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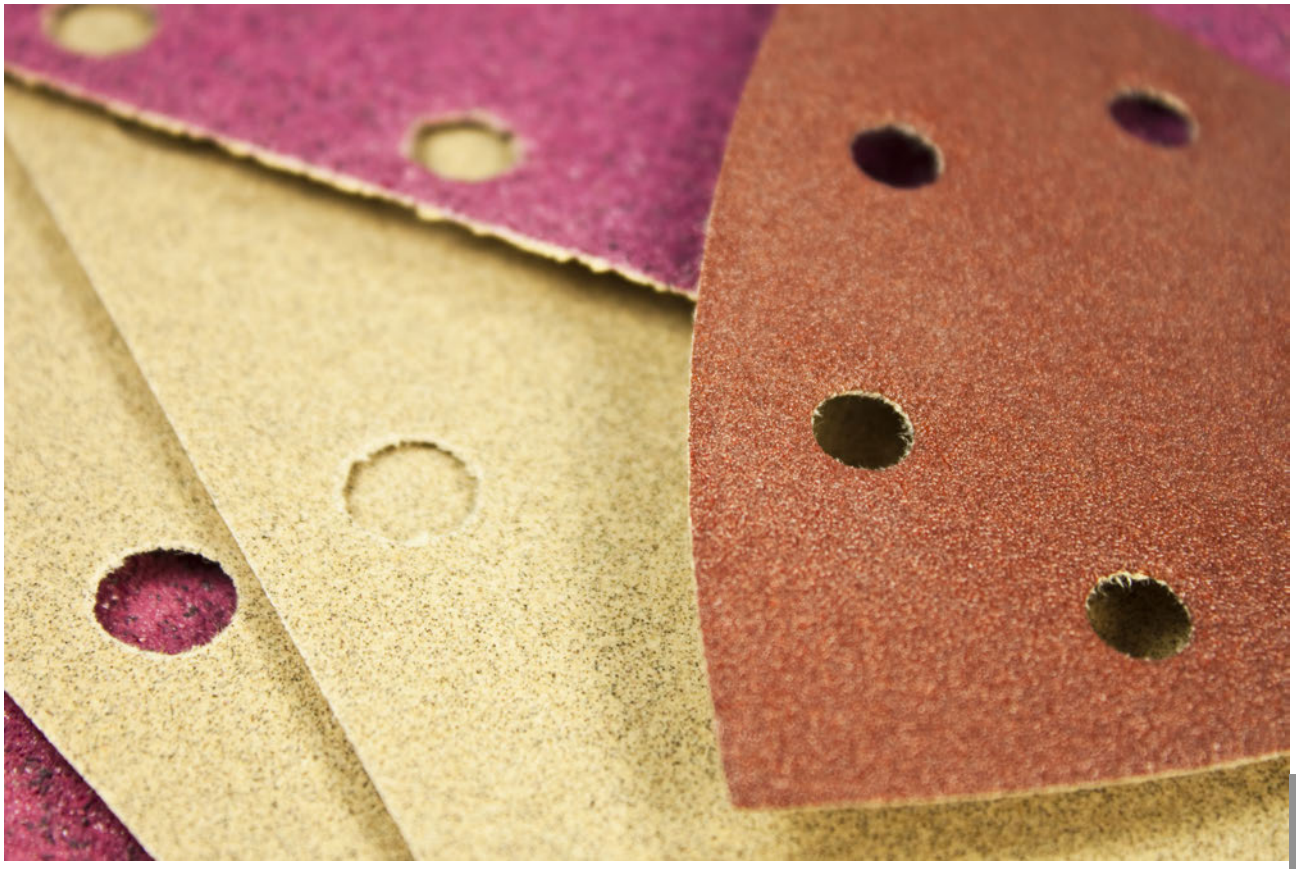
mApplication Abrasives

Basis weight measurement for abrasives or: How do I produce high-quality sandpaper?



Quality made in Germany

TEXTILE
NONWOVEN
COATING & CONVERTING
PAPER
EXTRUSION

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COATED ABRASIVES

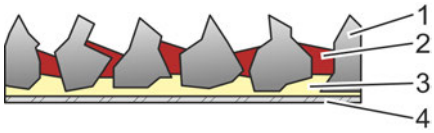
Whether professional or private individual, abrasives are used everywhere.

The commonly used term “sandpaper” means technically correct: *‘Coated’* abrasives, has undergone considerable optimisation and specialisation for a wide range of applications thanks to constant innovative progress. Sand has not been used already for a long time and, in addition to paper, many other backing materials are used.

From grinding to size and shape to creating a specific surface roughness, fine grinding or polishing, coated abrasives must have suitable properties for the application in question.

How are abrasives constructed?

Layers of abrasives



Layer structure of abrasives

Abrasives are built up in layers. Each of these layers has a specific function, which must be fulfilled exactly in order to guarantee the correct function of the abrasive. A famous quotation is especially true here: *‘The whole is more than the sum of its parts.’*

1 **Abrasive grain**
The abrasive grain itself must always face upwards with its tip and be applied in the correct density, as this determines the grain size of the abrasive. The quantity must be exact, otherwise the grain and product imprint will not match. In the worst case, this means rejects.

2 **Cover bond**
The cover bond anchors the abrasive grains to each other. Too little coating reduces the lateral support of the abrasive grains. The degree of grinding decreases, wear increases. A cover bond in different colours can also be used to distinguish between different product series.

3 **Basic bond**
The basic bond anchors the abrasive grain to the base. Too little of it and the abrasive grain does not hold properly. Too much of it and the abrasive grain sits too deep in the basic bond. This means that less of it can be used and the costs for the basic bond become too high.

4 **Backing**
The backing serves as a carrier. It must be stiff and resistant enough to ensure a long service life. At the same time, a high degree of flexibility is required in order to be able to use the abrasive paper universally. This is ensured by multiple impregnation and coating. These processes must be closely controlled.

What are the challenges in the production of abrasives?

The challenge

Best quality at the lowest cost

Decisive for the quality are the material of the abrasive grain, the properties of the backing and the composition of the binder, which connects the abrasive grain with the backing. Very important in this context is to adhere as precisely as possible to the compositions, thicknesses and weights of the individual layers during production. This is the only way to optimize the degree of grinding, wear and service life. The control of the correct composition of the layers is the most important task.

Correct thickness and basis weight of the individual layers of the abrasive are essential conditions for the function of the product.

Basic requirements

The customer attached particular importance to the following points in the application example:

- Quality control and regulation in the production of the carrier fabric
- Quality control and regulation of coatings in abrasive production
- Several measuring frames and sensors per line with central operation
- High accuracy, operational safety and reliability of the measuring system
- High protection of the measurement technology against abrasive dust / pressurized encapsulation
- Connection to master computer and OPC interface
- Sequential adjustment of recipe settings for product and roll changes
- Comprehensive services

The solution

Layer thickness measurement with Mahlo's Qualiscan QMS, the traversing quality control system for web products

The Qualiscan QMS can be used in virtually every area of industry in which products are produced as a web, or where they are finished (e.g. coated). The versatile sensors and measuring devices of the Qualiscan QMS series can sense, log and continuously control (in-process) such parameters as basis weight, coating weight, moisture or thickness in a variety of web-type products.

Qualiscan QMS-12

What are the challenges in the production of abrasives?

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Selected equipment of the plants

For the measuring and control tasks, a Qualiscan QMS quality control system with different measuring frames and sensors is used at the individual production steps.

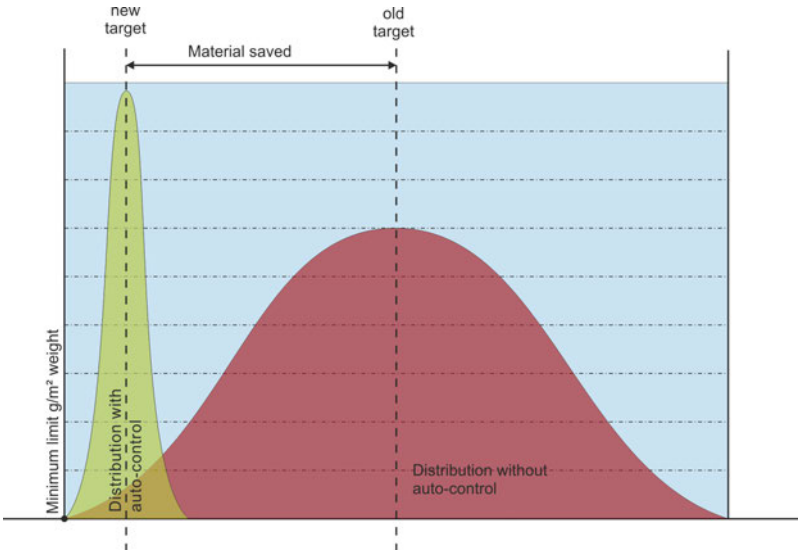
- Fabric finishing
  - Qualiscan QMS with 3 measuring frames with beta beam sensors for basis weight measurement
- Grain application
  - Qualiscan QMS with 3 - 4 measuring frames with beta beam sensors for basis weight measurement
- Cover bond
  - Qualiscan QMS with 2 measuring frames with beta beam sensors for basis weight measurement

Customer benefits

- Correct application quantities and uniformity of the layers in longitudinal and transverse direction
- Compliance with the required technical specifications of the abrasive
- Avoidance of cost-intensive deficient production and consequential costs
- Optimization of the use of raw materials and energy; production at lower cost

Material saving, quality assurance, production increase

The automatic basic weight control significantly reduces the spread of the basis weight and thereby ensure a more consistent end product. Suitable defined setpoints with minimum tolerance ranges save material and energy costs to a significant degree, in addition to safeguarding product quality. In addition, process reliability and production throughput increase.



What does Mahlo's quality control system do?

Qualiscan QMS

A modular system for measuring, logging and controlling critical process parameters over the entire process including basis weight, coating weight, moisture, layer thickness etc.

Customer benefits

- ✓ *Savings in raw materials and improved economy of production process*
- ✓ *Uninterrupted monitoring and logging of actual product quality*
- ✓ *Improvement in product quality, especially in conjunction with control function*
- ✓ *Very short amortization times for high profit potential*
- ✓ *Less rejects and material loss when changing products*

Control of basis weight and moisture on a Spunlace-Nonwoven system (courtesy of Selcuk Iplik Sanayi ve Ticaret A.S.)

Principle of operation

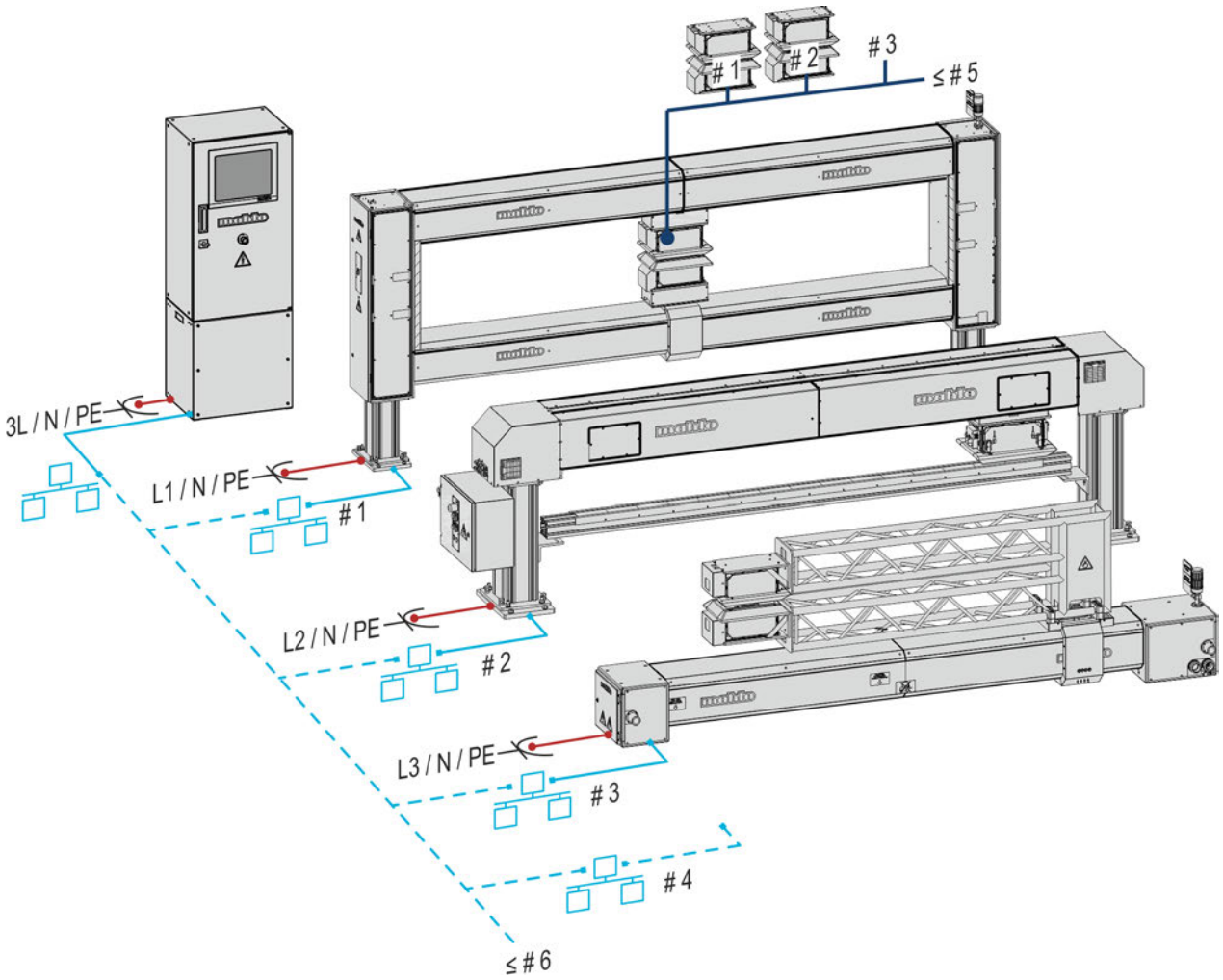
Basis weight control with the production of screen reinforcements from glass fibres and nonwovens (courtesy of Kirson Industrial Reinforcements GmbH)

Qualiscan QMS is a modular designed measuring and control system for process parameters of web-type products. Different measuring sensors (also called modules) measure the desired parameters either stationary or traversing across the entire working width. For this purpose, the sensors are installed in scanners (also called traversing frames or scanners). Depending on the scanner version, up to five sensors can be installed simultaneously.

The measured values are generated directly in the real-time processors of the sensors and scanners. The completed measuring data is transmitted to the central PC in the base via network lines. The latter handles the control of the scanners, visualization via touchscreen, logging of the data, recipes and (if desired) communication with host systems.

What does Mahlo's quality control system do?

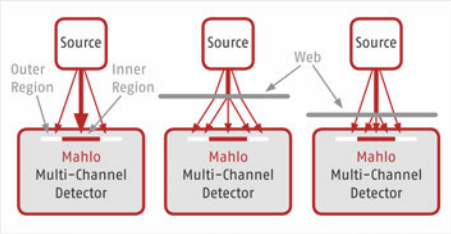
System architecture



The network structure allows for the easy expansion of the system. The individual components are connected via standard Ethernet network lines. Both the basis and scanners can be connected to the regular line supply. A wide range of special voltage is available as option.

What does Mahlo's quality control system do?

Grammage measurement



Measuring principle of the Gravimat DFI sensors

In this application example, beta-beam sensors from the Gravimat DFI sensor series were used to measure the coating quantity

The basis weight monitoring and control system measures the weight continuously, without contact, destruction-free and on moving product. The measurement is based on the attenuation of rays from a radioactive isotope through the substrate located in the measuring gap. This attenuation in intensity is an indication of the basis weight of the product.

Flutter allowed

The Mahlo DFI (Dynamic Flutter Independent) beta sensor uses a revolutionary new sensor technology with the following features: complete insensitivity to web flutter over the entire measuring gap, smallest beta radiation sources with highest measuring performance, highest scanning speeds for detection of smallest web defects and permanently error-free and cost-effective operation under the toughest conditions.

Measuring frame Webpro M

Webpro M: carries up to 3 sensors and spans up to 4 m.

Where space permits, the robust Webpro-M measuring frames were used. These were particularly necessary when it came to protection against the abrasive dust. The Webpro M can be encapsulated by overpressure. This prevents the entry of dust and dirt. The aggressive abrasive dust has no chance - this is guaranteed by exact measured values and a long life of the measuring frame.

The traversing frames of the Webpro M type are used for diverse applications in various industries. They are especially marked by their rugged and reliable design. Traversing frames of this type can be used for product widths up to max. 4 meters and can accommodate up to 3 Mahlo sensors. The compact design and use of precision linear guides permit installation even in restricted spaces and with widely different angles of inclination.

Measuring frame Webpro S

Webpro S: compact, robust, can be equipped with two sensors.

Sometimes there was just no room. Then the extremely compact Webpro S measuring frame was used. It still finds room even in the smallest gap.

The traversing frames of the Webpro S type were designed with the objective of providing an extremely compact but still rugged and reliable traversing platform for applications in which space conditions do not permit use of a conventional O-frame. The scanner manages a nominal width of max. 4 meters and can carry up to 2 sensors. The main area of application is fast-running coating machines, where their compact design usually leaves little space for the integration of conventional scanners.

Host computer interface

All data measured by Mahlo is transferred via an interface to the customer's host computer system. There they are used and logged for control purposes.

The host computer interface enables external applications to communicate with the Mahlo system. The data of the Mahlo system are used by a higher level host computer in the customer network for production control and automation.

Communication between host computer and the Mahlo system takes place using a specific communication protocol.

The following interfaces are available:

- Ethernet / IP
- Profibus
- Profinet
- Modbus TCP (separate instructions)
- OPC (separate instructions)

The respective interface of the used bus network is provided by Mahlo.

Host computer interface components:

- Network connection
  - to connect the host computer to the Mahlo system.
- Interface software
  - to configure the communication between host computer and Mahlo system. Runs in the background on the Mahlo system.

The host computer interface cannot be operated with the Mahlo control and display station. Operation and further processing takes place application-specific in the higher level host computer system.

APPLICATION EXAMPLE

The industry

Abrasives manufacturer

The example presented is a typical application in the industry of manufacturers of coated abrasives. The company selected here is one of the oldest abrasives manufacturers in Europe with subsidiaries all over the world. In addition, it is one of the few producers to manufacture both abrasive grain and abrasive backing.

Products

The portfolio includes over 1,000 grinding products for metal, wood and other materials.

These include self-sharpening abrasives made of ceramic grain or zircon corundum as well as abrasives made of aluminium oxide, silicon carbide and fleece.

At the end of the basic production process, the abrasives are produced in the form of rolls of abrasive sheets. These are assembled into abrasive belts, grinding wheels, rolls and sheets.

Customers

The company produces primarily for the industry, skilled trades and commerce. Worldwide distribution takes place via specialist dealers or directly to industrial end customers.

Why did they choose Mahlo?

Reasons to choose Mahlo

In the example presented here, the company decided to replace existing measurement technology from another supplier with new Mahlo systems. This was carried out on all 3 production lines: fabric finishing for the backing material, abrasive grain coating and top layer coating.

High reliability - good service

The abrasives manufacturer decided in favour of Mahlo because it already used Mahlo products elsewhere and was thus familiar with the proven high reliability and operational safety of the systems. The machines of the abrasive manufacturer run in full operation, the downtime must be kept as short as possible. Another clear change was Mahlo's more comprehensive, reliable and faster service compared to other vendors.

Reliability of a family business

Further points were the long-lasting quality and long service life of the devices as well as the fast availability of spare parts. In addition, the intensive and expert advice of the Mahlo experts on site at the customer's site was appreciated. Last but not least, the abrasives manufacturer was convinced by the safety of the third-generation family business, which produces its equipment exclusively at its headquarters in Bavaria.

Simply made in Germany ...

ABRASIVES PRODUCTION

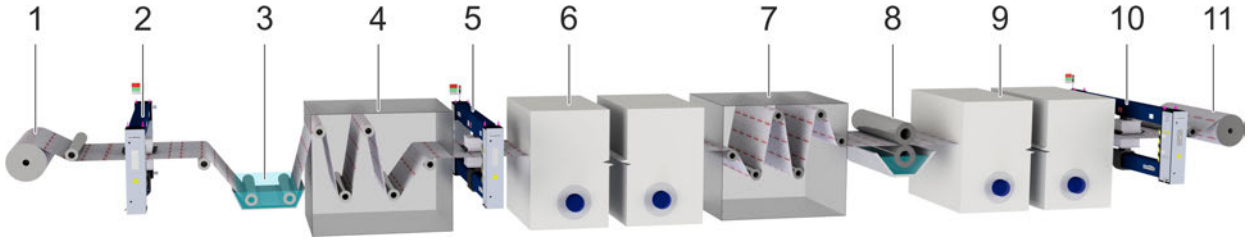
Coated abrasives

Abrasive production takes place in several steps. The aim is to manufacture a product with the best possible durability and the lowest possible material consumption.

- **Manufacturing abrasive backing**
  This is a separate process which precedes the production of the abrasives. It takes place in an upstream production line. This is where **basis weight measurement from Mahlo** comes into play for the first time.
- **Abrasive grain application**
  This is where the actual production of the abrasive begins.
  - **Stamping reverse side**
    Application of grain and running direction of the reverse side of the backing material for identification of the end product
  - **Base coat**
    Coating the backing material with basic binder. **Mahlo basis weight measurement** ensures the correct amount of binder.
  - **Grain application**
    The abrasive grains are applied to the substrate in one or two stages. **Mahlo's measurement** monitors and controls the process.
  - **Drying**
    A drying process fixes the base coat and grain application
- **Cover coat**
  In a further production step, the grain layer is coated with top binder. Again, a **Mahlo measurement** ensures the correct process.
- **Drying**
  Drying and slow curing of the finished fabric webs
- **Coiling**
  For further processing, the webs are rolled up on spools

Manufacturing abrasive backing

Fabric finishing



Production plant for abrasive backing with basis weight measurements at the important points (schematic sketch).

1 Unwinding
2 Basis weight measurement M1
3 Foulard (impregnation)
4 Stretch unit
5 Basis weight measurement M2
6 Dryer (stenter frame)
7 Stretch unit
8 Padding (coating)
9 Dryer (stenter frame)
10 Basis weight measurement M3
11 Winding

In the first production line, the backing for the abrasive is produced. The backing material for industrial, high-quality abrasives must withstand high mechanical stresses. In addition, high tensile strength and other technical properties are required, such as sufficient strength of the strip edge, good grain adhesion, low elongation or water and oil resistance.

In this application, a polyester fabric serves as the basis for the backing material. This is prepared in the fabric finishing line in such a way that it serves as a stable basis for grain application. For this purpose it is impregnated and coated and passes through several dryers and stretching plants in order to achieve the desired stiffness and dimensional stability. Paper, foil, cotton or mixed fabric backings are also common.

Uniform coating is essential

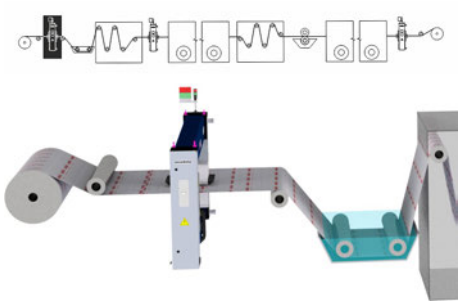
In order to achieve the desired function, it is important to apply the coating precisely metered and uniformly. This is achieved with basis weight measurements from Mahlo. The process control system used is a Qualiscan QMS system with measuring frames, each of which is equipped with beta sensors for basis weight measurement. Since the product does not exceed a weight of 1000 g/m², krypton emitters can be used at all measuring points. Due to their high resolution, these enable very accurate measurement results in the lower weight range.

Differential measurements

To obtain the basis weight of the respective layer, the value of the previous measuring point is subtracted from the measured value, e.g. M3 - M2 = basis weight at measuring point 3.

Manufacturing abrasive backing

Basic weight of backing material - measuring point M1



Measuring point M1: the initial weight of the abrasive backing is measured.

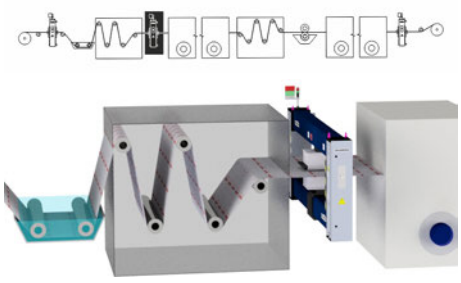
Sensor	Gravimat DFI (Krypton 85)
Scanner	WebPro M

The basis weight of the carrier material is determined directly after unwinding. This is the basis for determining the exact thicknesses and weights of the subsequent coatings in the further process.

Accurate measurement of the starting material

This value serves as the basis for all further measurements. This measurement must be correspondingly accurate, otherwise consequential errors will creep in.

Wet impregnation - measuring point M2



Measuring point M2: the weight of the wet impregnation is determined.

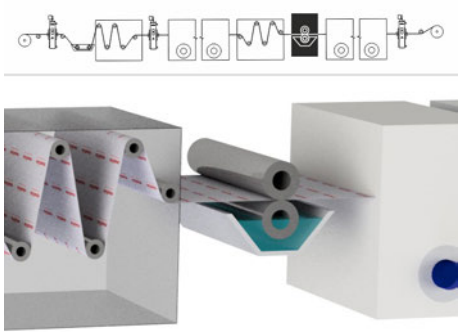
Sensor	Gravimat DFI (Krypton 85)
Scanner	WebPro M

After the first measurement, the product passes through a Foulard and is impregnated / dyed wet. In the subsequent stretching plant, the fabric is stretched in order to increase the dimensional stability for subsequent drying.
Before the dryer, the basis weight of the backing material is measured with wet impregnation.

Measurement of wet impregnation

Here it is checked whether the correct amount of impregnation has remained in the backing material. A measurement directly after the order immediately reveals any process deviations. This allows the operating personnel to react immediately.

Coating in padding



The abrasive backing is coated with a squeegee or padding (here: padding).

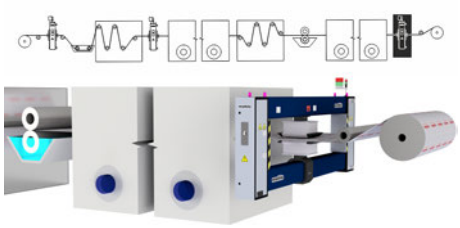
After the second basis weight measurement, the product passes through a stenter frame. Here the impregnated backing material is dried and fixed. After drying, an additional stretching unit follows, which further increases the dimensional stability.

The following coating is applied over a padding roller.

Coatings for various applications

Depending on the application, the backing material is coated at the bottom (padding) or / and at the top (squeegee). There are also more complex plants that have several impregnations and coatings connected in series. The backing material must be prepared differently for different grain layers and applications. This can be done in such plants in one operation.

Coating dry - measuring point M3



Measuring point M3: the final measurement on the finished product.

Sensor	Gravimat DFI (Krypton 85)
Scanner	WebPro M

After the web has passed the coating, it passes through a dryer. This is followed by the last measurement: with impregnation and coating. The backing material is now finished. The edges are still cut, it is rolled up and ready is the abrasive backing.

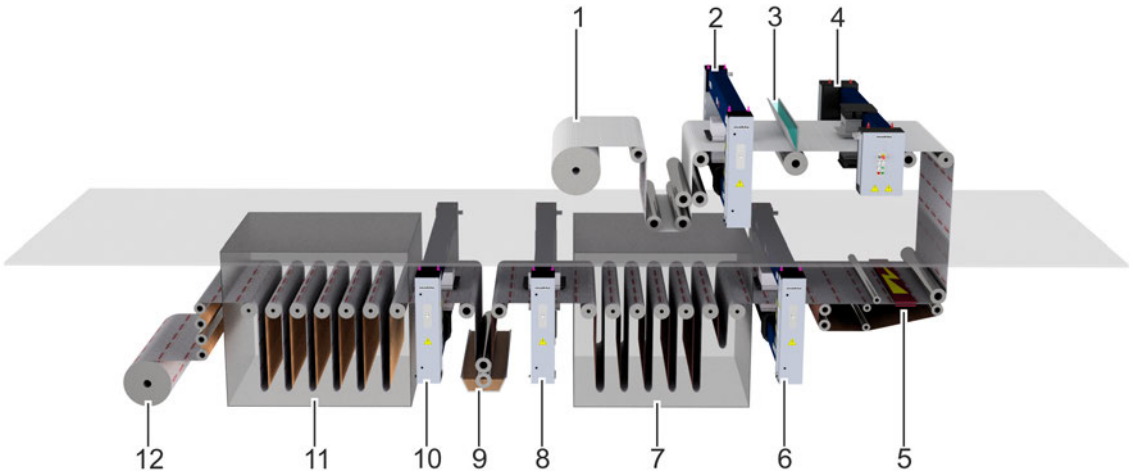
Measurement of the dried coating

The evaporated water reduces the weight of the impregnation after drying. This gives the exact dry weight of the coating without the water content.

The 3 measurements result in the exact weights of the individual components

- ✓ *M1: Backing material*
- ✓ *M2: Impregnation*
- ✓ *M3: Coating*

Abrasive grain application



Production lines for grain application on abrasives often extend over several floors and building parts (schematic sketch).

1 Unwinding
2 Basis weight measurement M1
3 Basic binder (coating with squeegee)
4 Basis weight measurement M2
5 Grain scattering
6 Basis weight measurement M3
7 Drying basic binder
8 Basis weight measurement M4
9 Cover coat (padding)
10 Basis weight measurement M5
11 Drying cover coat
12 Winding

In the production line for grain application, the production of the actual abrasive begins. The base coat, grain and cover coat are applied.

Two Qualiscan QMS systems are used here for process control. Both systems are equipped with several Webpro M and S measuring frames and Gravimat DFI basis weight sensors with krypton or strontium emitters. The measured values are transferred via an OPC interface to a higher-level host computer system, which controls the production line.

When applying the grain, it is important that the measuring frames can be flushed with air. The aggressive dust particles of the grain scattering would otherwise damage the measurement technology. The pressurised encapsulation prevents the entry of foreign material.

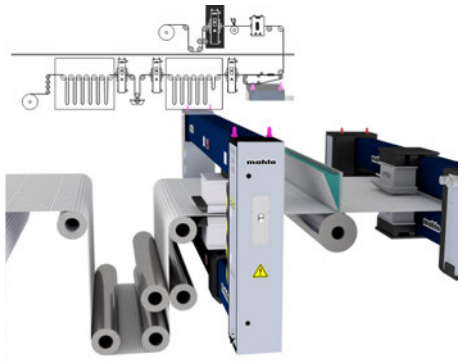
Stamping reverse side

Important information can be found on the back of sandpaper.

Information about the end product is printed on the reverse side of the backing material. These are e.g. the grain, arrows for the later grinding direction, brand names or similar.

Base coat

Basic weight of backing material - measuring point M1



Measuring point M1: first measurement of the abrasive backing.

Sensor	Gravimat DFI (Krypton 85)
Scanner	WebPro M

A stable polyester fabric with a hard consistency serves as the starting material for the grain application. The backing was prepared in the fabric finish suitably.

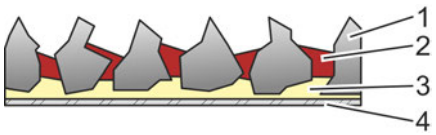
The first basis weight measurement takes place directly after the fabric infeed. The weight of the backing material is measured for a constructive differential measurement of carrier, basic bond, grain layer and cover bond. Both WebPro M and S are suitable as measuring frames.

The space conditions for the installation and the ambient conditions (e.g. dusty atmosphere during grain application) are decisive. The Gravimat DFI with Krypton 85 is used as the sensor, since the measuring range is below 1000 g/m². In this weight range, krypton offers a higher resolution and thus a more accurate measurement result than strontium.

Accurate measurement of the starting material

This value serves as the basis for all further measurements. This measurement must be correspondingly accurate, otherwise consequential errors will creep in.

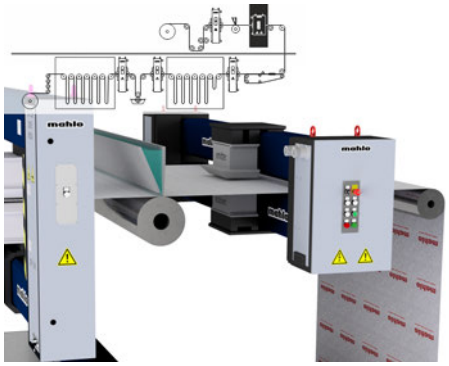
Basic bond



Layer structure of abrasives

1 Abrasive grain
2 Cover bond
3 **Basic bond**:
The basic bond anchors the abrasive grain to the backing. Too little of it and the abrasive grain does not hold properly. Too much of it and the abrasive grain sits too deep in the basic bond. This means that less of it can be used and the costs for the basic binding become too high.
4 Document

Basic bond - Measuring point M2



Measuring point M2: the weight of the basic binder is determined.

Sensor	Gravimat DFI (Krypton 85)
Scanner	WebPro S

The second measuring point is located behind the application unit. A one-sided resin coating is applied to the fabric using a squeegee. Depending on the intended use of the abrasive, different resins are used. The binders are usually based on resins of phenol, urea, epoxy or melamine. The abrasive grain later adheres to the basic bond.

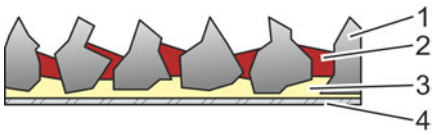
A fabric with resin is thus measured. The value of the first measurement is subtracted from the value of this measurement. This produces the basis weight of the resin layer. Krypton-85 is also used as the sensor, as the fabric is still relatively thin. A WebPro-S measuring frame is used due to the installation situation with restricted space.

Measurement of the resin base coat

The basic bond anchors the abrasive grain to the backing and thus forms the basis for the function of the abrasive. A coating that is too thin also leads to loss of functionality, increased costs or even rejects, as does a coating that is too thick.

Grain scattering

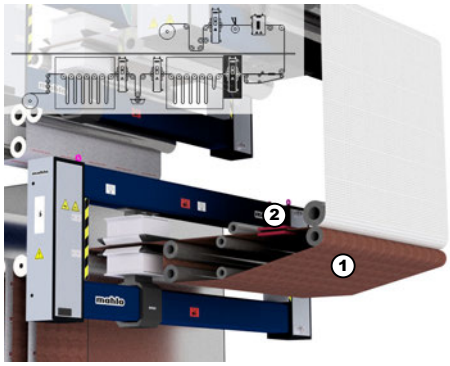
Abrasive grain



Layer structure of abrasives

1 **Abrasive grain**:
The abrasive grain itself must always face upwards with its tip and be applied in the correct density, as this determines the grain size of the abrasive. The quantity must be exact, otherwise the grain size and product imprint will not match. In the worst case, this means rejects.
2 Cover bond
3 Basic bond
4 Document

Grain scattering - measuring point M3



Measuring point M3: the basis weight of grain scattering is measured.

Sensor	Gravimat DFI (strontium 90)
Scanner	WebPro M

1 Conveyor belt with grain scattering
2 Device of static charging

The fabric consisting of fabric and resin runs over a suction roller for grain scattering. The grain layer is applied here.

The abrasive base runs above a conveyor belt ① on which the grains are transported. The backing material is statically charged ② and attracts the grains that adhere to the base binder. The electrostatic process ensures that all grains are aligned with the tip pointing upwards. The method can also be used to precisely control the uniform particle size distribution and the type of spreading (open or dense spreading).

Measurement of grain layer

Grain application by means of static charging gives the goods their central product properties. Distribution and quantity of dispersion are immensely important and must be closely controlled. A measurement directly after the order immediately reveals any process deviations. This allows the operating personnel to react immediately.

The 3 measurements result in the exact weights of the individual components

- ✓ *M1: Backing material*
- ✓ *M2: Basic bond wet*
- ✓ *M3: Grain application*

Depending on the desired properties, different grain types are used. Common materials are corundum, zircon corundum, ceramic corundum or silicon carbide. The grains differ in characteristics such as grain hardness, toughness, self-sharpening and service life. Some abrasive manufacturers also produce the abrasive grains themselves.

The grain application is a very dusty matter, the measuring frame must therefore offer particularly good dust protection. An air-purged measuring frame is used here. Due to the overpressure in the measuring frame, no particles can penetrate from the outside. The same technology is also used, for example, for measuring frames in potentially explosive atmospheres.

Cover coat

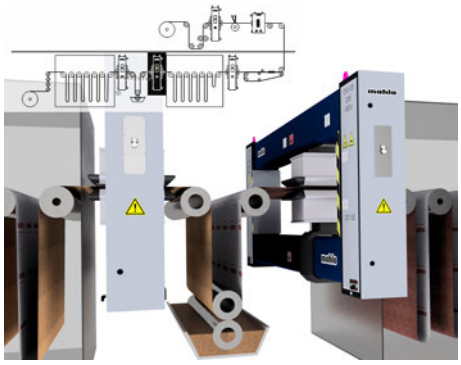
After grain scattering, the web runs into the drying process. Here the basic binder is dried so that the grains are firmly bonded to the backing material. The drying lines are long and the drying process takes quite a while.

Although the measuring frames could still be connected to the previous QMS base, the top coat is a new, separated operation after the long drying time. A connection with the previous regulation would not make sense. Therefore, the following measuring points were covered with a new, separate Qualiscan QMS system.

Basic bond dry - measuring point M4

Sensor	Gravimat DFI (strontium 90)
Scanner	WebPro M

After drying, the basis weight is determined again and it is assessed whether the abrasive grain has been applied correctly. Due to the high basis weight, strontium 90 is measured here.

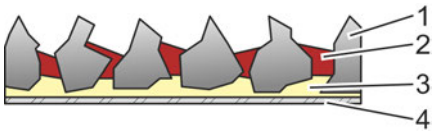


Measuring point M4: Measurement of basic bond with finished grain.

Measurement of dry grain layer

The dry basic bond is measured. Here you have the final value of backing + basic bond + grain. This value serves as the basis for regulating the cover coat.

Cover bond

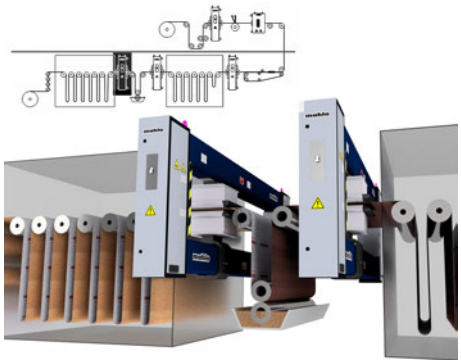


Layer structure of abrasives

1 Abrasive grain
2 **Cover bond**
The cover bond anchors the abrasive grains to each other. Too little coating reduces the lateral support of the abrasive grains. The degree of grinding decreases, wear increases. A cover bond in different colours can also be used to distinguish between different product series.
3 Basic bond
4 Document

The cover coat follows directly after the drying process, but is also often outsourced to another, independent production line. The basis weight of the starting material (grain layer with dried basic bond) was determined at the last measuring point.

Wet cover coat - measuring point M5



Measuring point M5: the weight of the wet cover bond is measured.

Sensor	Gravimat DFI (strontium 90)
Scanner	WebPro M

The measuring point is located behind the application unit. A one-sided resin coating is applied to the fabric using application rollers. The top coat binder serves to hold and bond the abrasive grains together. By adding colour, the product also receives the desired colour codes.

The value of the previous measuring point is subtracted from the result to determine the absolute basis weight of the cover bond.

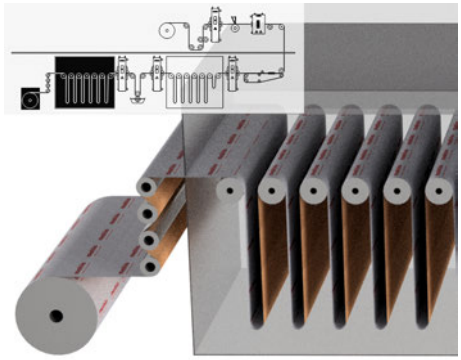
Measurement of the resin cover coat

The cover bond anchors the abrasive grains to each other. Too little coating reduces the lateral support of the abrasive grains. The degree of grinding decreases, wear increases. A coating that is too thick drives up the cost of the cover bond.

The 2 measurements result in the exact weights of the individual components

- ✓ *M4: Basic bond dry (backing + basic bond + grain)*
- ✓ *M5: Cover bond wet*

Drying, harden, winding



For further processing, the abrasive paper is rolled onto large rolls.

The product with cover coat is now dried, cured and rolled up. The raw material is ready for sale or for further processing into the end product.

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11/2019 Subject to revision!