer plants in Europe. Fertilizer production is a complicated process which includes several different unit operations; First all raw materials and possibly used coloring agents are mixed up in different reactors, so that slurry (fertilizer liquid) is mainly homogenous. After mixing slurry is injected to a granulation drum, where fertilizer particles get their round shape. After cooling and coating the granules can be packed to sacks. The process also includes effective gas scrubbing system to meet the environmental requirements.

Changing a fertilizer type is usually a continuous operation where the new raw materials are mixed with the old ones in reactors, causing a product that doesn't meet the specified or standard requirements of any type of fertilizer. This material is called off-spec material and it can be recycled back to the production process. The problem is that with current process the only possibility to recycle colored off-spec material is feed it to the reactor stage where the granules are completely melted without causing coloring issues to the final product. Occasionally this can lead to problems in the production where the liquid slurry is too thick to move from a reactor to the other. Then the recycling is impossible and causes problem in the storage where space is needed.

The aim of this work was to find a comminution machine that is able to grind the off-spec material to the proper size allowing the straight recycling also to the granulation stage. When the particle size is reduced enough, they are completely covered with slurry in granulation stage and even when used differently colored recycling material, no coloring issues are noticed in the final product. Using this simple unit process it is possible to increase the off-spec recycling capacity, free more storage space and improve its flexibility.

2. Size reduction and installations

2.1 Size reduction

Size reduction of different materials is a basic unit operation in many different fields of the process industry. The basic idea is to reduce particle sizes of material under handling by cutting or breaking those to smaller pieces. The reason for size reduction is usually need for smaller size, but it can also be desired shape, size or number of particles. The functions of mechanics in machines made for size reduction are usually based on same principles: compression, impact, attrition and rubbing.

Hukki, R.T 1964. Mineraalien hienonnus ja rikastus. Keuruu: Kustannusosakeyhtiö Otavan kirjapaino, 214)

2.2 Differences between crushing, milling and grinding

Crushers are usually low-speed machines that are designed for breaking large lumps, ores and stones, even over to the diameter size of one and half meter. According to Harriott, Warren and Smith (2005, 988) a primary crusher is able to handle everything coming from the main face and reducing them to the lumps of size to 150 – 250 mm. A secondary crusher is able to reduce the size of lumps after first crushing in to size around 6 mm.

According to Hukki R.T (1964, 104), commonly is said that for a price per unit crushing is cheaper that grinding to a certain point, so crushing should be get as close as possible to that limit. A thumb rule for crushing is that ores should be crushed to the maximum size of 10 mm.

Grinders are size reductions machines that often follow crushers in the processes where even finer product is desired after crushing, usually size between intermediate and powder. Different grinders are usually named to mills, for example hammer mills, universal mills and attrition mills. Because of the name, verb milling is also been used as a synonym for grinding.

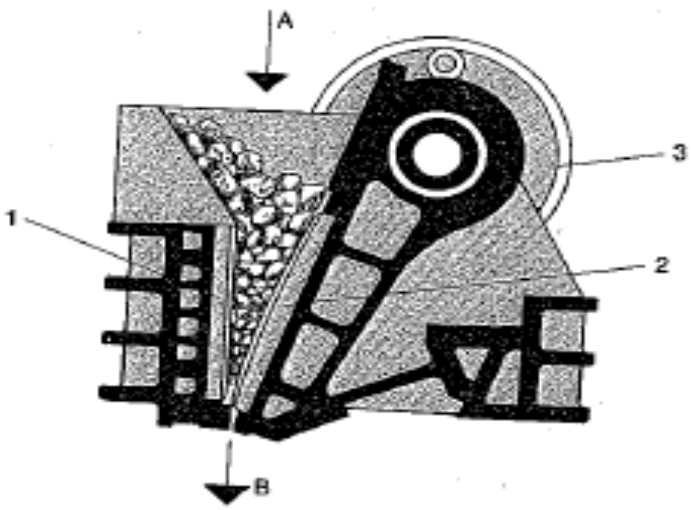
(Harriott Peter, McCabe Warren L. & Smith Julian C. 2005, Unit operations of Chemical Engineering, 984)
(Mineraalien hienonnus ja rikastus 1964, 104)

2.3 Crusher and mill types

This chapter is about different crusher and mill types in the order of descending feed material size.

2.3.1 Jaw crusher

Jaw crusher is consisting of two vertical jaws installed to a V form, where the tops of the jaws are further away from each other than the bottoms. One jaw is stationary and the other is in reciprocating movement towards the stationary jaw. Using an eccentric mechanism makes the movement of the jaw. Feed is entering to crusher from the top and lumps are crushed between jaws. Usually both jaws are covered with manganese steel plate, which are replaceable. Also in some types the plates can be turned upside down after a while, extending the replacement time. The following figure is presenting a cross-section of a jaw crusher.



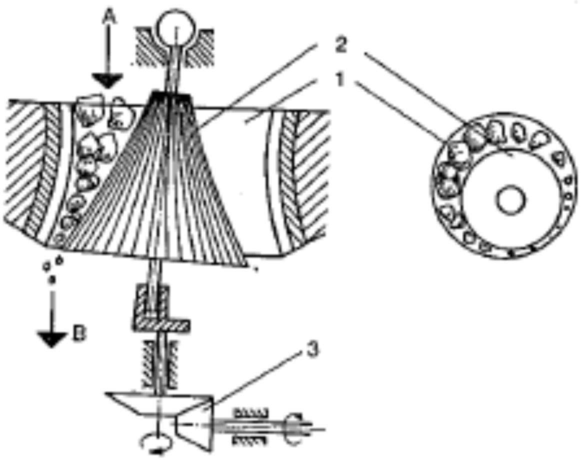
A. Material feed
B. Material outlet
1. Sationary jaw
2. Reciproating jaw
3. Eccentric mechanism

Figure 1: Jaw crusher (Pihkala 2003, 9, figure text: Aleksi Puurunen)

(Mineraalien hienonnus ja rikastus 1964, 105 – 107)

2.3.2 Cone crusher

Cone crusher is consisting of a crushing chamber, a crushing cone and a operating mechanism. The cone is built in to a vertical shaft, which is supported from the top with a bowl-shaped bearing and from the other end to an eccentric operating mechanism. Feed is dropped to the crusher from the top and it is crushed between the crushing chamber and the slowly rotating cone. Cone crushers are mostly used in large scale crushing in mining industry. The following figure is presenting a cross-section of a cone crusher.



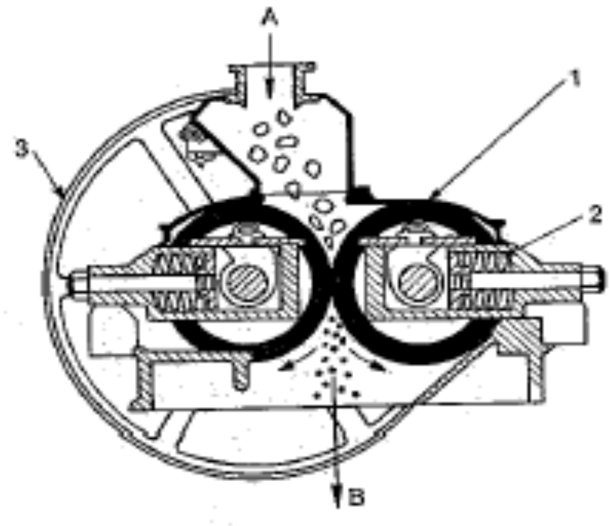
A. Material feed
B. Material outlet
1. Crushing chamber
2. Crushing cone
3. Eccentric operating mechanism

Figure 2: Cone crusher (Pihkala 2003, 10, figure text: Aleksi Puurunen)

(Pihkala, J, Opetushallitus 2003. Prosessitekniikan yksikköprosessit. 3. uud. p. Helsinki: Hakapaino Oy)

2.3.3 Roller crusher

Roller crusher is consisting essentially of two opposite directions driven cylinders that are mounted on horizontal shafts. The other shaft is mounted permanetly in the frame and the other is leaning on robust springs. The gap between cylinders can be adjusted, so the size of crushed product is easily adjustable. Usually both cylinders are covered with manganese steal. Crushing ratio is usually lower than in other crusher and roll crusher is suitable for fine crushing. The following figure is presenting a cross-section of a roll crusher.



A. Material feed
B. Material outlet
1. Cylinder
2. Springs
3. Using mechanism

Figure 3: Roll crusher (Pihkala 2003, 11)

(Mineraalien hienonnus ja rikastus 1964, 119)

2.3.4 Hammer mill

A Hammer mill is constructing of a high-speed, usually horizontally shafted rotor turning inside a cylindrical casing. The mill contains a certain amount of hammers that are pinned to the rotor disk and the hammers are swinging to the edges because of centrifugal force. Feed is dropped to mill from the top of the casing and it's crushed between the casing and the hammers. After crushing the material falls through from the opening in the bottom. The following figure is presenting a cross-section of a hammer mill.

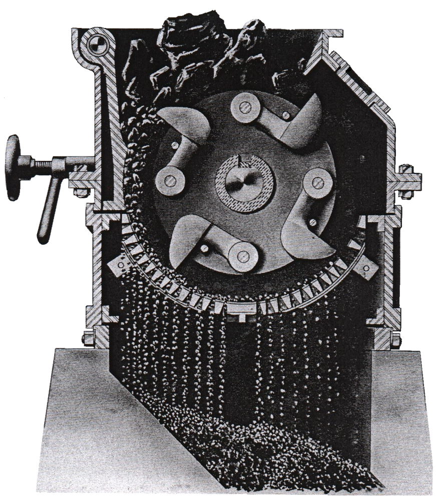
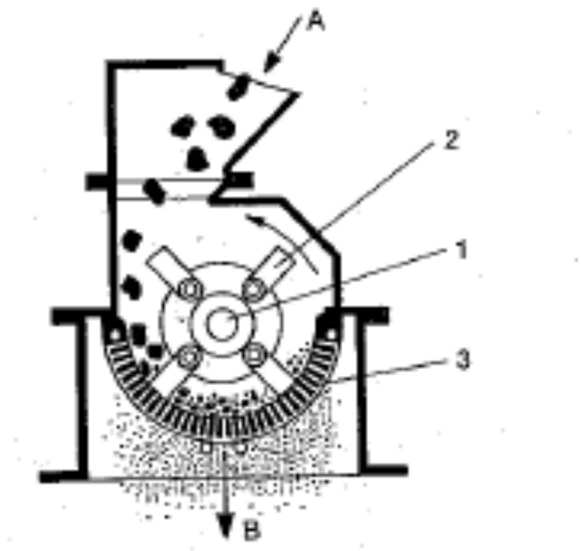


Figure 4: Hammer mill (Chemical Engineering, Volume 2, Particle Technology and Separation Processes 1991, 968, Figure text: Aleksi Puurunen)

2.3.5 Impact mill

Impact mills are often used with materials, which are soft or which are easily cleaving from the surface. Unlike many other crushers or mills, in the impact mill the size reduction is based on impact, not to compression. The mill is constructing of a fast spinning rotor and beaters attached to the rotor. Feed is entering to the mill from the top and crushing starts immediately when the feed is impacted with beaters towards the mills inner surface. Impact mill can also be equipped with a bottom screen, which prevents material leaving the mill until it's fine enough to pass through the screen. The following figures are presenting a cross-section and a real of an impact mill.



A.	Material feed
B.	Material outlet
1.	Rotor
2.	Beaters
3.	Screen

Figure 5: Impact mill (Prosessitekniikan yksikköprosessit 2003, 11, figure text: Aleksi Puurunen)

(Prosessitekniikan yksikköprosessit 2003,11)

Figure 6: Hosokawa Alpines impact mill (http://www.hosokawa.co.uk/alpine.php, figure text Aleksi Puurunen)

2.3.7 Drum mills

Drum mills are horizontally rotating slightly inclined cylinders, usually filled with metal objects like rods and balls, which are intensifying grinding. Feed is entering to mill from the other end and outlet is at the other end. Feed is grinded during its way through the mill. In some cases cylinder can also be without grinding objects and feed material is simply grinding itself in the rotating cylinder. This is called autogenous mill and it’s usually used grinding of ore.

Lining of the cylinder plays very important role. It needs to protect the mill from abrasions and at the same time it needs to able to lift material and possible grinding objects up from the bottom of cylinder. Figure 7 is presenting different lining types.

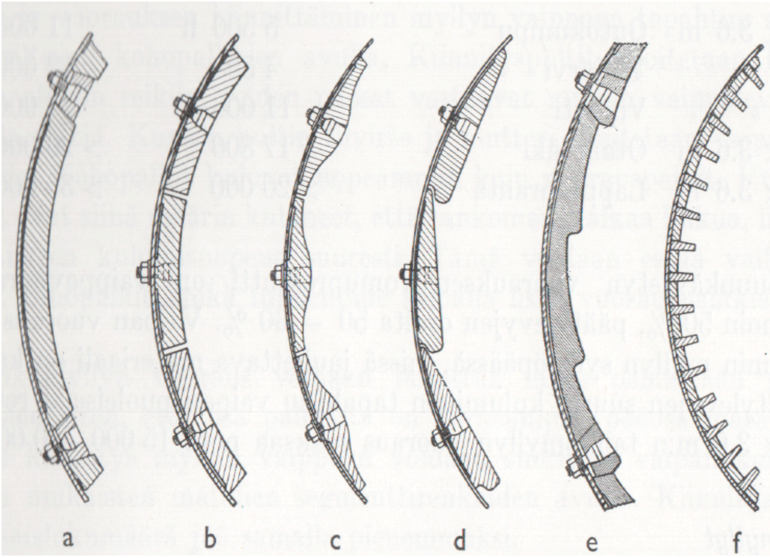


Figure 7: Different lining types ((Mineraalien hienonnus ja rikastus 1964, 232)

a & b) smooth liners

c) wave liner

d) ship-lap liner

e) step liner

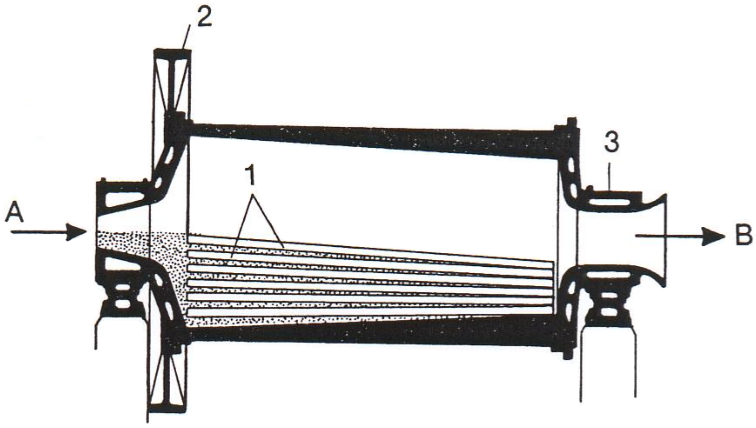
f) Osborn liner

(Mineraalien hienonnus ja rikastus 1964, 231–232)

2.3.7.1 Rod mill

The rod mill is constructing of a long rolling cylinder and long rods inside the cylinder.

Cylinders are usually equipped with special liners called lifter liners, which are preventing long and heavy rods to slide on the cylinder lining and helping them to lift up. Because of the high kinetic energy of a dropping rod, it’s important to pay attention to protecting the cylinder when choosing a liner for the mill. The following figure is presenting a cross-section view of a rod mill.

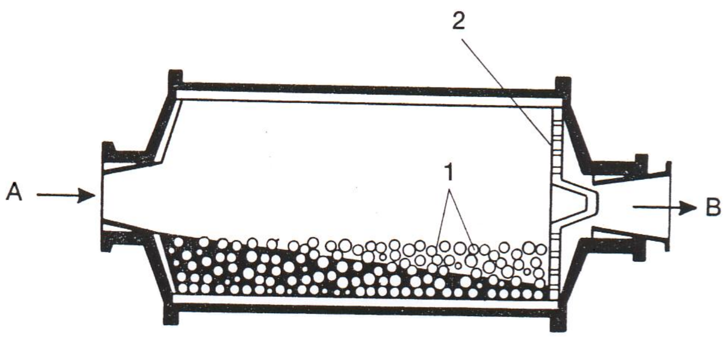


A. Material feed
B. Material outlet
1. Rods
2. Using mechanism
3. Bearings

Figure 8: Rod mill (Pihkala 2003, 16, figure text: Aleksi Puurunen)

2.3.7.2 Ball mill

Ball mill is same kind of mill as rod mill, except it's filled with balls instead of rods. Because of balls have greater ratio of surface area than rods they are more suitable for fine grinding. Balls are also lighter, so the kinetic energy of a single dropping ball is smaller than a rod, so lining of the cylinder can be more focused to grinding. The following figure is presenting a cross-section of a ball mill



A. Material feed
B. Material outlet
1. Balls
2. Outlet screen

Figure 9: Ball mill (Pihkala 2003, 18, figure text Aleksi Puurunen)

(Mineraalien hienonnus ja rikastus 1964, 229–232)

2.4 Methods of evaluating crusher performances

The baseline for evaluating crusher performances was to compare how close crusher suppliers were able to crush off-spec material to the given specifications, which are presented in the table 1. These specifications are given from Yaras engineers and they are based on long-term working experience with crushed fertilizer. Capacity is also one important issue that is handled later in the chapter 4.4.

Table 1: Specifications for grinded product

D50	1.2–1.4mm
<0.5mm	10% max
0.5–1.0mm	10% (5%–15%)
1.0–1.5mm	60% (45%–75%)
1.5–2.0mm	15% (10%–20%)
>2.0mm	5% max

D50-value is a particle size where 50% of the total mass is cumulated when particle size analyze is performed by using Yaras Kesizer 2000, which is later presented in the chapter 4.2. The value is representing the average particle size of the analyzed sample. D50-values of crushed samples are compared later in the figure 18.

The specification in the table 1 are presenting idealistic situation and it is highly needed to take into consideration, that the size range of off-spec material can vary a lot and mass product can sometimes be lumpy after laying in a bunker.

This thesis is focusing only on comparing the results of particle size analyzes and the suggestion of a crusher type is based on them. However it is good to mention, that when acquisition of a crusher continues after this work, the following arguments presented in next paragraphs should be taking in to consideration.

Accessory equipment for the crusher are as important as the crusher and price range for them varies a lot, as also in crushers. Accessory equipment can also play significant role in the selection of a crusher, because for example a single screw conveyor before the crushing can break lumps from the feed material so well, that a cheaper or more energy efficient crusher could be used.

Crushing produces always air and dust and this is a big issue that needs to take into consideration while planning the placement for the crusher. In some cases a cyclone is needed to handle the produced air and dust.

It would be reasonable to chrch maintenance intervals of the crushers, prices for the spare parts like a new rotor and the accessory equipment and find out how many workers is needed to perform a basic maintenance.

3. Crushing tests at crusher suppliers

At the beginning of the this thesis, contacts were taken to the following companies: Sandvik, Atritor Ltd, Christy Turner Ltd, Megatrex, Hosokawa Alpine and Jäckering. Atritor Ltd and Christy Turner answered immediately telling the job would be impossible with their crushers, referring to the specifications in the Table 1. In the beginning Sandvik offered their hammer crusher, but later they didn’t get any contact. Hosokawa Alpine, Jäckerig and Megatrex were willing to run test with their crushers, even if they told desired specifications were really strict.

3.2 Megatrex

The First crushing test was performed at Megatrex 16.10.2010 in Lempäälä, Finland. Before sending the sample Megatrex also offered opportunity to transport their pilot version of the crusher to Yaras plant and run test drives there, but it was decided by Yaras engineers to make the test firstly on Megatrexs site. Circa 40 kg of off-spec material was sent to Megatrex and after receiving the package Megatrex offered possibility to come to see the test performance. The test drive was performed free of charge.

The crusher type Megatrex is offering is called Atrex. The working principle of Atrex is two horizontally shafted rotors rotating in opposite directions, which are crushing the feed entered to center of rotors from above.

The crushing test was made by using 5 different rotation speeds. The test report is reference number 1. All the different samples were collected to containers and transported to Yaras laboratory where the granule size analyses where taken from the each sample with Kesizer 2000, and reports of those analyses are in appendices 2 – 5. Appendix number 6 is an analyze taken before crushing. One sample, run with 1500 rpm, was decided to left out because it was clearly too fine. The following figure is presenting crushing test at Megatrex.

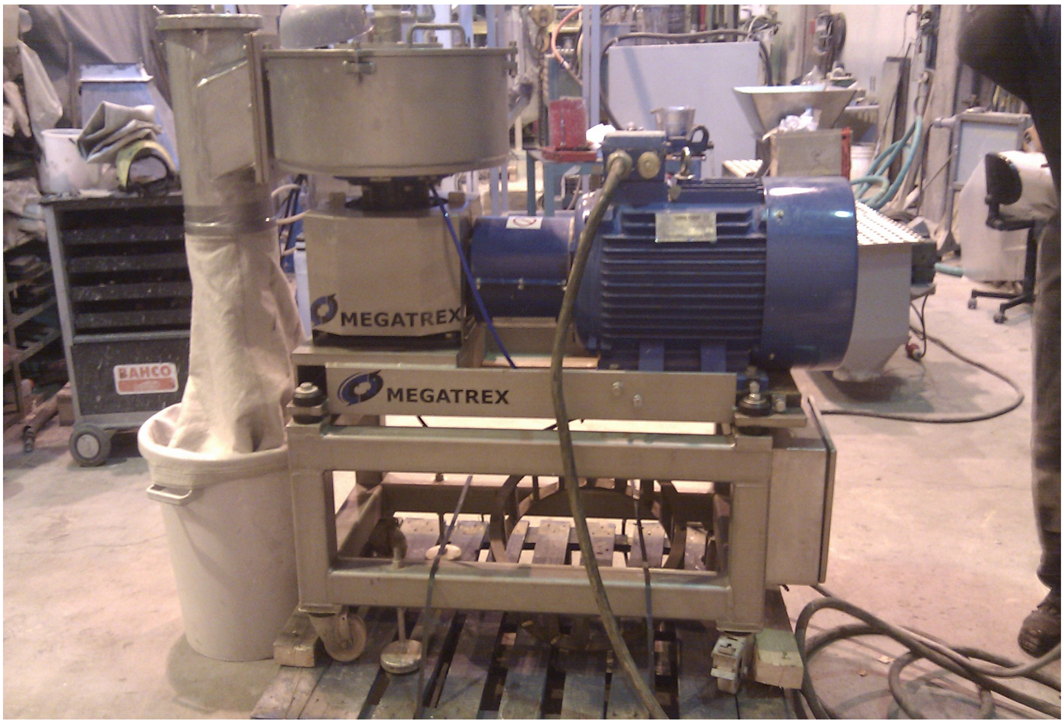


Figure 10: Crushing test at Megatrex (Photo: Aleksi Puurunen)

3.3 Jäckering

The Second crushing test was performed in January by Jäckering in Hamm, Germany.

In Jäckerings website they are notifying that when they perform a crushing test in their test laboratory, the minimum amount of sample is 200 kg. However they agreed to run tests with lower amount and 20 kg of off-spec material was sent to Jäckering. The test drive was performed free of charge.

The crusher type Jäckering is offering is called Ultra-Rotor, model 1, which is an air turbulence mill. The working principle of the mill is a high peripheral speed-rotating rotor within a solid stator which are accelerating fed particles to very high speed with in the air eddies. Feed is entering to the mill from the base of the rotor and on leaving the grinding zone it enters a sifting section where the oversized particles are returned to the bottom of the grinding zone. The following figure is presenting Jäckerings Ultra-Rotor mill.

Figure 11: Ultra-Rotor mill (http://www.jaeckering.de, figure text Aleksi Puurunen)

Jäckerings Ultra-Rotor mill is planned to grind the feed very fine and for the desired specifications the crushed product appeared to be a bit too fine. Even if the sample didn't match the requirements, the company sent one sample of crushed material for the evaluation, which is appendix 7 and report from test are appendices 8 and 9. Granule size analyze before crushing is appendix number 24.

3.4 Hosokawa Alpine

Hosokawa Alpine performed the third crushing test in February in Augsburg, Germany. The company was a natural choice for a candidate to this work, because it has supplied a crusher for former Kemira Growhow to Harjavalta plant and cooperation has been flawless. Alpine charged 1700 € + vat. from the test day and asked circa 600 kg of off-spec material, which was sent with cargo transportation. It the deal is made with Alpine, the price of the test is reimbursed from the price of the deal.

The offered crusher type is called Alpine Fine Impact Mill 315 UPZ. The type of the mill is a pin mill and it is consisting of a rotating and a stationary pin disc.

Because of the high amount of sample material, Alpine was able to use a volumetric feeding screw in the feeding of the test runs. They performed 13 tests by using different milling equipment and different mill speeds. One test, number 12, was made with the Alpine Hammer Mill 25 MZ. The test was aiming to the second fineness requirement, 1,5mm –2,0mm, but the mill was unable to produce the fineness in an economic way. At the end test runs number 10, 12 and 13, which we too clearly too fine for, were left out of shipping to Finland. Test reports of Hosokawa Alpines are appendices 10–12 and granule size analyses of crushed samples are samples 13–23. Granule size analyze before crushing is appendix number 24. The following figures are presenting Hosokawa Alpines Fine impact mill and Hammer mill.

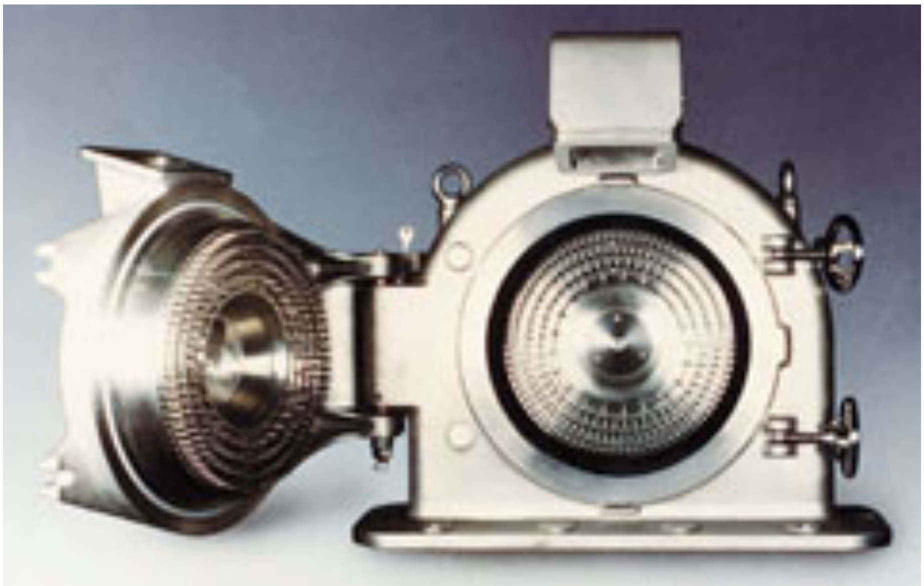


Figure 12: Fine impact mill UPZ (http://maprema.com, figure text Aleksi Puurunen)

Figure 13: Hammer mill (http://www.usinenouvelle.com, figure text Aleksi Puurunen)

4. Defining design values

4.1 Inlet material specification

Inlet material specification was performed at Yara Uusikaupunki plant. Firstly the samples were collected randomly from the off-spec material bunker to a plastic container, as seen in the figure 14.

Figure 14: Samples in plastic container (Aleksi Puurunen)

After the samples were collected, the specification was performed by using Yaras own granule size analyzer, Kesizer 2000.

4.2 Kesizer 2000

Kesizer 2000 is consisting of a metal cupboard, feed chute, stroboscope back lighting, CCD camera and computer. The feed chute, back lightning and the camera are inside of the cupboard and the camera is connected to the computer trough a logic system.

The feed is poured to the feed chute from the top of cupboard trough a funnel, which is seen in the figure 15, in the upper left. The feed chute is transferring the feed to the other end of the cupboard, where it falls down between the camera and the stroboscope back lighting, finally ending to the bottom of the cupboard to a peaker. While the feed is dropping down in front of the CCD camera, almost every single particle is photographed in the air. The camera takes approximately 6000 pictures in 5 minutes. This photographed data is sent to a computer trough a logic system and the computer is calculating wanted details from the taken pictures, for example roundness and diameters.

Figure 15: Kesizer 2000 (Aleksi Puurunen)

(Kesizer2000 mittausperiaate.pdf, unpublished)

4.3 Capacity

The ideal capacity of the crushed material should be circa 10 t/h, when smooth feed is enabled using a conveyor before. This value is given by Yaras engineers. Based on tests in supplier laboratories and their experience, all three suppliers should able to fulfill this requirement easily.

Megatrex and Jäckering are planning and dimensioning every machine individually for the wanted capacity values.

Hosokawa Alpine announced in their test report, that a 800 UPZ would be big enough for the requirement. They already run one test, appendix 19, using 5000 kg/h capacity in their test laboratory.

4.4 Outlet material specification

Outlet material specifications were also performed by using the Kesizer 2000, in order to get a reliable basis for the comparing of the crushing results. The machine is developed by Kemira Growhow in the former development center in Espoo and it is particularly made for analyzing fertilizers. The size range of the particles is from 0,1 to 6 mm. However this size range is depending of amount of the particles, which are photographed to a single photo. The feed rate of the feed chute can be adjusted from the computer, but in some cases where very fine samples are analyzed, the feed rate is too high for the camera. This means that the camera doesn't have enough pixels to save every fine particle and when the amount of the particles are very high, the chance for a particle leaving behind of the other when the picture is taken, is growing. In this cases the results aren't so accurate. This fact needs to be highly considered in this thesis, because most of the crushed samples are very fine and the results aren't completely accurate. Figure 16 is one of the sample containers from Hosokawa Alpine.

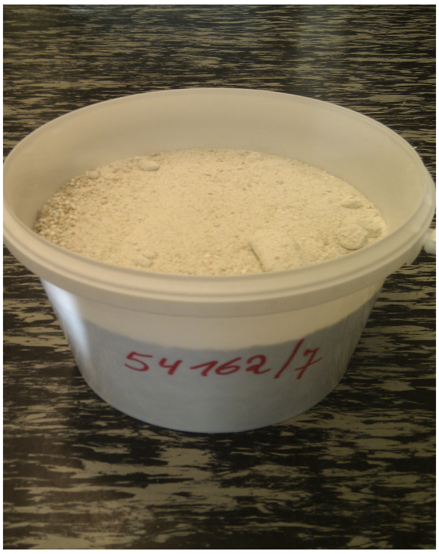


Figure 16: Sample container (Aleksi Puurunen)

All the granule size analyzes were performed 21.03.2011 and those are listed to appendices.

The following figure is picturing the results of analyzing granule sizes of outlet materials of the different crushers. The data is collected from the appendix 3,4,5,7,13,14,21, and 23. Some of the analyses were left out of the chart because of non matching results.

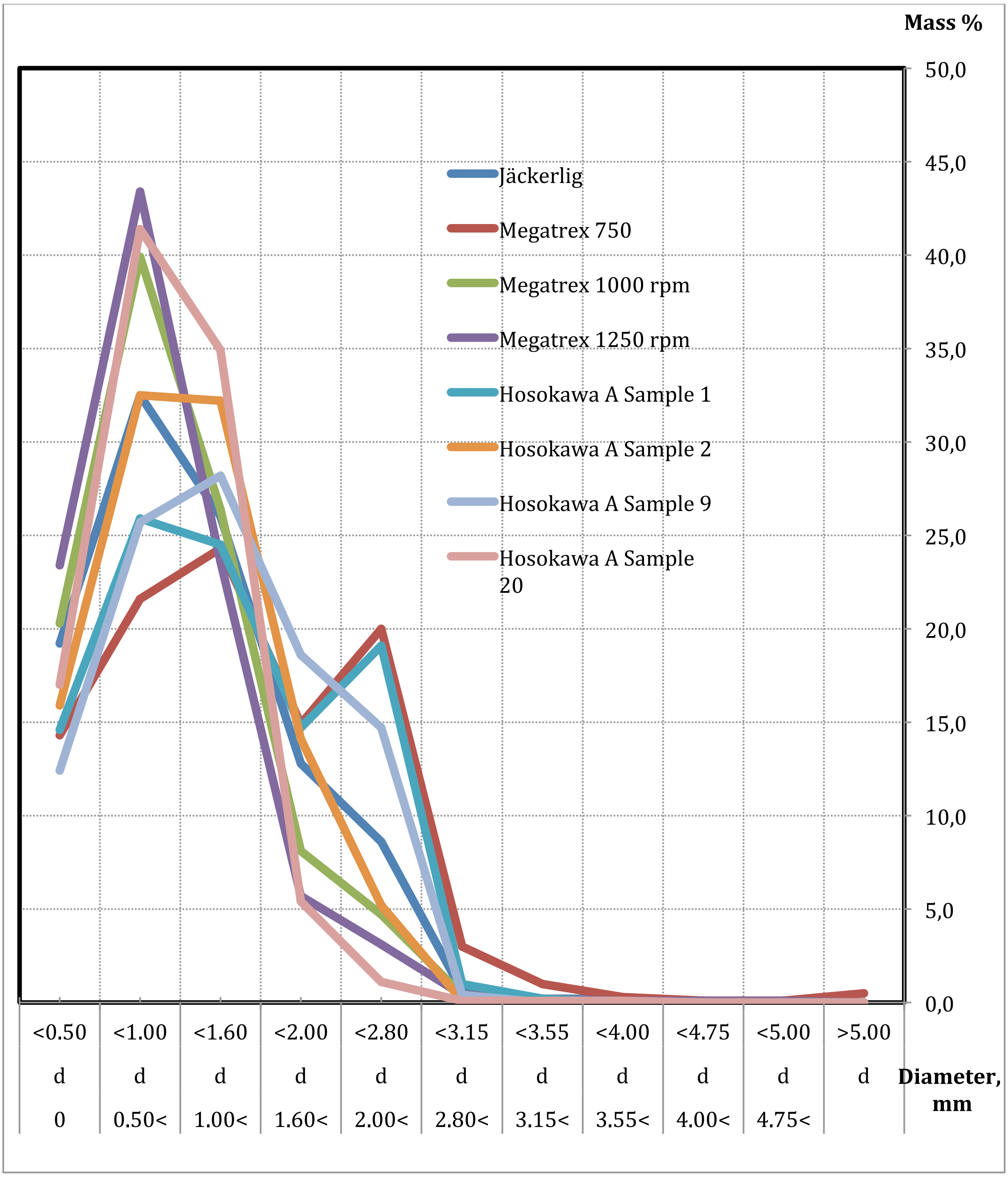


Figure 17: Granule size analyzes of outlet materials

Comparing the results in excel appeared to be a bit inaccurate, because the mass percentage values are presented only in 11 screen classes in Kesizer 2000 analyzes. The screen scale is then circa 0,5 mm, unlike in the figure 17 screen classes are in circa every 0,05 mm as seen in figure 18, so visual comparing of the results is much accurate.

However figure 17 is giving a good survey from results, where many appeared to form a similar result.

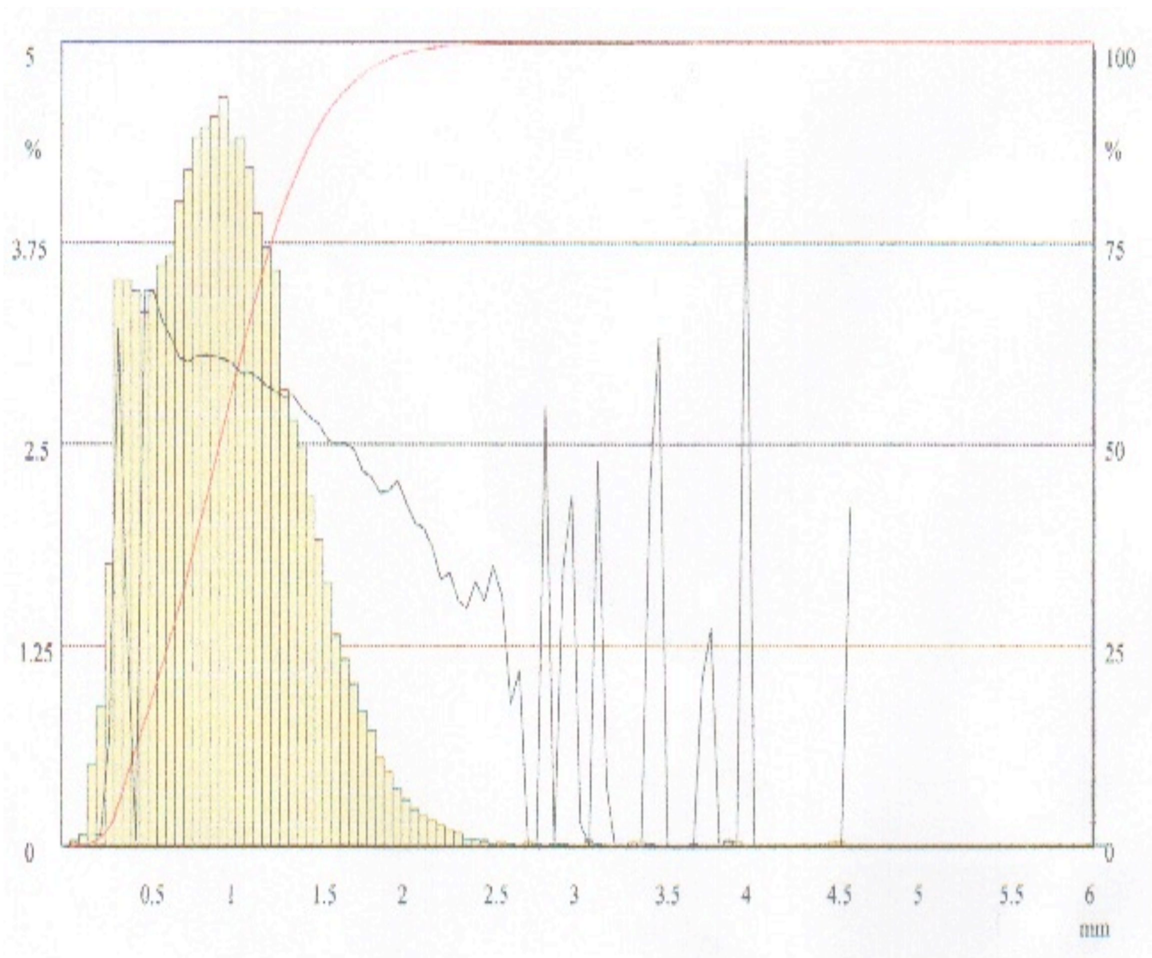


Figure 18. Kesizer 2000 analyze screen classes

Figure 19 is representing D50-values of the same data used in the figure 17.

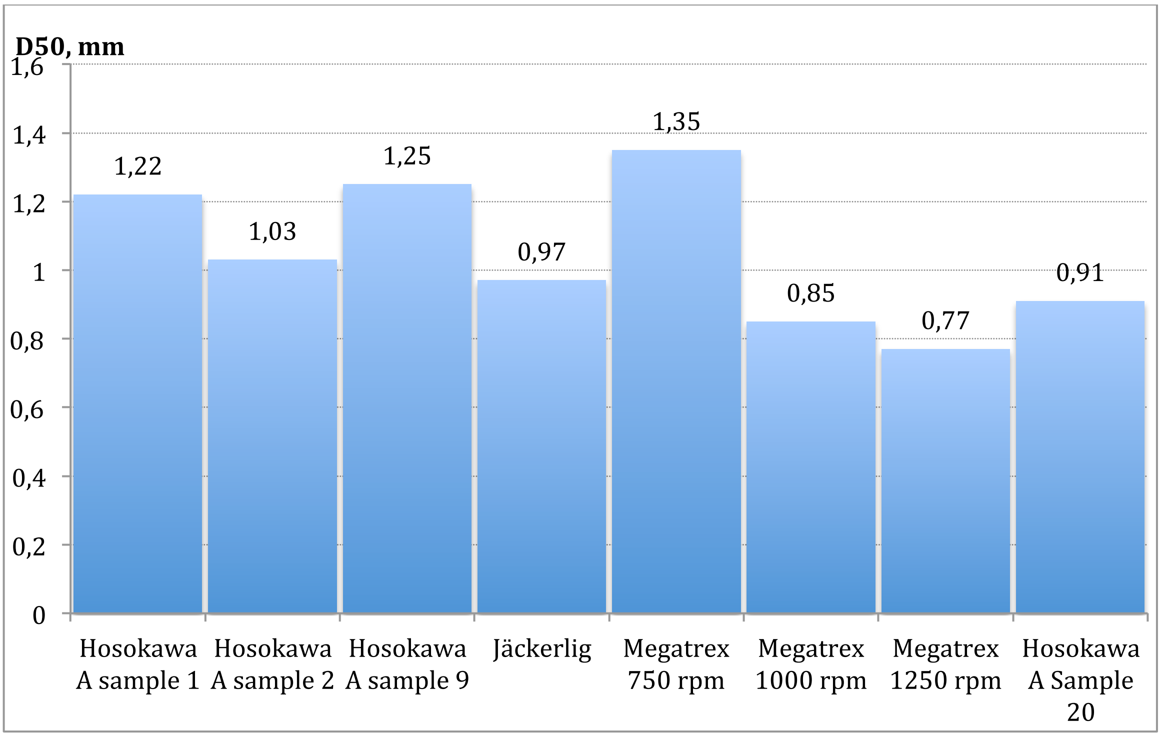


Figure 19: D-50 values

From analyses can be seen that the higher rotating speed is used, the more constant the results are. Perhaps using a smaller mill and higher rotating speeds there are possibilities to find a right crusher that is still able to fulfill needed capacity.

5. Suggestion of crusher type and possible crusher suppliers

Visual comparing of analyzes pointed out to be hard, even when narrower screen classes can be seen. Because a clear selection could not be found and as already seen in figure 17, many samples pointed out to be very similar, it is necessary to continue this research.

5.1 Continuing this research

As already mentioned in chapter 2.4, this thesis focused only comparing the results of particle size analyzes and there are many other things that are needed to take into consideration. Every crusher is different: price, needed accessories, maintenance interval and so on. Perhaps there is a chance to continue this work by continuing this research as another thesis.

As mentioned in chapter 3.4, Megatrex offered an opportunity for running test-drives at Yaras plant. This would be my next action after comparing the analyses, because Megatrex and Hosokawa Alpine had very similar results, but Alpine was able to use smooth feed unlike Megatrex, so would be important to stay in contact with them. If a smooth feed to Atrex can be arranged at Yaras plant, new test drives should be performed, because there is a possibility that crushed material can fulfill the specifications. This operation would also be cheap because Megatrex is a Finnish company, so the distance isn't long.

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Appendices

1. Megatrex test report
2. Megatrex analyze 500rpm
3. Megatrex analyze 750rpm
4. Megatrex analyze 1000rpm
5. Megatrex analyze 1250rpm
6. Analyze of the Megatrex- sample before crushing
7. Jäckering analyze
8. Jäckering test report 1/2
9. Jäckering test report 2/2
10. Hosokawa Alpine test report 1/3
11. Hosokawa Alpine test report 2/3
12. Hosokawa Alpine test report 3/3
13. Hosokawa Alpine analyse of sample 1
14. Hosokawa Alpine analyse of sample 2
15. Hosokawa Alpine analyse of sample 3
16. Hosokawa Alpine analyse of sample 4
17. Hosokawa Alpine analyse of sample 5
18. Hosokawa Alpine analyse of sample 6
19. Hosokawa Alpine analyse of sample 7
20. Hosokawa Alpine analyse of sample 8
21. Hosokawa Alpine analyse of sample 9
22. Hosokawa Alpine analyse of sample 11
23. Hosokawa Alpine analyse of sample 20
24. Analyze of the Jäckering and Hosokawa Alpine- sample before crushing

MEGATREX

15.10.2010

Koeajon pöytäkirja

Paikka: Telinetie, Lempäälä, Finland

Paikalla Megatrex Oy:ltä: Hannu Nikanto
Miika Partanen

Asiakas: Yara Uusikaupunki
Aleksi Puurunen
Puh. 044 3636130

Käsiteltävä materiaali: Lannoitelajitelma, NPK 15-15-15

Koeajolaitteisto

Tyyppi: Atrex G 30
Moottoriteho: 30 kW

Roottoristo:
4 kehää, perusmalli, ulkohalkaisija 500 mm

Muut laitteet:

Materiaalin syöttö: suppilon kautta kauhalla kaatamalla

Kp	ATREX rpm	Huomioita
1	500	1000 rpm ylöspäin jauhettu tuote alkoi muuttua tasalaatuisen väriseksi ja jauhemaiseksi. Tiheämmällä roottoristolla (enemmän siipiä) ja tasaisella syötöllä (hihnakuljetin) sekä suuremmalla pesän täyttöasteella voidaan vaikuttaa jauhetun tuotteen tasalaatuisuuteen.
2	750	
3	1000	
4	1250	
5	1500	

Muuta: Kaikista koepisteistä otettiin näytteet, joista analysoidaan raekoko Yara:n toimesta

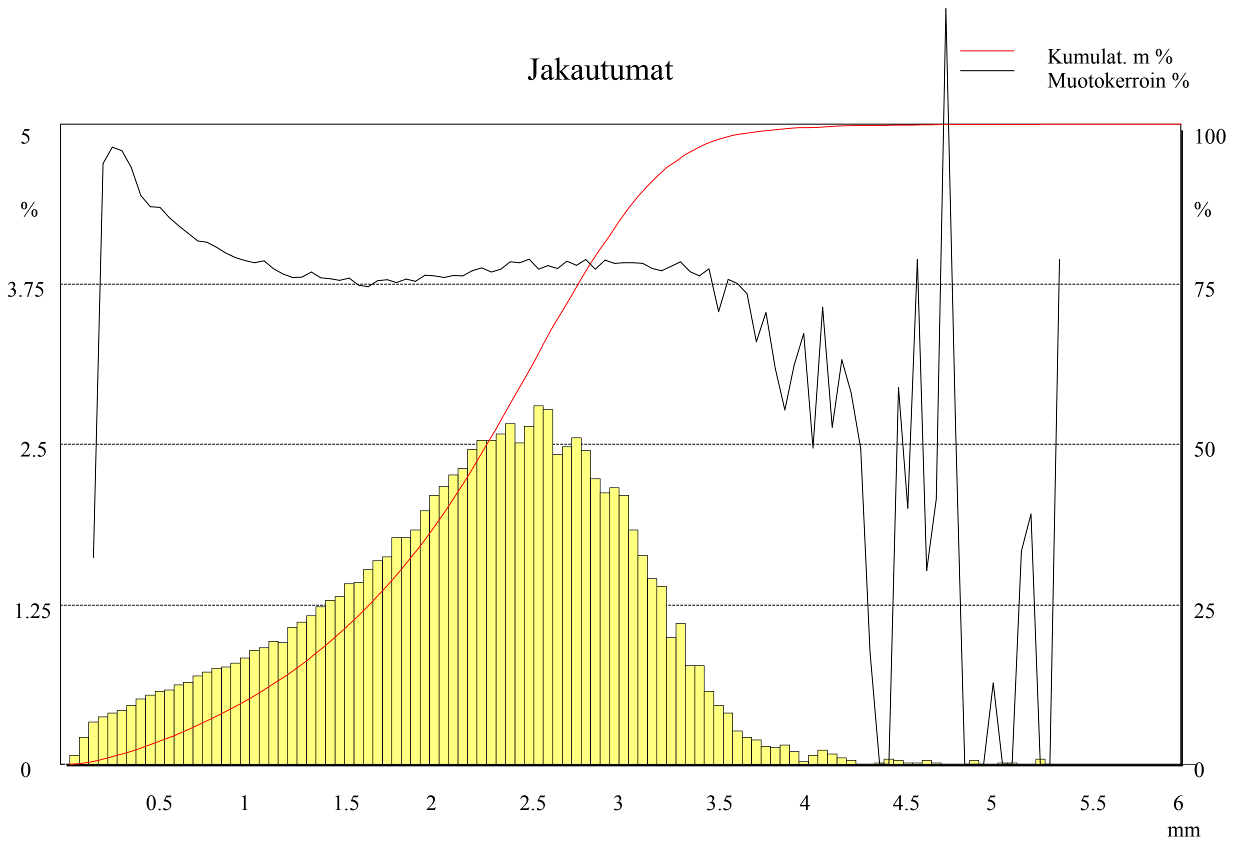
21.03.2011
13:36
Alirae 500rpm_2011032

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**Alirae 500rpm**	Linja	
Npaikka	**Megatrex**	Tapl	
Lajike	**Alirae 500rpm**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.1**		< 2 mm	**38.14**	D 5 mm	**0.64**
4.75 < d < 5.00	**0.0**	**0.1**	> 4 mm	**0.5**	D 50 mm	**2.25**
4.00 < d < 4.75	**0.4**	**0.5**	+2-4mm	**61.36**	D 90 mm	**3.09**
3.55 < d < 4.00	**1.3**	**1.8**	+2-5mm	**61.81**	UI %	**20.7**
3.15 < d < 3.55	**6.5**	**8.3**	> 4.75mm	**0.1**	MK %	**77.55**
2.80 < d < 3.15	**13.5**	**21.8**	+2-4.75 mm	**61.77**	kpl	**111065**
2.00 < d < 2.80	**40.1**	**61.9**	-1 mm	**10.26**	Alik.%	**38.1**
1.60 < d < 2.00	**14.2**	**76.1**	+2.8-5 mm	**21.69**	Tuotek.%	**61.4**
1.00 < d < 1.60	**13.7**	**89.8**			Ylik.%	**0.5**
0.50 < d < 1.00	**7.0**	**96.8**			Pyöreys	**0**
d < 0.50	**3.3**	**100**				



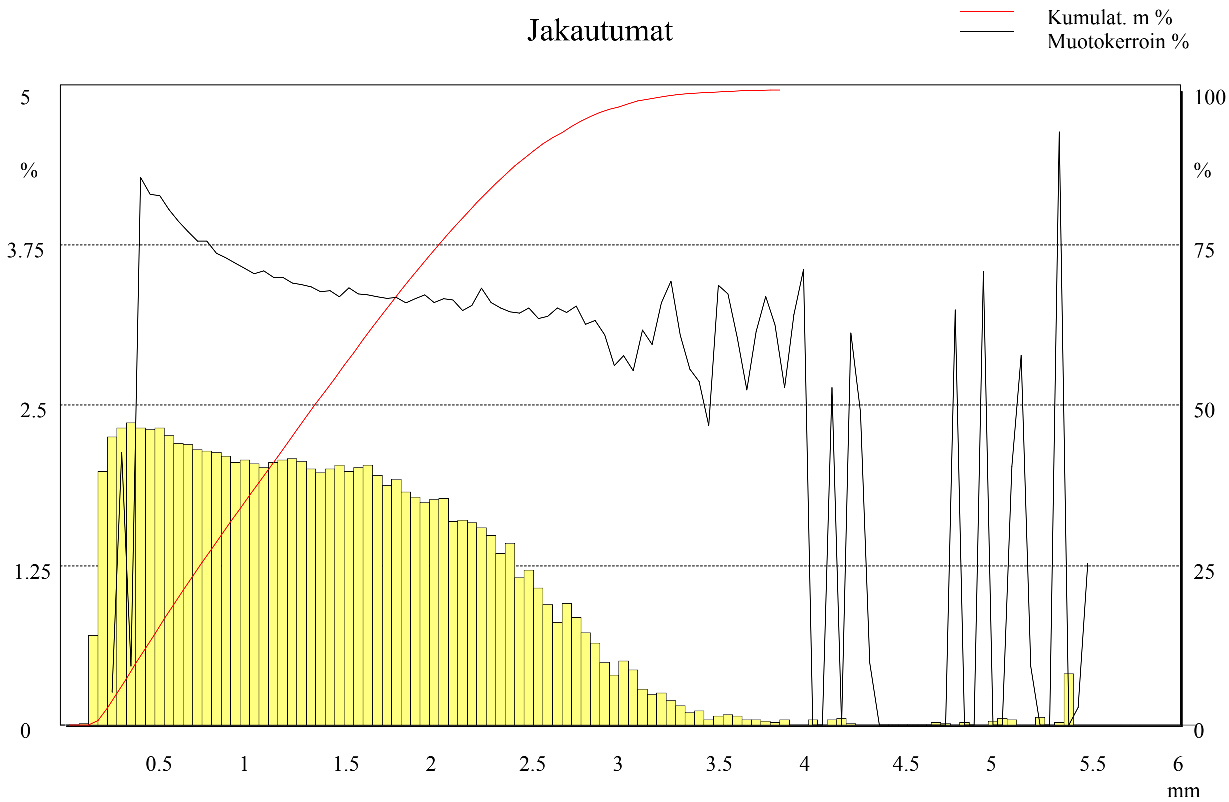
21.03.2011
13:45
Alirae 750rpm_2011032

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**Alirae 750rpm**	Linja	
Npaikka	**Megatrex**	Tapl	
Lajike	**Alirae 750rpm**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.5**		< 2 mm	**75.03**	D 5 mm	**0.30**
4.75 < d < 5.00	**0.1**	**0.6**	> 4 mm	**0.7**	D 50 mm	**1.35**
4.00 < d < 4.75	**0.1**	**0.7**	+2-4mm	**24.27**	D 90 mm	**2.51**
3.55 < d < 4.00	**0.3**	**1.0**	+2-5mm	**24.46**	UI %	**12.0**
3.15 < d < 3.55	**1.0**	**2.0**	> 4.75mm	**0.6**	MK %	**69.29**
2.80 < d < 3.15	**3.0**	**5.0**	+2-4.75 mm	**24.36**	kpl	**200221**
2.00 < d < 2.80	**20.0**	**25.0**	-1 mm	**35.86**	Alik.%	**75.0**
1.60 < d < 2.00	**14.9**	**39.9**	+2.8-5 mm	**4.46**	Tuotek.%	**24.3**
1.00 < d < 1.60	**24.3**	**64.2**			Ylik.%	**0.7**
0.50 < d < 1.00	**21.6**	**85.8**			Pyöreys	**0**
d < 0.50	**14.3**	**100**				



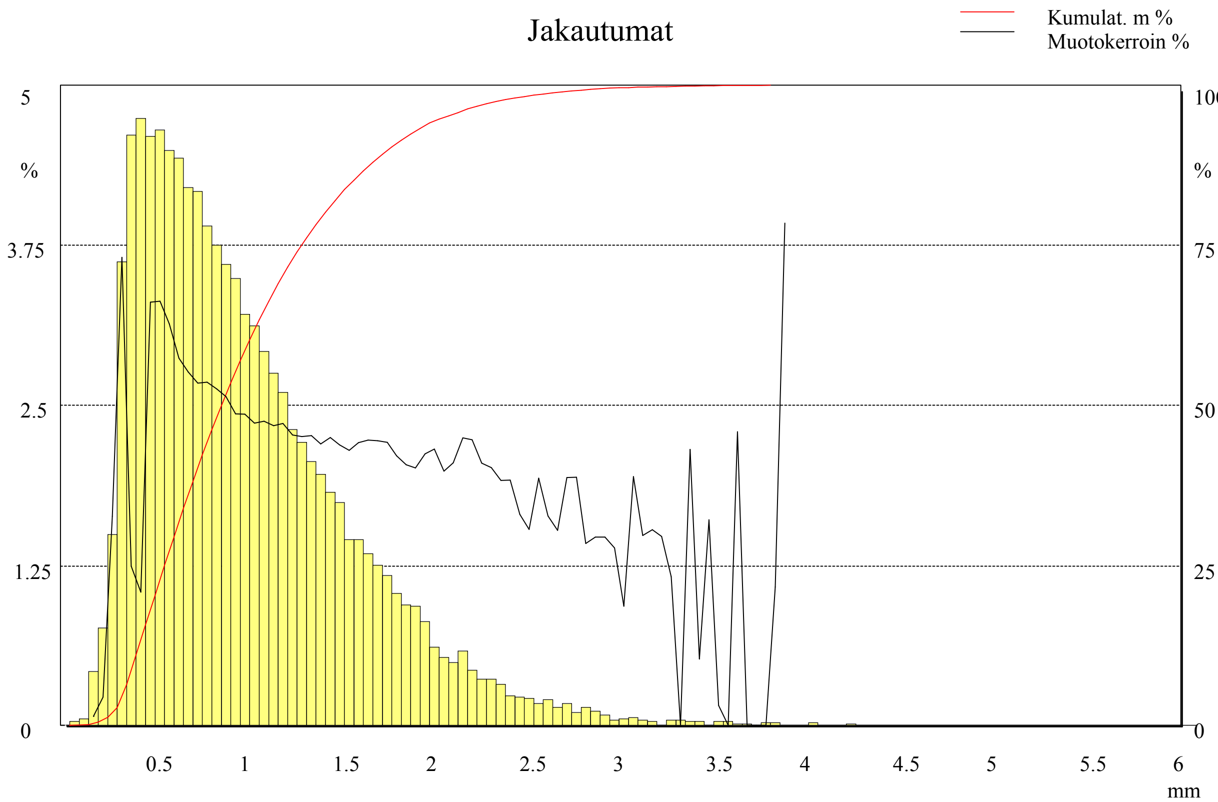
KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**Alirae 1000rpm**	Linja	
Npaikka	**Megatrex**	Tapl	
Lajike	**Alirae 1000rpm**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**94.68**	D 5 mm	**0.33**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.85**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**5.3199999999999**	D 90 mm	**1.73**
3.55 < d < 4.00	**0.1**	**0.1**	+2-5mm	**5.32**	UI %	**19.1**
3.15 < d < 3.55	**0.2**	**0.3**	> 4.75mm	**0.0**	MK %	**49.13**
2.80 < d < 3.15	**0.4**	**0.7**	+2-4.75 mm	**5.32**	kpl	**314563**
2.00 < d < 2.80	**4.7**	**5.4**	-1 mm	**60.21**	Alik.%	**94.7**
1.60 < d < 2.00	**8.1**	**13.5**	+2.8-5 mm	**0.67**	Tuotek.%	**5.3**
1.00 < d < 1.60	**26.4**	**39.9**			Ylik.%	**0.0**
0.50 < d < 1.00	**39.9**	**79.8**			Pyöreys	**0**
d < 0.50	**20.3**	**100**				

Jakautumat



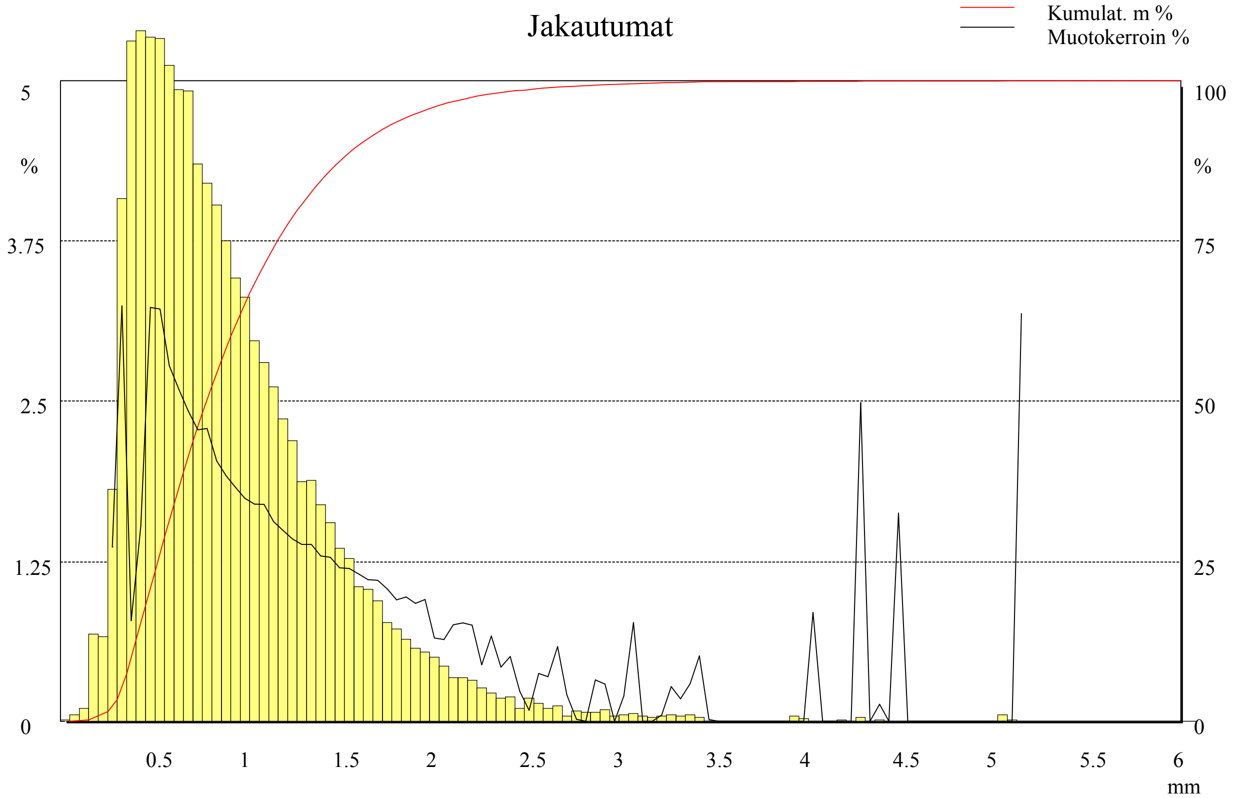
21.03.2011
14:12
Alirae 1250rpm_2011032

KESIZER 2000   GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**Alirae 1250rpm**	Linja	
Npaikka	**Megatrex**	Tapl	
Lajike	**Alirae 1250rpm**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**96.13**	D 5 mm	**0.32**
4.75 < d < 5.00	**0.1**	**0.1**	> 4 mm	**0.1**	D 50 mm	**0.77**
4.00 < d < 4.75	**0.1**	**0.2**	+2-4mm	**3.77**	D 90 mm	**1.58**
3.55 < d < 4.00	**0.1**	**0.3**	+2-5mm	**3.86**	UI %	**20.3**
3.15 < d < 3.55	**0.2**	**0.5**	> 4.75mm	**0.1**	MK %	**32.67**
2.80 < d < 3.15	**0.4**	**0.9**	+2-4.75 mm	**3.81**	kpl	**334889**
2.00 < d < 2.80	**3.1**	**4.0**	-1 mm	**66.83**	Alik.%	**96.1**
1.60 < d < 2.00	**5.7**	**9.7**	+2.8-5 mm	**0.75**	Tuotek.%	**3.8**
1.00 < d < 1.60	**23.6**	**33.3**			Ylik.%	**0.1**
0.50 < d < 1.00	**43.4**	**76.7**			Pyöreys	**0**
d < 0.50	**23.4**	**100**				



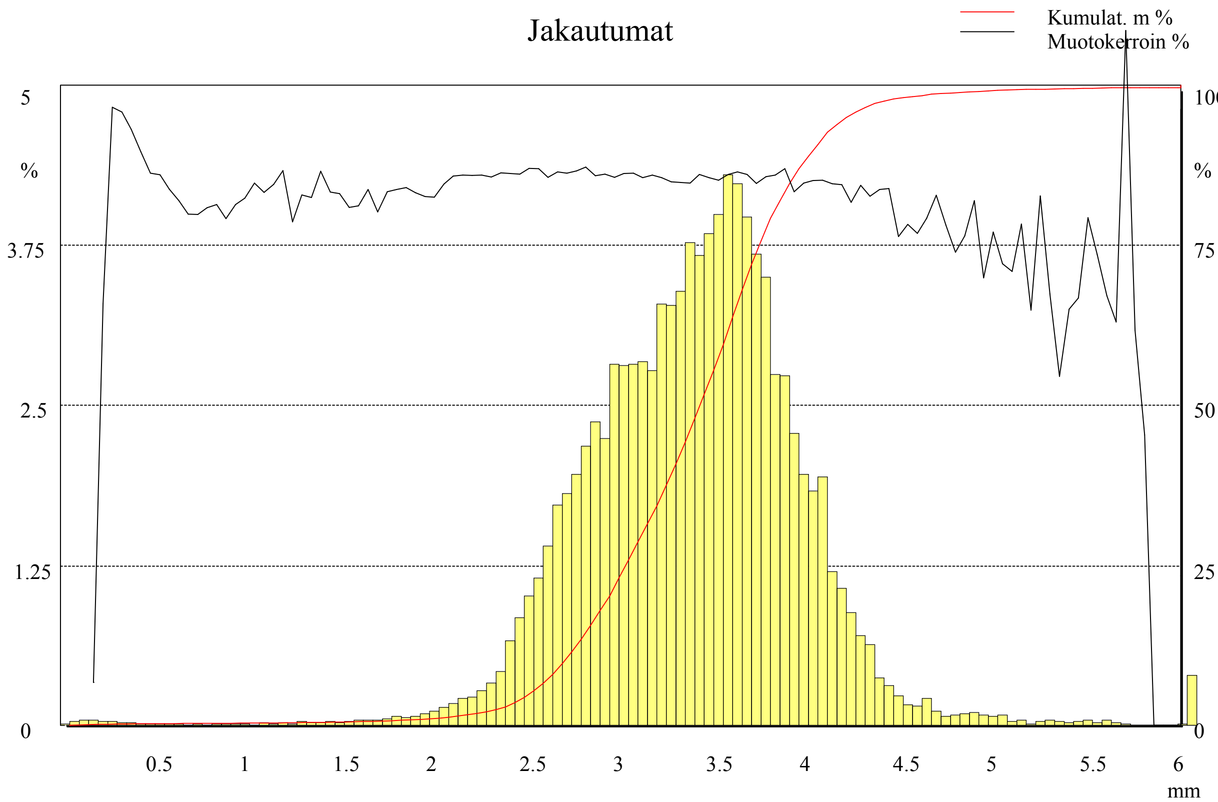
21.03.2011
13:14
Alirae_201103211314.da

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**Alirae**	Linja	
Npaikka		Tapl	
Lajike	**Alirae**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.8**		< 2 mm	**1.10**	D 5 mm	**2.48**
4.75 < d < 5.00	**0.4**	**1.2**	> 4 mm	**9.3**	D 50 mm	**3.38**
4.00 < d < 4.75	**8.1**	**9.3**	+2-4mm	**89.6**	D 90 mm	**3.98**
3.55 < d < 4.00	**26.9**	**36.2**	+2-5mm	**98.14**	UI %	**62.3**
3.15 < d < 3.55	**29.5**	**65.7**	> 4.75mm	**1.2**	MK %	**85.58**
2.80 < d < 3.15	**18.7**	**84.4**	+2-4.75 mm	**97.72**	kpl	**13524**
2.00 < d < 2.80	**14.5**	**98.9**	-1 mm	**0.32**	Alik.%	**1.1**
1.60 < d < 2.00	**0.5**	**99.4**	+2.8-5 mm	**83.65**	Tuotek.%	**89.6**
1.00 < d < 1.60	**0.3**	**99.7**			Ylik.%	**9.3**
0.50 < d < 1.00	**0.1**	**99.8**			Pyöreys	**0**
d < 0.50	**0.2**	**100**				



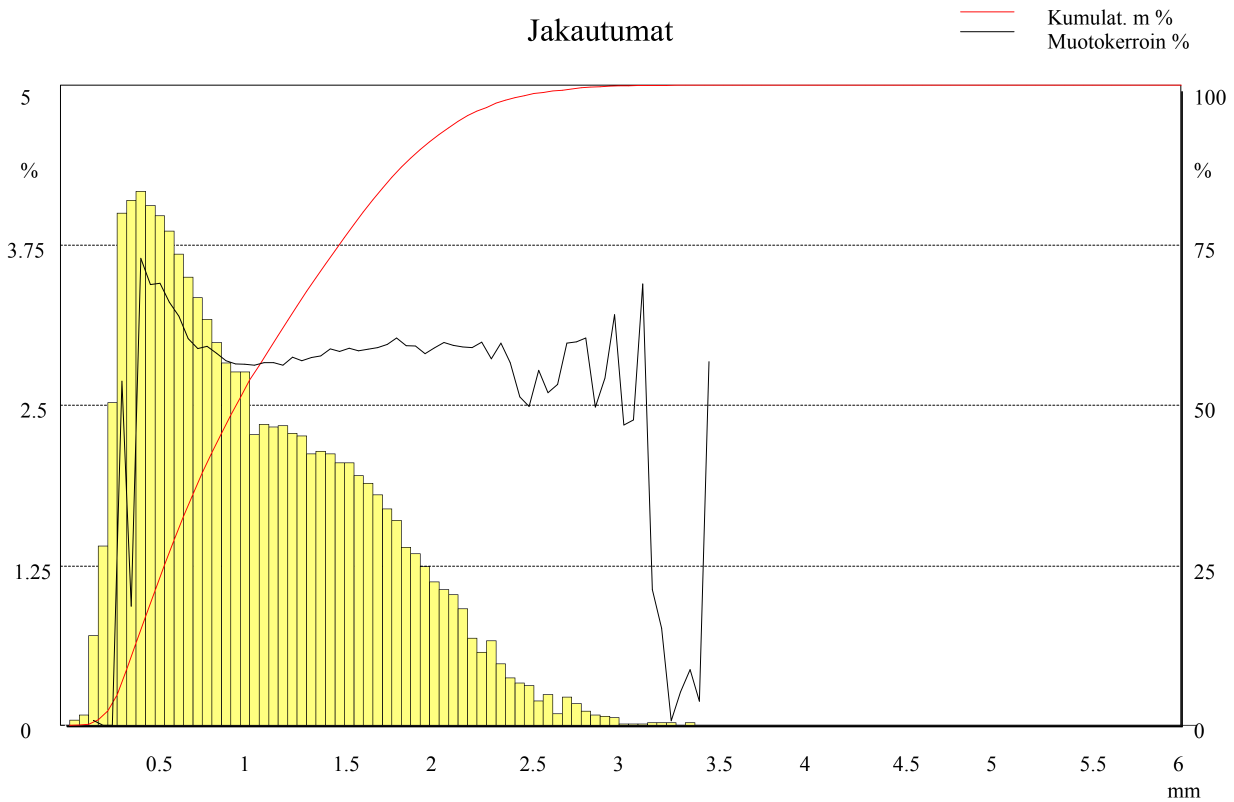
22.03.2011
12:03
Jäckerling_20110322120

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**Jäckerling**	Linja	
Npaikka	**Jäckerling**	Tapl	
Lajike	**Jäckerling**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**92.27**	D 5 mm	**0.30**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.93**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**7.73**	D 90 mm	**1.90**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**7.73**	UI %	**15.8**
3.15 < d < 3.55	**0.1**	**0.1**	> 4.75mm	**0.0**	MK %	**60.92**
2.80 < d < 3.15	**0.3**	**0.4**	+2-4.75 mm	**7.73**	kpl	**205619**
2.00 < d < 2.80	**7.4**	**7.8**	-1 mm	**53.94**	Alik.%	**92.3**
1.60 < d < 2.00	**12.1**	**19.9**	+2.8-5 mm	**0.32**	Tuotek.%	**7.7**
1.00 < d < 1.60	**26.3**	**46.2**			Ylik.%	**0.0**
0.50 < d < 1.00	**32.9**	**79.1**			Pyöreys	**0**
d < 0.50	**21.1**	**100**				



Altenburger Maschinen
Jäckering GmbH

Vorsterhauser Weg 46 · Postfach 17 33 · D-59007 Hamm
Tel. 02381/4220 · Fax 02381/422136 · E-mail: jaeckering@jaeckering.de

JÄCKERING

Mr. Aleksi Puurunen aleksi.puurunen@gmail.com

Finland

St/Neu 17.02.2011

ULTRA-ROTOR
Test Grinding of your Off-Spec Material

Dear Mr. Puurunen,

We are very sorry for the late reply to your last e-mail concerning the test grinding of your off-spec material in our ULTRA-ROTOR Test Centre.

Meanwhile, we had the opportunity to have the right machine available and made the first tests with your product.

Unfortunately, we could not match your specifications.

We realized the trials on our small ULTRA-ROTOR, model I, mill and here are the test data:

ULTRA-ROTOR, Type: ULTRA-ROTOR, Model I

- main motor: 18,5 kW

Filter Plant:

- filter area: 3,5 m^2
- motor of the rotary valve: 0,5 kW

Ventilator:
- motor: 15 kW

...

	Test 1
Inlet temperature, mill	17°C
outlet temperature, mill	17°C
product temperature, filter	17°C
current consumption (idling)	5,4 Amp
current consumption (maximum)	28 Amp
current consumption (with product)	5,5 Amp
installed energy	34 kW
initial moisture content	0,04%
capacity (feeding product)	> 100 kg/h
fineness	40% < 0,5 mm 6% < 2,0 mm

As you certainly know, our ULTRA-ROTOR is a special mill, particularly for the very fine grinding.

We have prepared some small hand samples for you for evaluation.

We are sorry, that we did not match your requirements and hope, that we will have a better chance next time.

Wishing you all the best for your dissertation, we are remaining for today with our

Best regards,

ALTENBURGER MASCHINEN
J Ä C K E R I N G GMBH

enclosures
samples
(under separate mail)

. . .

HOSOKAWA
ALPINE Aktiengesellschaft

Postfach 101151, D-86001 Augsburg ž Tel.: 0821/5906-0 ž Fax 0821/5906-438
Internet: http://www.hosokawamicron.com

Yara Suomi Oy
Mr. Aleksi Puurunen
Mechelininkatu 1a
P. O. Box 900
FI-00181 Helsinki
FINNLAND

Date	branch ref.	Contact Person	Dial 59 06 -
18th February 2011	Chemicals/C1/Hai	Stefan Haider	425
		E-mail: s.haider @alpine.hosokawa.com	

Test Report No.: 54162

total Pages: 3

Product : Fertiliser
NPK 15-15-15 (YaraMila, 15-6, 5-12,5+1,5S)

Product nature: granulate, coarse
Particle size distribution analized with Alpine Air Jet Sieve 200 LS-N:

0,48% < 200 µm	4,9% < 500 µm	11,7% < 1,25 mm
25,6% < 2 mm	70% < 3,15 mm	99% < 6 mm
Agglomerates up to 200 mm		

Moisture content: 0,35% (crushed and analized at 105°C)
bulk density: 1080 g/l

Fineness Requirement: The product should be processed on the Alpine Fine Impact mill 315 UPZ in order to get the required particle size distribution. The max. capacity should be determined. Following fineness requirements were asked:

1)	50% < 1,2 -1,4 mm	Max. 5% > 2mm	Max. 10% < 0,5mm
2)	50% < 200 µm	Min. 99% < 2mm	

The projected capacity was 10 t/h.

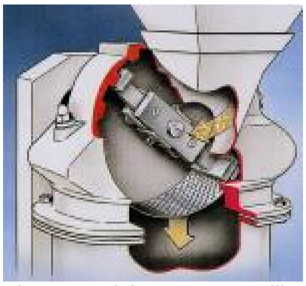
HOSOKAWA
ALPINE Aktiengesellschaft

Test-Report No.: 54162, Customer: Yara, Finland

Page: 2
Date: 9th Febuary 2011

Comments on the test results

Picture 1:Alpine Fine Impact Mill UPZ



Picture 2: Alpine Hammer Mill MZ

The product made available to us in a Bigbag, was processed in our testing centre on the Alpine Fine Impact Mill 315 UPZ and in one trial in the Alpine Hammer Mill 25 MZ.

The feeding of the material was done by a volumetric feeding screw. At material outlet below the filter a rotary valve was installed.

In the tests no. 1-13, we ran different milling equipment and different mill speeds in order to find the best suitable for reaching the required particle size distributions.

For the first fineness target (d50= 1,2 - 1,4 mm) we ran the tests no. 1 to 9 and 11. Like we expected, the particle size distributions were the same we sent to you in the beginning of the project. With all variations of parameters, we were not able to reach the required steep particle size distribution. Nevertheless, we tried to optimise the result. We produced different samples for your evaluation.
Also, we saw, that in the feed material already 5 % of fines are included. According to this and the fact, that we create fines when we mill this product it is nearly impossible to get this particle size distribution only in milling.
In order to optimise the steepness of particle size distribution like we produced, tests on a roller crusher could be done.
The tests no. 10,12 and 13 were ran to get the second fineness requirement (d50= 200 µm). Here we found out, that the hammer mill is not able to produce this fineness in a economic way. For the fine impact mill UPZ it was no problem to produce the required product in test no. 13. For the required 10 t/h a 800 UPZ would be big enough.

The particle sizes were analized with the Alpine Air Jet Sieve 200 LS-N. You are kindly requested to examine our samples by your own means. On the following page we are listing our test data. We took 3kg samples of all the trials, please indicate which samples we should send to you.
We are looking forward with interest to receiving your comments on the test and remain,
yours sincerely

HOSOKAWA ALPINE Aktiengesellschaft

i. V Werner Dilberowic **i. A. Stefan Haider**

Test Report No.: 54162, Company: Yara Suomi Oy, Finnland

Material: Fertilizer, NPK 15-15-15

no.	machine type	equipment and setting	n-mill	m	t	m/t	Alpine Air Jet Sieve 200 LS-N				
			rpm	kg	min	kg/h	<100 µm	<200 µm	<500 µm	<1,25 mm	< 2 mm
							%	%	%	%	%
		target I:							**max. 10**	**≈50**	**min. 95**
		target II:						**≈50**			**min. 99**
1	315 UPZ	cross beaters; longitudinal slot sieve LS 3x50	3.000	50,0	0,8	3750		8,5	25,8	50,9	75,1
2	"	"; LS 2x15	"	50,0	0,7	4286		13,1	32,9	68,9	96,8
3	"	"	1.500	50,0	2,5	1200		18,0	36,3	58,7	82,8
4	"	plate beaters; triangular ribbed grinding track	2.000	50,0	1,6	1875		22,6	44,8	79,6	96,6
5	"	swing beaters; "	"	50,0	0,8	3750		14,9	32,4	56,1	77,3
6	"	"; LS 3x50	"	25,0	0,4	3750		4,9	14,1	35,6	61,7
7	"	like trial no. 1	5.000	25,0	0,3	5000		19,3	39,9	71,6	87,0
8	"	"; LS 2,5x15	4.000	25,0	0,4	3750		17,6	40,5	77,1	95,1
9	"	"	2.500	25,0	0,36	4167		7,8	20,0	47,3	78,3
10	"	plate beaters; triangular ribbed grinding track	7.100	25,0	2,6	577	84,2	96,4	99,7	spots >	100,0
11	"	cross beaters; LS 2x15	2.000	25,0	0,56	2679		16,4	38,8	67,8	91,5
12	25 MZ	swing beaters; sieve ø 2	3.000	5,0	1,0	300	15,4	30,1	64,6	99,4	spots >
13	315 UPZ	plate beaters; triangular ribbed grinding track	4.300	30,0	0,7	2571	33,0	**51,4**	85,5	99,9	100,0

legend:

no.	trial number
UPZ=	Alpine Fine Impact Mill UPZ
MZ=	Alpine Hammer Mill MZ
n=	speed of mill
t=	duration of test
m=	quantity fed
m/t=	throughput rate

Particle size indicated in cumulative throughs percentages, thus ranging from zero to percentage indicated.

remarks:

[redacted]

21.03.2011
15:00
HA 54162/2_201103211

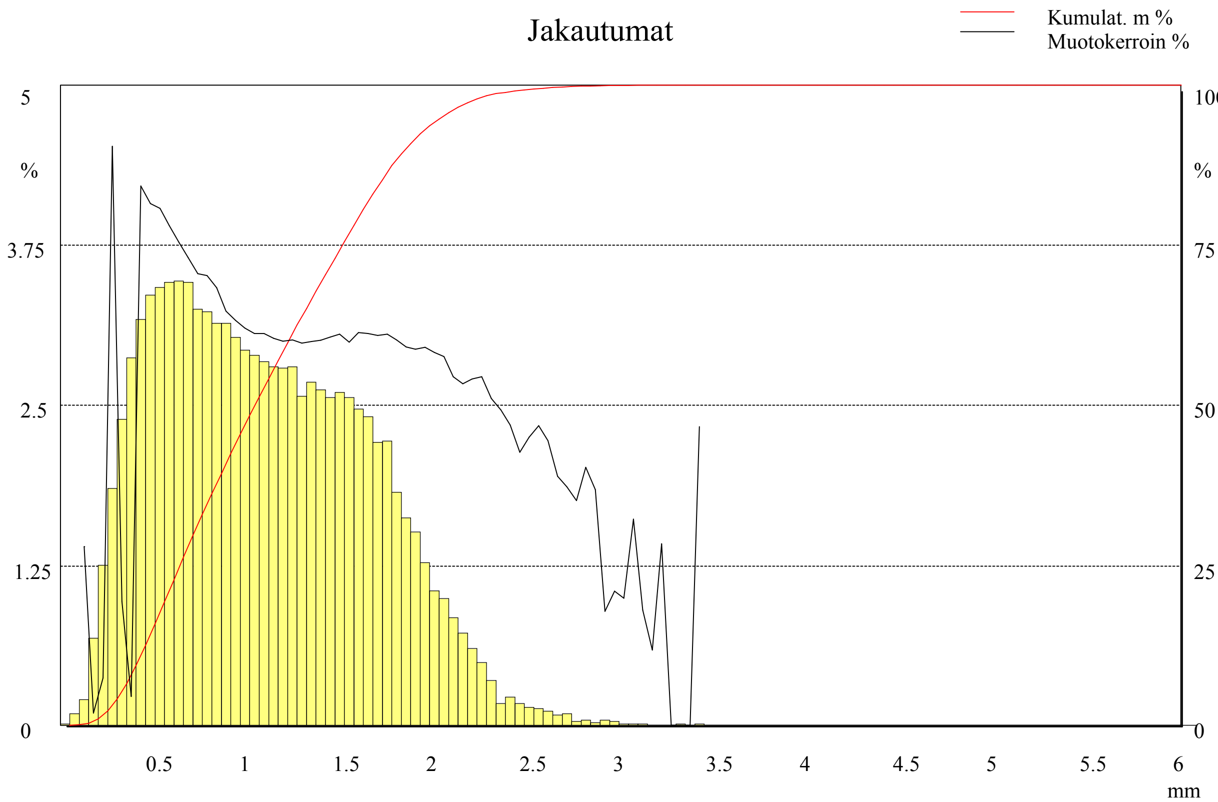
KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**HA 54162/2**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/2**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**94.69**	D 5 mm	**0.32**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**1.03**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**5.31**	D 90 mm	**1.82**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**5.31**	UI %	**17.6**
3.15 < d < 3.55	**0.0**	**0.0**	> 4.75mm	**0.0**	MK %	**63.56**
2.80 < d < 3.15	**0.1**	**0.1**	+2-4.75 mm	**5.31**	kpl	**392679**
2.00 < d < 2.80	**5.2**	**5.3**	-1 mm	**48.4**	Alik.%	**94.7**
1.60 < d < 2.00	**14.1**	**19.4**	+2.8-5 mm	**0.14**	Tuotek.%	**5.3**
1.00 < d < 1.60	**32.2**	**51.6**			Ylik.%	**0.0**
0.50 < d < 1.00	**32.5**	**84.1**			Pyöreys	**0**
d < 0.50	**15.9**	**100**				

Jakautumat



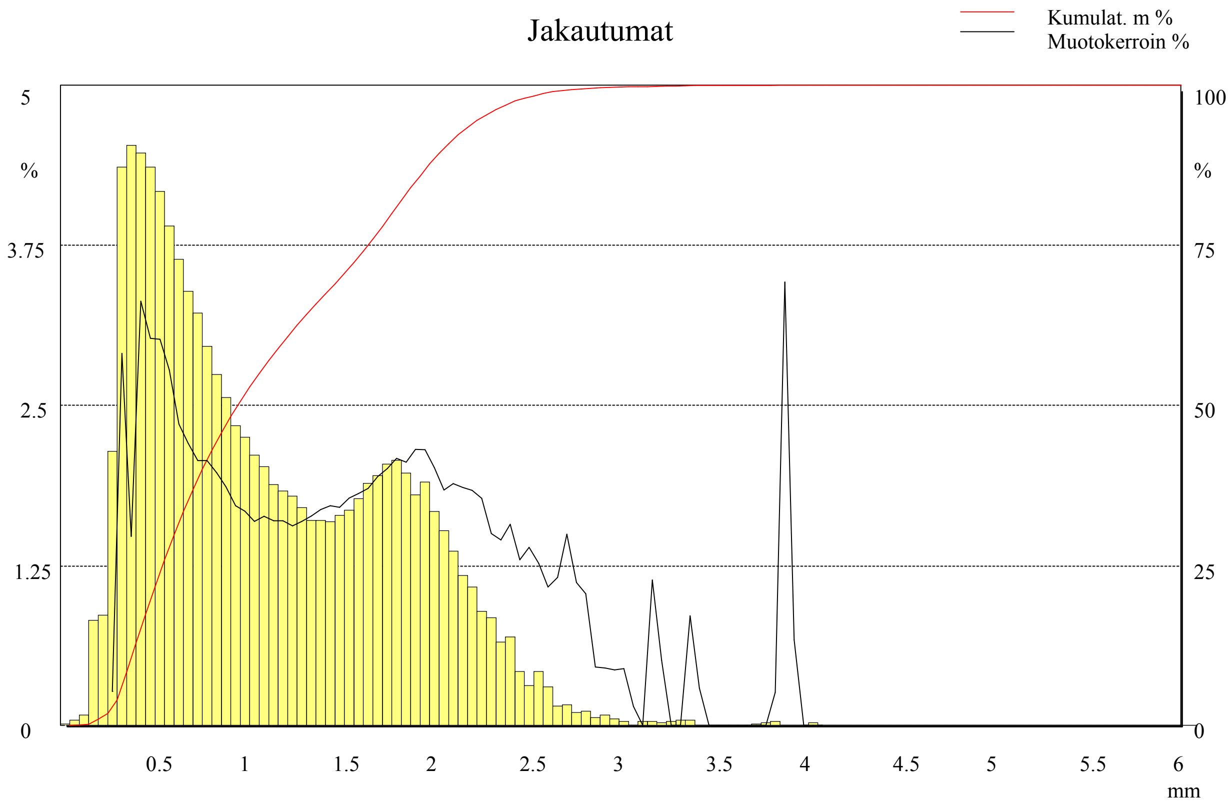
22.03.2011
10:57
HA 54162/3_201103221

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/3**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/3**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**89.34**	D 5 mm	**0.31**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.94**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**10.66**	D 90 mm	**2.02**
3.55 < d < 4.00	**0.1**	**0.1**	+2-5mm	**10.66**	UI %	**15.3**
3.15 < d < 3.55	**0.1**	**0.2**	> 4.75mm	**0.0**	MK %	**37.36**
2.80 < d < 3.15	**0.3**	**0.5**	+2-4.75 mm	**10.66**	kpl	**248150**
2.00 < d < 2.80	**10.2**	**10.7**	-1 mm	**52.84**	Alik.%	**89.3**
1.60 < d < 2.00	**15.3**	**26.0**	+2.8-5 mm	**0.49**	Tuotek.%	**10.7**
1.00 < d < 1.60	**21.2**	**47.2**			Ylik.%	**0.0**
0.50 < d < 1.00	**31.2**	**78.4**			Pyöreys	**0**
d < 0.50	**21.7**	**100**				



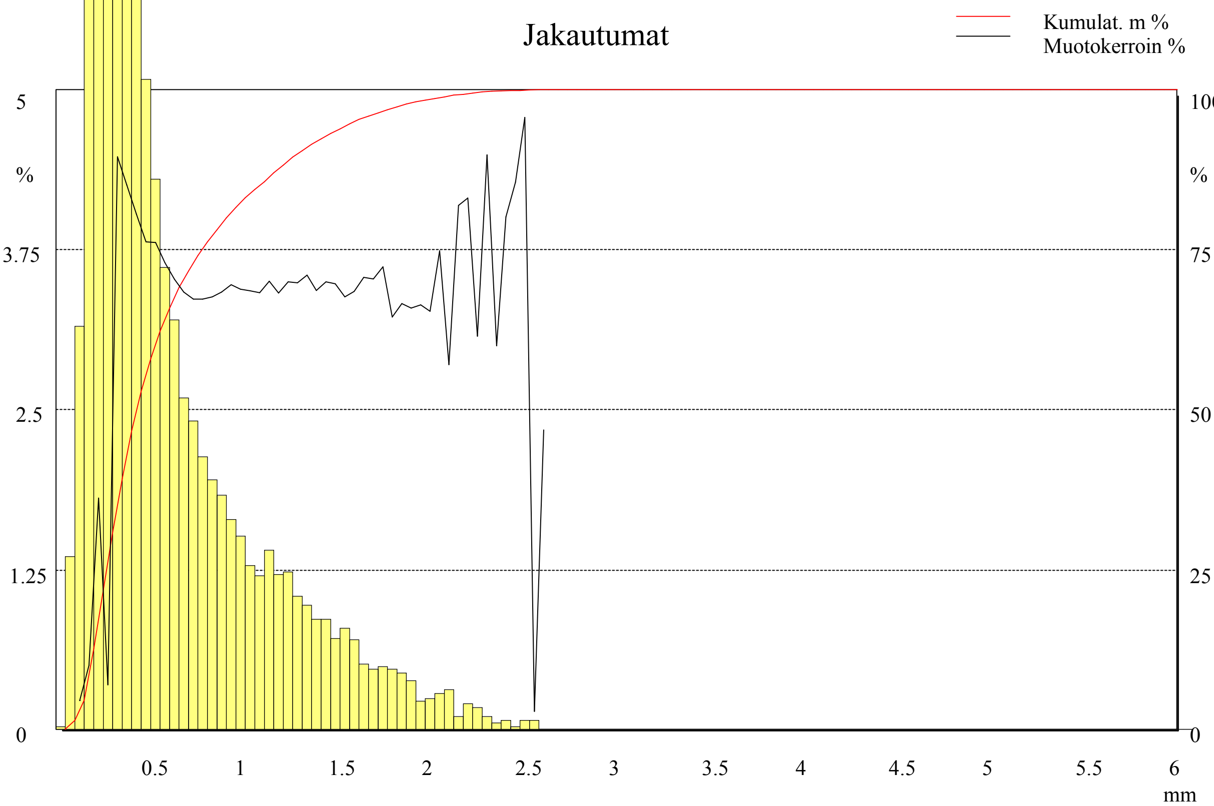
22.03.2011
11:08
HA 54162/4_201103221

KESIZER 2000   GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/4**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/4**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**98.56**	D 5 mm	**0.15**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.43**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**1.44**	D 90 mm	**1.28**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**1.44**	UI %	**11.7**
3.15 < d < 3.55	**0.0**	**0.0**	> 4.75mm	**0.0**	MK %	**75.12**
2.80 < d < 3.15	**0.0**	**0.0**	+2-4.75 mm	**1.44**	kpl	**23054**
2.00 < d < 2.80	**1.4**	**1.4**	-1 mm	**83.09**	Alik.%	**98.6**
1.60 < d < 2.00	**3.2**	**4.6**	+2.8-5 mm	**0.00**	Tuotek.%	**1.4**
1.00 < d < 1.60	**12.3**	**16.9**			Ylik.%	**0.0**
0.50 < d < 1.00	**25.2**	**42.1**			Pyöreys	**0**
d < 0.50	**57.9**	**100**				



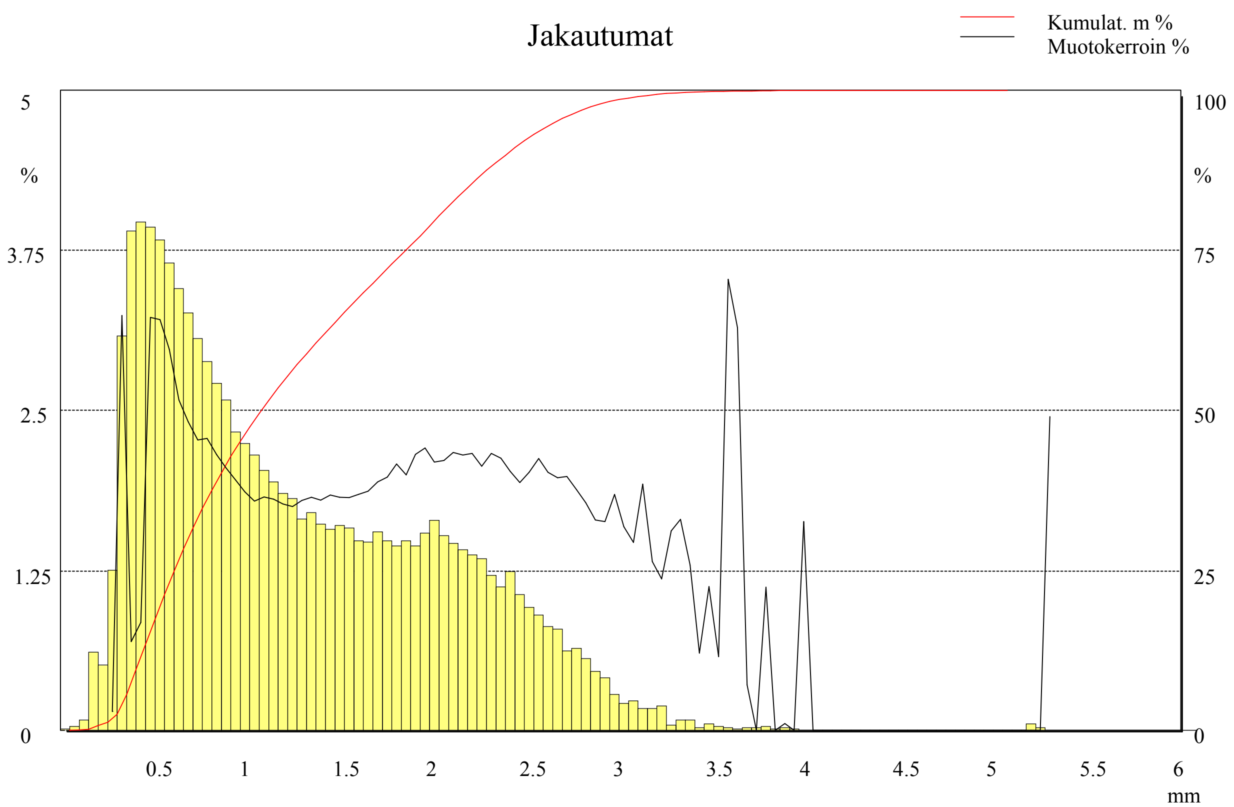
22.03.2011
10:47
HA 54162/5_201103221

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/5**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/5**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.1**		< 2 mm	**80.37**	D 5 mm	**0.34**
4.75 < d < 5.00	**0.0**	**0.1**	> 4 mm	**0.1**	D 50 mm	**1.06**
4.00 < d < 4.75	**0.0**	**0.1**	+2-4mm	**19.53**	D 90 mm	**2.36**
3.55 < d < 4.00	**0.1**	**0.2**	+2-5mm	**19.57**	UI %	**14.4**
3.15 < d < 3.55	**0.5**	**0.7**	> 4.75mm	**0.1**	MK %	**40.92**
2.80 < d < 3.15	**1.9**	**2.6**	+2-4.75 mm	**19.57**	kpl	**306368**
2.00 < d < 2.80	**17.0**	**19.6**	-1 mm	**47.36**	Alik.%	**80.4**
1.60 < d < 2.00	**12.0**	**31.6**	+2.8-5 mm	**2.56**	Tuotek.%	**19.5**
1.00 < d < 1.60	**21.0**	**52.6**			Ylik.%	**0.1**
0.50 < d < 1.00	**30.0**	**82.6**			Pyöreys	**0**
d < 0.50	**17.4**	**100**				



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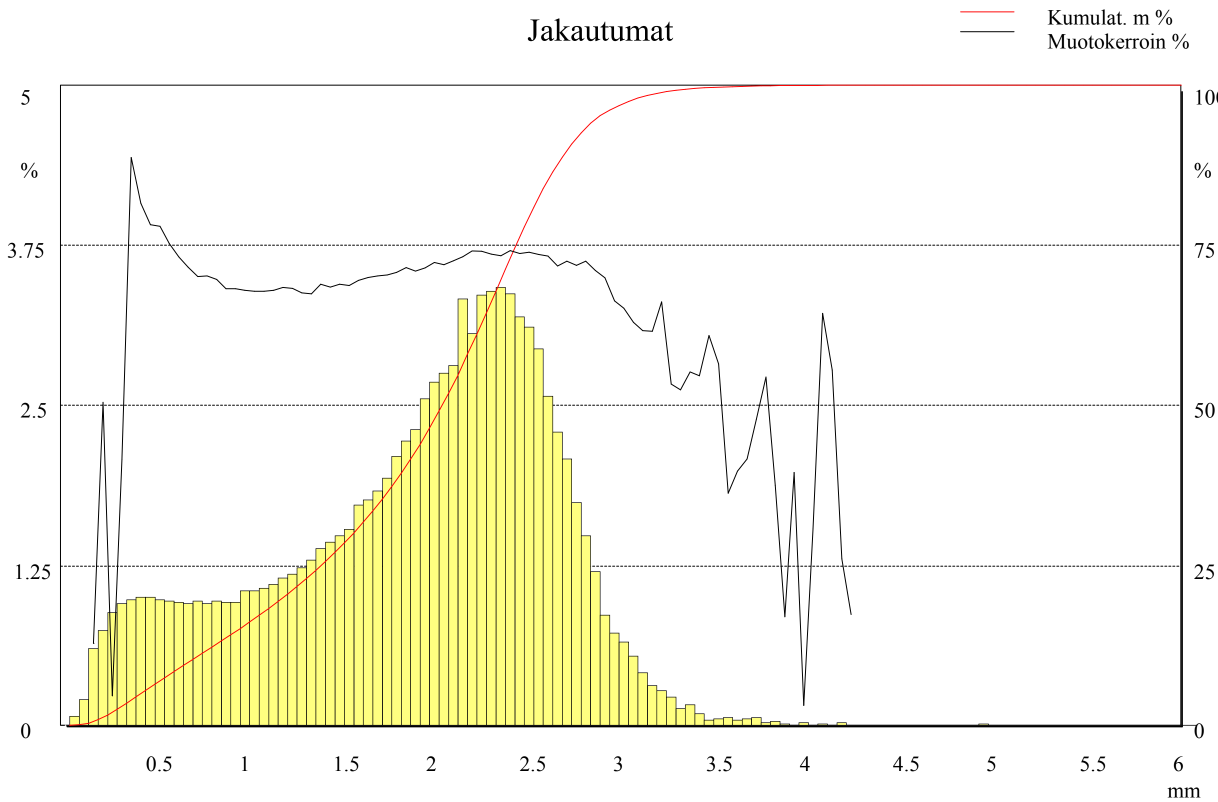
21.03.2011
15:07
HA 54162/6_201103211

KESIZER 2000   GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**HA 54162/6**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/6**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**49.13**	D 5 mm	**0.43**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**2.02**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**50.87**	D 90 mm	**2.68**
3.55 < d < 4.00	**0.2**	**0.2**	+2-5mm	**50.87**	UI %	**16.0**
3.15 < d < 3.55	**1.0**	**1.2**	> 4.75mm	**0.0**	MK %	**71.66**
2.80 < d < 3.15	**4.7**	**5.9**	+2-4.75 mm	**50.86**	kpl	**191041**
2.00 < d < 2.80	**44.9**	**50.8**	-1 mm	**16.14**	Alik.%	**49.1**
1.60 < d < 2.00	**17.4**	**68.2**	+2.8-5 mm	**5.98**	Tuotek.%	**50.9**
1.00 < d < 1.60	**15.6**	**83.8**			Ylik.%	**0.0**
0.50 < d < 1.00	**9.7**	**93.5**			Pyöreys	**0**
d < 0.50	**6.4**	**100**				

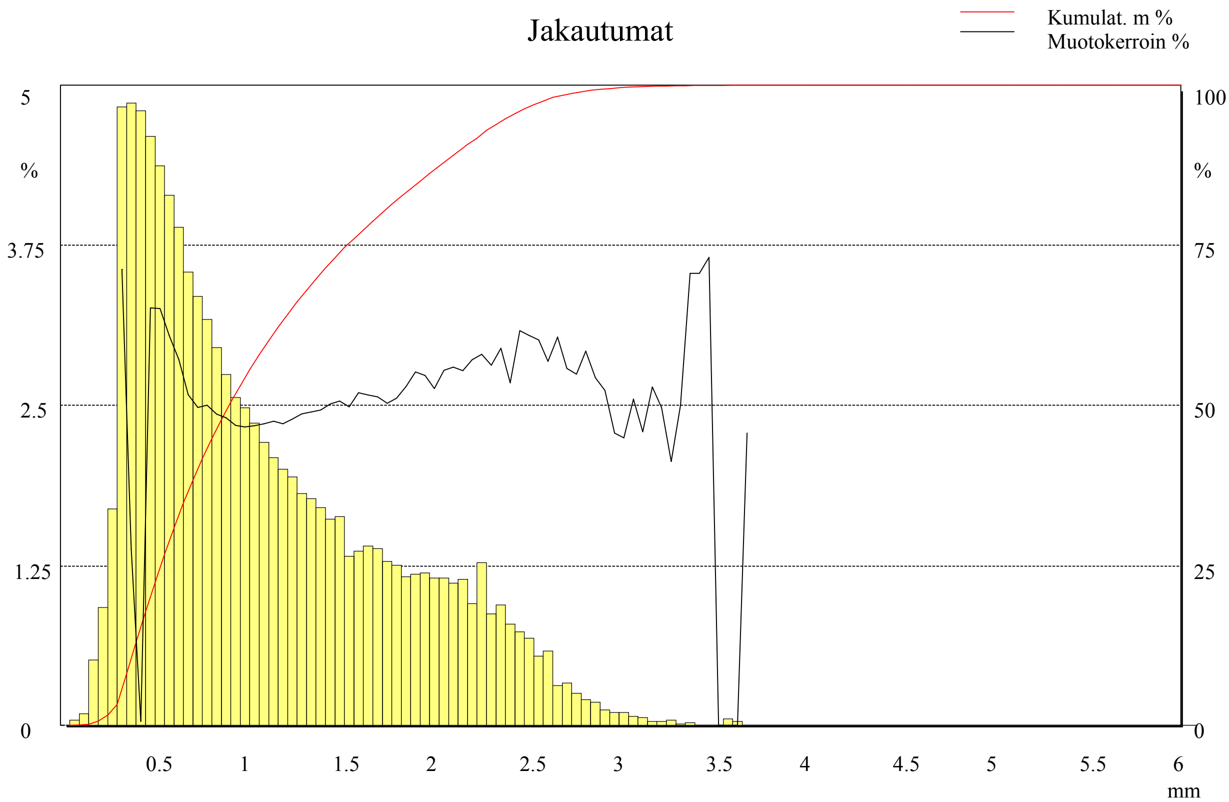


KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/7**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/7**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**87.32**	D 5 mm	**0.32**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.89**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**12.68**	D 90 mm	**2.12**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**12.68**	UI %	**15.1**
3.15 < d < 3.55	**0.2**	**0.2**	> 4.75mm	**0.0**	MK %	**53.87**
2.80 < d < 3.15	**0.7**	**0.9**	+2-4.75 mm	**12.68**	kpl	**223126**
2.00 < d < 2.80	**11.8**	**12.7**	-1 mm	**55.53**	Alik.%	**87.3**
1.60 < d < 2.00	**10.0**	**22.7**	+2.8-5 mm	**0.84**	Tuotek.%	**12.7**
1.00 < d < 1.60	**21.8**	**44.5**			Ylik.%	**0.0**
0.50 < d < 1.00	**33.2**	**77.7**			Pyöreys	**0**
d < 0.50	**22.3**	**100**				



22.03.2011
11:18
HA 54162/8_201103221

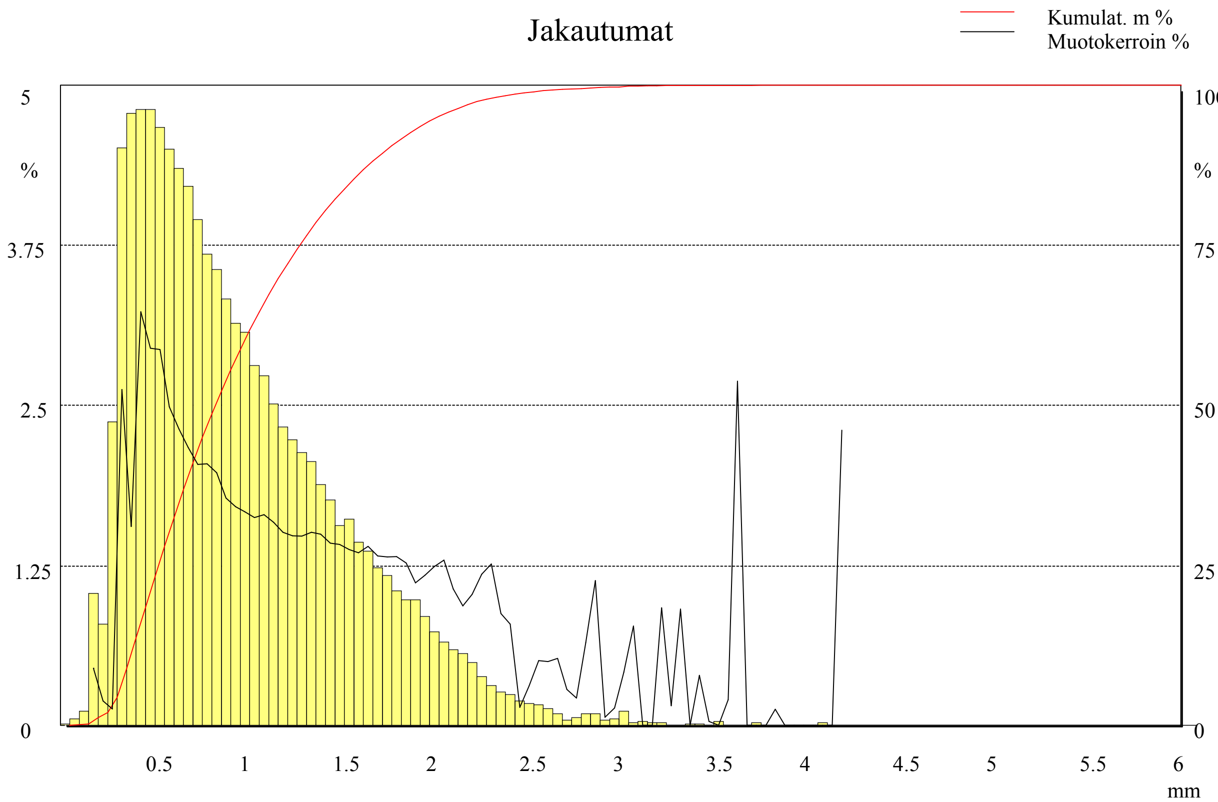
KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/8**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/8**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**95.12**	D 5 mm	**0.31**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.82**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**4.88**	D 90 mm	**1.73**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**4.88**	UI %	**17.9**
3.15 < d < 3.55	**0.1**	**0.1**	> 4.75mm	**0.0**	MK %	**32.31**
2.80 < d < 3.15	**0.4**	**0.5**	+2-4.75 mm	**4.88**	kpl	**284557**
2.00 < d < 2.80	**4.4**	**4.9**	-1 mm	**61.73**	Alik.%	**95.1**
1.60 < d < 2.00	**8.4**	**13.3**	+2.8-5 mm	**0.47**	Tuotek.%	**4.9**
1.00 < d < 1.60	**25.0**	**38.3**			Ylik.%	**0.0**
0.50 < d < 1.00	**38.5**	**76.8**			Pyöreys	**0**
d < 0.50	**23.3**	**100**				

Jakautumat



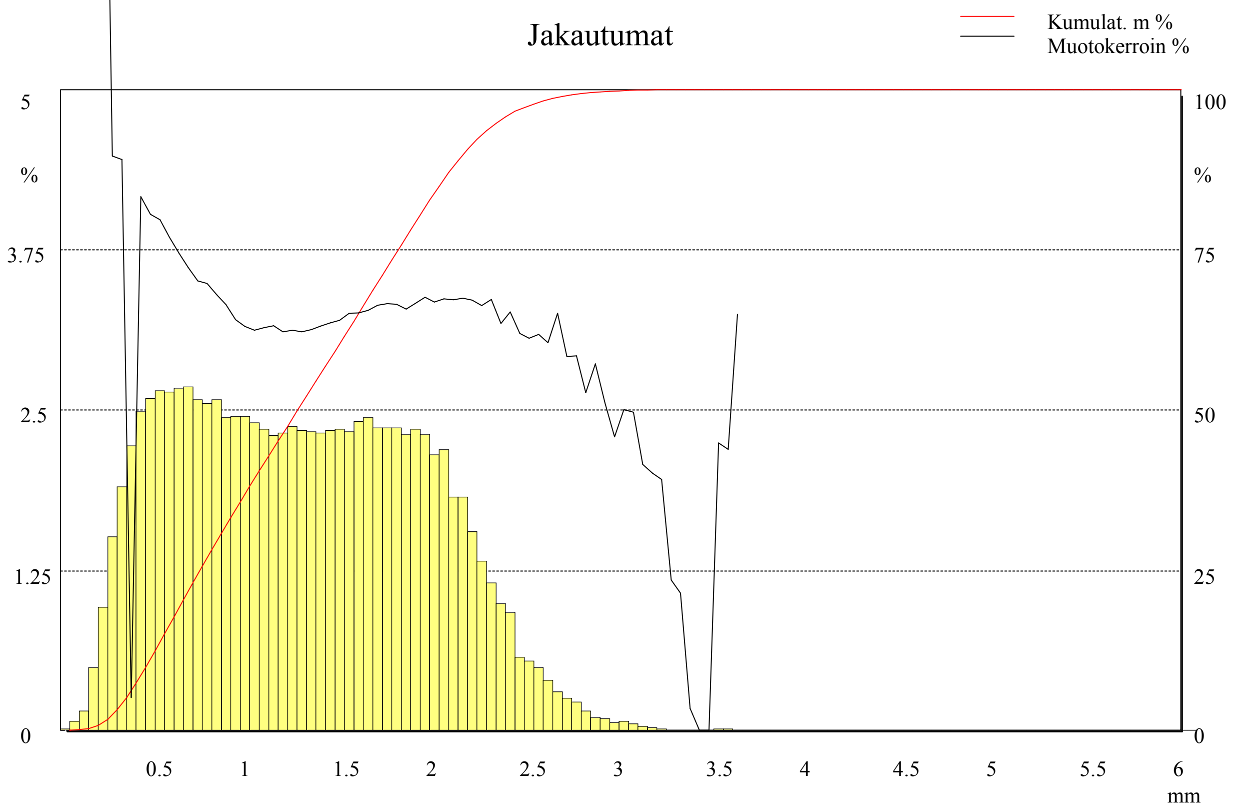
21.03.2011
14:33
HA 54162/9_201103211

KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**HA 54162/9**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/9**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**84.88**	D 5 mm	**0.35**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**1.25**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**15.12**	D 90 mm	**2.13**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**15.12**	UI %	**16.4**
3.15 < d < 3.55	**0.0**	**0.0**	> 4.75mm	**0.0**	MK %	**67.08**
2.80 < d < 3.15	**0.4**	**0.4**	+2-4.75 mm	**15.12**	kpl	**392605**
2.00 < d < 2.80	**14.7**	**15.1**	-1 mm	**38.08**	Alik.%	**84.9**
1.60 < d < 2.00	**18.6**	**33.7**	+2.8-5 mm	**0.45**	Tuotek.%	**15.1**
1.00 < d < 1.60	**28.2**	**61.9**			Ylik.%	**0.0**
0.50 < d < 1.00	**25.7**	**87.6**			Pyöreys	**0**
d < 0.50	**12.4**	**100**				



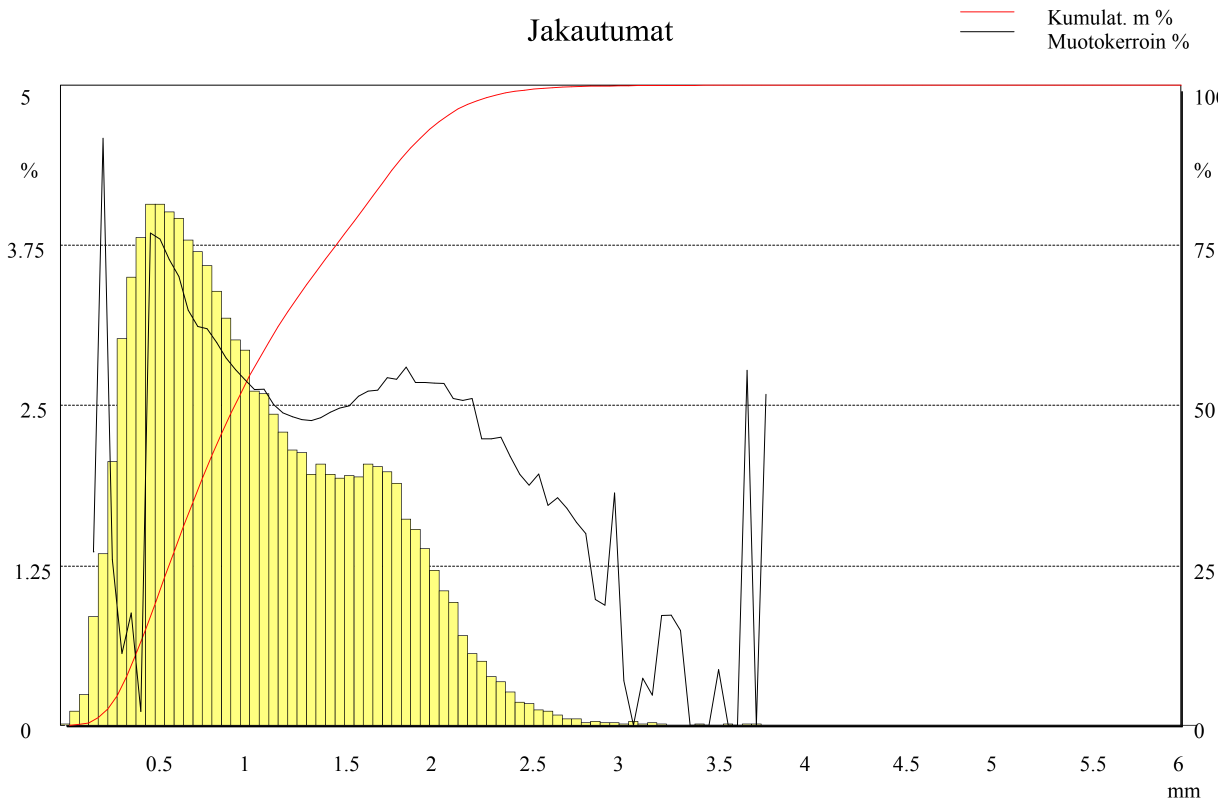
KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**21.03.2011**	Aika	**13.09**
Tehdas	**HA 54162/11**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/11**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**94.28**	D 5 mm	**0.31**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.92**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**5.72**	D 90 mm	**1.85**
3.55 < d < 4.00	**0.0**	**0.0**	+2-5mm	**5.72**	UI %	**16.8**
3.15 < d < 3.55	**0.0**	**0.0**	> 4.75mm	**0.0**	MK %	**55.30**
2.80 < d < 3.15	**0.1**	**0.1**	+2-4.75 mm	**5.72**	kpl	**455567**
2.00 < d < 2.80	**5.5**	**5.6**	-1 mm	**54.64**	Alik.%	**94.3**
1.60 < d < 2.00	**13.7**	**19.3**	+2.8-5 mm	**0.19**	Tuotek.%	**5.7**
1.00 < d < 1.60	**26.0**	**45.3**			Ylik.%	**0.0**
0.50 < d < 1.00	**35.6**	**80.9**			Pyöreys	**0**
d < 0.50	**19.0**	**100**				

Jakautumat



22.03.2011
11:27
HA 54162/20_20110322

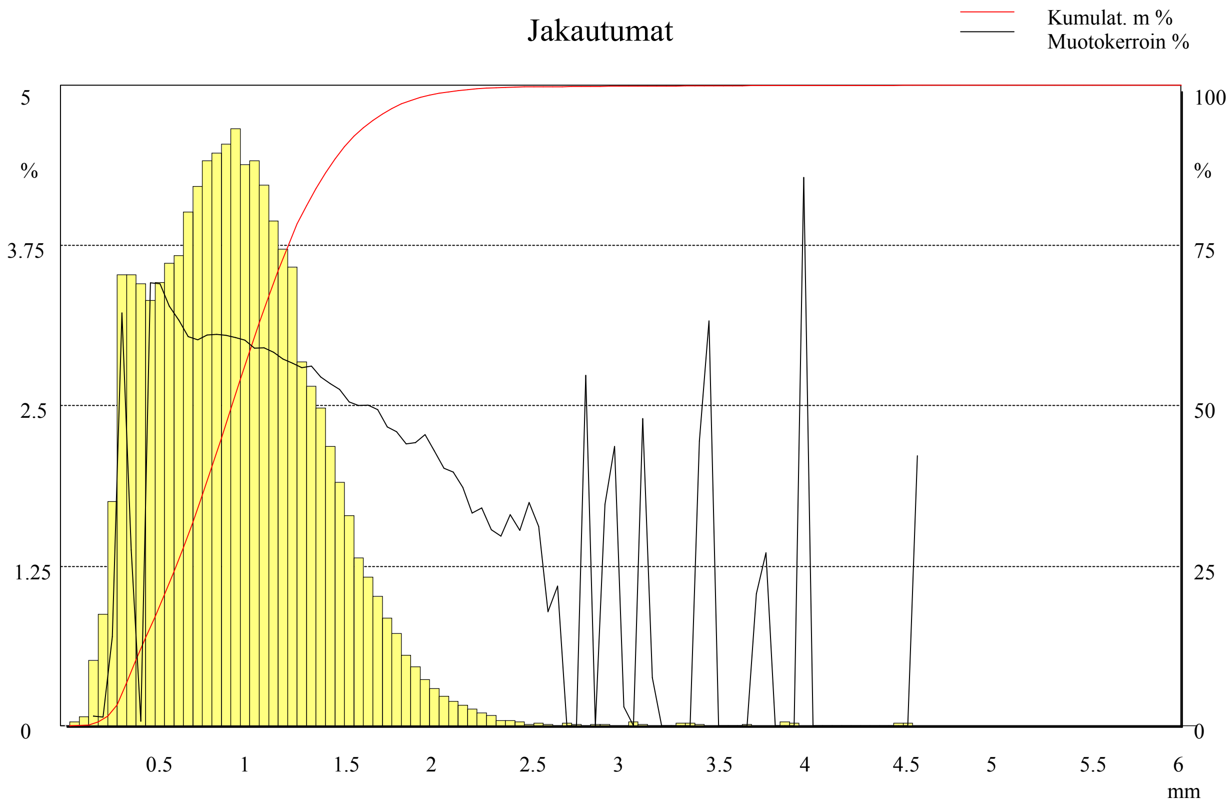
KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**HA 54162/20**	Linja	
Npaikka	**Hosokawa Alpine**	Tapl	
Lajike	**HA 54162/20**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.0**		< 2 mm	**98.72**	D 5 mm	**0.33**
4.75 < d < 5.00	**0.0**	**0.0**	> 4 mm	**0.0**	D 50 mm	**0.91**
4.00 < d < 4.75	**0.0**	**0.0**	+2-4mm	**1.28**	D 90 mm	**1.49**
3.55 < d < 4.00	**0.1**	**0.1**	+2-5mm	**1.28**	UI %	**22.1**
3.15 < d < 3.55	**0.1**	**0.2**	> 4.75mm	**0.0**	MK %	**59.21**
2.80 < d < 3.15	**0.1**	**0.3**	+2-4.75 mm	**1.28**	kpl	**315441**
2.00 < d < 2.80	**1.1**	**1.4**	-1 mm	**58.46**	Alik.%	**98.7**
1.60 < d < 2.00	**5.4**	**6.8**	+2.8-5 mm	**0.21**	Tuotek.%	**1.3**
1.00 < d < 1.60	**34.9**	**41.7**			Ylik.%	**0.0**
0.50 < d < 1.00	**41.4**	**83.1**			Pyöreys	**0**
d < 0.50	**17.0**	**100**				

Jakautumat



KESIZER 2000 GRANULE SIZE ANALYSER

PVM	**22.03.2011**	Aika	**10.15**
Tehdas	**Alirae Saksan vertailuun**	Linja	
Npaikka	**C-6 bunkkerista**	Tapl	
Lajike	**Alirae Saksan vertailuun**	Erä	
Tila		Tuotealue	**2.0 - 4.0**
Tekijä		Resoluutio (um)	**61**

Huom

Seulojen valinta	Massa %					
d > 5.00	**0.7**		< 2 mm	**2.57**	D 5 mm	**2.19**
4.75 < d < 5.00	**0.4**	**1.1**	> 4 mm	**6.0**	D 50 mm	**3.16**
4.00 < d < 4.75	**5.0**	**6.1**	+2-4mm	**91.43**	D 90 mm	**3.83**
3.55 < d < 4.00	**17.2**	**23.3**	+2-5mm	**96.77**	UI %	**57.2**
3.15 < d < 3.55	**27.3**	**50.6**	> 4.75mm	**1.0**	MK %	**85.71**
2.80 < d < 3.15	**23.3**	**73.9**	+2-4.75 mm	**96.41**	kpl	**33795**
2.00 < d < 2.80	**23.6**	**97.5**	-1 mm	**0.13**	Alik.%	**2.6**
1.60 < d < 2.00	**2.1**	**99.6**	+2.8-5 mm	**73.13**	Tuotek.%	**91.4**
1.00 < d < 1.60	**0.4**	**100.0**			Ylik.%	**6.0**
0.50 < d < 1.00	**0.0**	**100.0**			Pyöreys	**0**
d < 0.50	**0.1**	**100**