

ACTION C.4: Peittoo Recycling Park: Demonstration of separation of NdFeB magnets from metal scrap & infrastructure application for foundry sand waste

Beneficiary responsible for implementation:

City of Pori

Description:

What

This action implements aims 1.2., 2.1. 2.2. 3.3., 5.1. and 6.2. of NWP.

This action aims at the concrete demonstration of the recycling of industrial by-products. The aim is to increase the handling, testing and recycling of industrial by-products, to reduce industrial waste and phase out industrial landfilling. Two cases identified and analysed in the preparatory action A.2 will be implemented.

Sub-action C.4.1: Building facilities for demonstrating separation of NdFeB magnets from metal scrap

Sub-action 1 is a pre-industrial scale application. It is preceded by the ERDF-funded project - *Recycling of NdFeB magnets* which will run until 2017. This ERDF-project focuses on determining and testing the technical aspects on a laboratory scale. It will determine the testing and measurement methods applied in this action.

NdFeB magnets are widely used in generators, electric motors and loudspeakers, for instance. The mass percentage of magnets in metal scrap varies according to the equipment in question. The magnet powder produced by the demonstration equipment will be analysed, and the amount of magnets in each type of metal scrap as well as the amount of rare earth metals in each type of magnet powder will be calculated. The data collected will be used in order to determine the profitability and the usability of the recycled material.

The recycled material used for the demonstration will be collected and pre-separated by Kuusakoski Oy which operates in the Peittoo and Tahkoluoto areas of Satakunta.

For manufacturing the test magnets, the batch size of the demonstration equipment is approximately 100 kg per batch. The estimated process time for a batch is 5 - 6 hours. As some of the magnets in end of life products cannot be dismantled before recycling, the relative amount of magnet material is not 100% of the processed material.

In the demonstration process, minimum of 6 batches will be produced, i.e. minimum 600 kg of test magnets will be manufactured. This has been calculated as the optimal maximum amount that is realistic with planned resources and in circumstances where there are no previous practises on testing this technology in a Finnish operational environment. This amount is estimated to give an adequate statistical view on the quality of the produced material mixture deriving from various recycling material inputs used in the demonstration process. The number of test batches is set to the minimum of 6, which optimizes the cost-efficiency of the magnet manufacturing. The end products are tested and the feasibility of the process is dependent on whether the magnetic properties of the recycled magnets are

good enough to make them as a merchantable product. The planned amount of batches is considered sufficient to make this conclusion.

Sub-action C.4.2: Building test fields for infrastructure application for foundry sand waste

Sub-action 2 is a pilot scale application. Measurement methods and the evaluation process of the impacts will be determined in the complementary action *Circular economy and industrial symbiosis in Satakunta region* which is scheduled for 2016 - 2017.

Test fields will be built at the Peitto recycling park. They will be monitored in various climate conditions for a minimum period of one year. The test results will be used for applying for a legal permit for an infrastructure application for foundry sand waste.

Material mixtures consisting of foundry sand waste, foundry dust, slag and mass from the furnace mixed with gravel and crushed stone are first tested and analysed in laboratory scale. The waste material from the foundry is classified as non-hazardous waste. Foundry sand waste consist mainly of quartz sand. Both foundry sand waste and foundry dust consist bentonite (7 % bentonite clay in sand and 30 % bentonite in dust), which works as a binding agent in the mixture, and increases its density. Furnace material (slag and mass) and crushed stone increase the carrying capacity of the material. The aim is to create an optimal material mixture that will make the construction fields durable and unfreezable.

The mixing of the material will be done in a blending machine or using a shovel loader. In the procedure, the amount of each material will be controlled.

If the results indicate that suitable mixtures can be found, 2 -3 test fields consisting of various mixtures can be built. The final amount of each material needed for the test fields is estimated to be as follows: 4500 t foundry sand waste, 300 t furnace slag, 200 t furnace mass and 0 – 1000 t foundry dust. These amounts equal one-year waste production of the foundry. The structure of the test fields as well as the material construction will be determined according to the laboratory tests that are run before starting this action. According to the experiences of the companies involved, it is estimated that the size of each test field should be approx. 5 acres.

The carrying capacity of the test fields will be tested with a weight dropping machine. The sinking of the ground will be measured by using levelling instruments. The density of the material will either be measured by using volumeter, or calculated comparing field tests and Proctor compaction tests. The test fields will be built at the Peitto recycling park. If the material proves to be suitable, it will be used in building various kinds of material handling fields in the Peitto area. The main aim however, is to get a suitable material mixture for any kind of construction purposes (earthworks) in the future.

The fields will be monitored in various climate conditions for a minimum period of one year. Through the monitoring process, information will be collected on sinking, freezing and condensing of the material. The water streams will be monitored on phenol index, fluoride, polycyclic aromatic hydrocarbons, mixtures of benzene, toluene, and the three xylene isomers, and metals (Al, Hg, Cd, Cr, Cu, Pd, Ni, Fe, Zn). The monitoring sequence will be determined after the laboratory tests. The test results will be used for applying for a legal permit for an infrastructure application for foundry sand waste.

Componenta Finland Oy is searching for suitable and cost-effective local applications to recycle waste produced at their plants. Peitto recycling park is located only 20 km from

Componenta Finland Oy, which makes it profitable to use the material for building the park. This concept will reduce the need for landfilling the waste arising from the foundries. The foundry sand waste is at moment handled by the Peittoon Kierrätystermiinaali Oy, which is considered to be a suitable partner in handling and mixing and using the mixed material in the future.

How

Sub-action C.4.1: Separation of NdFeB magnets from metal scrap

In sub-action 1, industrial-scale demonstration equipment for the recycling of NdFeB magnets will be built. The equipment will be used to demonstrate how scrap magnets can be broken down into magnet powder, and further to be used in the production of new magnets. The purpose of the action is to demonstrate the efficiency of the equipment and the applied techniques, i.e. hydrogen decrepitation and jet milling techniques in the magnet separation process. This sub-action is preceded by an ERDF-funded project *Recycling of NdFeB magnets*, in which a method for separating NdFeB magnets and rare earth metals from metal scrap will be developed and tested on a laboratory scale, and the usability of the recycled material will be analysed.

Sub-action C.4.2: Infrastructure application for foundry sand waste

In sub-action 2, test fields of foundry sand waste mixed with other construction materials like gravel and crushed stone will be built at the Peittoon recycling park. The waste material used in the demonstration is the sand waste generated by the mould production process of Componenta Finland Oy's foundry. The durability and the environmental acceptability of the material mixture will be tested and analysed from the viewpoint of legal requirements for infrastructure construction. This sub-action is preceded by the complementary action *Circular economy and industrial symbiosis in Satakunta region* in which the measurement methods and the evaluation process of the impacts will be determined.

Where

Industrial by-products for the demonstrations will be acquired from Satakunta region. The pre-separation of the materials in sub-action 1 will be performed at the Peittoon recycling park. The test fields of sub-action 2 will be built at the Peittoon recycling park.

When

This action will be conducted during phase one.

Sub-action C.4.1 is scheduled for 01/2017 - 12/2018

Sub-action C.4.2 is scheduled for 11/2016 - 12/2018.

Why - Reasons why this action is necessary:

Sub-action C.4.1: Separation of NdFeB magnets from metal scrap

Approximately 54 kt of NdFeB magnets are scrapped worldwide each year (around 3kt in EU). Approximately one third of the weight of the magnets consists of the rare earth metals Nd, Pr, Dy, Tb and Gd. At present metal prices, the value of these rare earth metals in scrapped magnets lies between USD 1.6 and 2.0 billion. The European Union imports more

than 90 % of its rare earth metals requirements from countries such as China. Using the method demonstrated in this project could increase the self-sufficiency of Europe in the production of Nd, Pr, Dy, Tb and Gd. The EU is trying to improve access to rare earth metals, reduce their consumption and enhance extraction conditions across the continent.

Sub-action C.4.2: Infrastructure application for foundry sand waste

Componenta is a major casting solutions provider in Europe. Most of Componenta's production waste is sorted for reuse and 60% of the waste was reused in 2014. More effective recycling is one of the key goals of the Group's environmental policy. Componenta Finland Oy is searching for suitable and cost-effective local applications to recycle waste produced at their plants. Peittoo recycling park is located only 20 km from Componenta Finland Oy, which makes it profitable to use the material for building the park. The amount of sand waste generated by Componenta Finland's foundry in Pori is approx. 4.5 kt a year. If proved environmentally acceptable and financially profitable, this concept will reduce the use of natural resources and need for landfilling since this best practice method will be easy to transfer to similar waste materials from other foundries in Finland and across the EU.

The action will support the main targets of the Finnish NWP: increased utilization of mineral waste and industrial by-products.

Constraints and assumptions:

Sub-action C.4.1

The success of this demonstration is highly dependent on cooperation with local permanent magnet manufacturer Neorem Magnets Oy. There is a small risk (5% probability estimated) that during the planned time of the demonstration they have their process capacity in full use and can't provide the effort needed for this demonstration. This would mean that finished magnets could not be manufactured from the recycled material. In this case optional end use for the recycled rare earths could be found as additive of special metal compounds and the suitability of recycled material for permanent magnet manufacturing could be verified based on the tested chemical composition (especially oxygen and carbon contents).

On technical side there is a risk that the demonstration equipment is not able to produce magnet powder with low enough oxygen and carbon contamination to be used in permanent magnet production.

Even if the technical aspects would make it possible to produce permanent magnets using partly recycled magnet powder, the process has to be optimized for it to be economical compared to using only fresh powder.

Sub-action C.4.2

If the material mixture is environmentally unaccepted, it will not be approved for infrastructure construction. Using the material mixture should be more cost-effective than the present procedure.

Expected results:

Sub-action C.4.1 is expected to result in the creation of a method for separating NdFeB magnets from metal scrap on industrial scale. As a best practice, the method and technologies can easily be transferred to similar waste materials in Finland and across the EU. The hydrogen decrepitated powder from recycled magnets with sufficiently low oxygen and carbon contaminations can be mixed with fresh NdFeB powder and used in production

of sintered NdFeB magnets. The expected contamination levels limit the proportion of recycled powder to estimated 10 - 25% of the mixture. The usage of recycled materials produced by this method can thus reduce the need for imported rare earth metals (Nd, Pr, Dy, Tb, Gd) in European magnet production by 10 - 25 %.

Information about current amount of magnet waste is not yet available. Guyonnet et. al. [1] estimate the amount of Nd in permanent magnet waste flow to be around 570 tons in EU in 2010. The total amount of Neodymium based permanent magnet waste calculated using this figure with typical Pr and Dy contents and the total Rare earth content of magnets would be around 2500 - 3000 tons. Current waste amount can be assumed slightly higher. As the EU's annual production of NdFeB magnets is around 1000 tons, the aforementioned mixing ratio of recycled and fresh material would make it possible to make use of around 5 - 10% of the magnet waste.

Sub-action C.4.2 is expected to result in an infrastructure application for foundry sand waste. It will generate data necessary for obtaining a legal permit for a material mixture consisting foundry sand waste to be used in infrastructure construction. The method can easily be transferred to similar waste materials in Finland and across the EU.

[1] *Material flow analysis applied to rare earth elements in Europe, Journal of Cleaner Production, Elsevier, 2015, 26 p.*

Cost estimation:

City of Pori:

Travel 7 180 €, External assistance 140 000 € + 7% overheads = 157 483 €, procedure: framework contract with in-house consulting unit Prizztech Ltd. The costs of Prizztech Ltd will not include any elements of profit or overheads, and they will present the best value for money.

All public permanent staff will be specifically seconded to the project.

Deliverables:

- Report on test results of sub-action 1: Separation of NdFeB magnets from metal scrap
- Report on test results of sub-action 2: Infrastructure application for foundry sand waste

Milestones:

- Completion of demonstration equipment for the NdFeB magnet separation process (action 1) / 31.12.2017
- First batch of separated magnet powder produced from NdFeB magnet scrap (action 1) / 31.12.2018
- Optimal material mixture of foundry sand waste and other construction materials for infrastructure construction ready for concrete testing (action 2) / 31.3.2017
- Infrastructure test field at the Peitto recycling park (action 2) / 30.8.2017
- Test reports of monitoring the test fields ready (action 2) / 30.9.2018
- Infrastructure application for foundry sand waste approved (action 2) / 31.12.2018