Process and Material Assured Compound Production

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Besides instruction and control of the process, quality-assured mixing requires also a specification and tracing of the applied raw materials. These requirements apply to both, master batch and final batch and can be realized entirely with today's computer and software systems developed for the control of batch processing.

The production process is completely documented with the help of process and guidance values. The use of materials can be verified in two ways:
- Starting with the raw material, each path from arrival to the final batch is traceable.
- Starting with the final batch, every used raw material is traceable.

Material and data flow in mixing

In order to follow the mentioned requirements, first, the procedure of the mixing needs to be documented. This includes information about the material flow within the mixing facility, where raw materials are weighed and added to the compound. Subsequently, an image of the material flow is shown on the system in the form of a flow pattern-related visualization.
Production process control will be saved as a working plan in the system and controlled during the production of the compound. The specification of the material flow origins in the recipe components and their equivalent storage or process places. Monitoring is done at so-called I-points (identification points) where material movements can be noted and controlled. Fig. 1 shows a sample of a mixing plant with one mixer. The facility consists of a silo installation for carbon blacks, fillers and the conveyer system for oils. Pre-weighed chemicals are partially controlled at a weight-aligned sum control scale.
Also, conveyer scales for weighing elastomers or master batches are sometimes used for this (manually or by using a rubber sheet feeder). Furthermore, the mixing facility consists of the mixer, an open mill and the batch-off with a wig-wag system to deposit the sheet on pallets.

At the relevant raw material input or transfer points (I-points) identification systems are installed, ensuring an exact tracing of the material and transport device flow. Labelling of the arriving raw material batch, the PE bags, mixing samples, and the mixed rubber sheets is usually done by labels with a clear text and a barcode print. Labelling of the pallets, the transport and circulatory containers can be done with both, barcode labels and electronic transponders.

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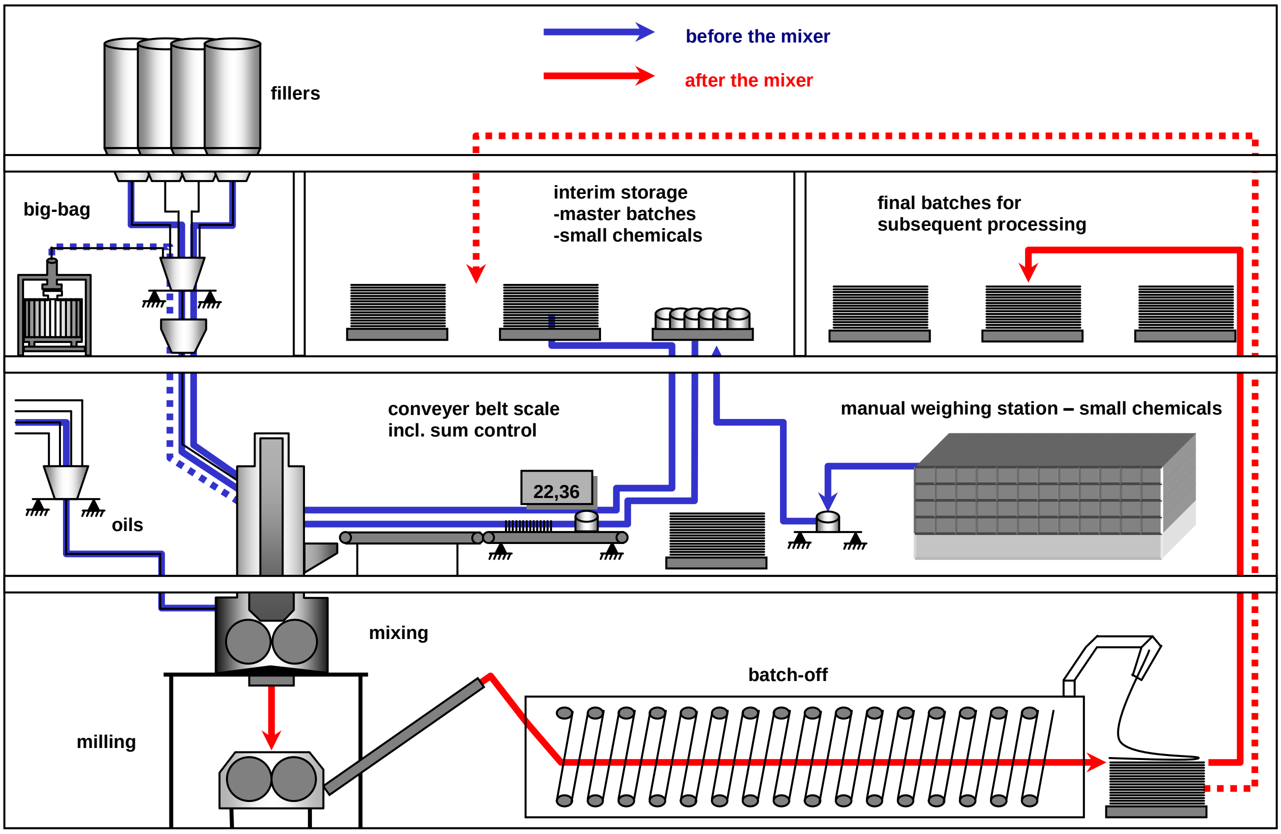

fig. 1: sample of a mixing facility, material flow within the mixing facility

Storage, feeding and weighing systems

The storage and feeding of raw materials and chemicals can be divided into closed and open systems. Major components, such as carbon blacks and white fillers are generally stored in closed silos, providing fixed supply pipes to the scales of the mixing facilities.
So-called small chemicals are manually weighed quite often. With simple weighing stations, the raw material is taken directly from the delivery packaging. Modern sites are equipped with a major number of containers with lockable filling and removal doors. A fixed allocation of raw material and container is made. In the past years, facilities were developed, providing raw materials being automatically transported via screw conveyors, weighed and filled into custom-labeled PE bags. In order to avoid material losses during transport, the bags are automatically heat-sealed at the end.

Relating to the procedures, different requirements are being made to the material and data flow depending on the installed facility.

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a) Silo installation

With silo installations only the filling procedure of the supplied materials needs to be controlled. By using barcodes all relevant data is taken from the delivery papers. The assigned silo saved in the system opens respectively controls the given conveying path from the filling station to the relevant silo. The material entry with its characteristic data is saved in the system.

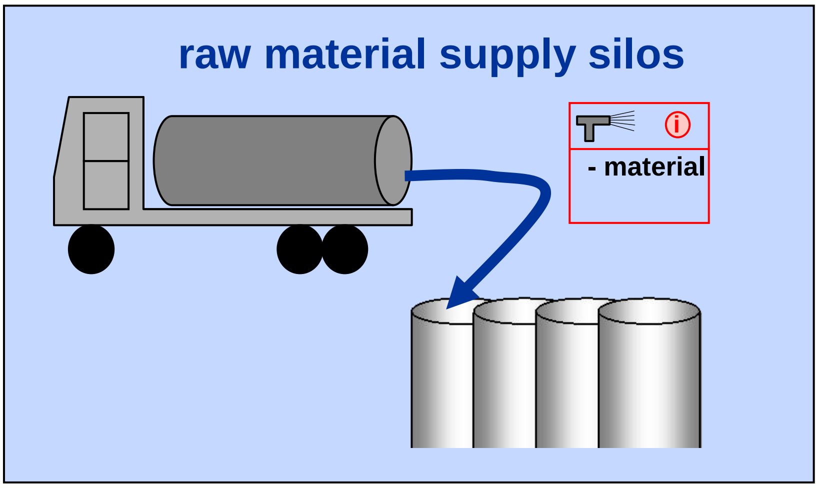

fig. 2: raw material supply

Material and data flow:

I. Filling procedure:
- Identification of the delivered material: supplier, quantity, lot number, expiry date
- Release circuit between filling station and the corresponding silo
- Controlled silo filling with storage of raw material data, date and test date

II. Material requirement during mixing:
- Release circuit of the conveying path from silo to the automatic scale
- Feeding and dosing
- Automatic weighing
- Filling into the intermediate bin of the mixer (if existing)
- Release into the mixer

b) Big-bag, flow bin, plasticiser plants

Just like with silo installations, these facilities need to control and save the allocation of the raw material to the parts-removal or linking station. After connecting the big-bag or the flow bin the conveying path up to the mixer is self-contained, avoiding any material mix-up.
Here also, just like with the silo installations, barcode scanning systems are used to monitor the linking and/or the filling procedure with plasticizers.

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Material and data flow:

I. Filling procedure:
- Identification of the delivered material: supplier, quantity, lot number, expiry date
- Provision of big-bag/flow-bin with saving the raw material data, date and test date
- Insertion of suction spout respectively connection of flow-bin
- Confirmation of the suction spout position respectively of the flow-bin station

II. Material requirement during mixing:
- Release circuit of the conveying path from big-bag station to automatic scale
- Process continues as under a) II.

c) <u>Storage of small chemicals in bins</u>

With these facilities the following control and documentary procedures of the material flow need to be followed.

1. Control of the filling procedure of the small chemical containers.
2. Assignment and filling of the weighed chemicals to boxes, buckets or bags (with the latest technology it is possible to heat-seal and label these bags with barcodes).
3. Control of the weighed chemical before feeding into the mixture (reading device at the conveyer scale or at the infeed-belt).

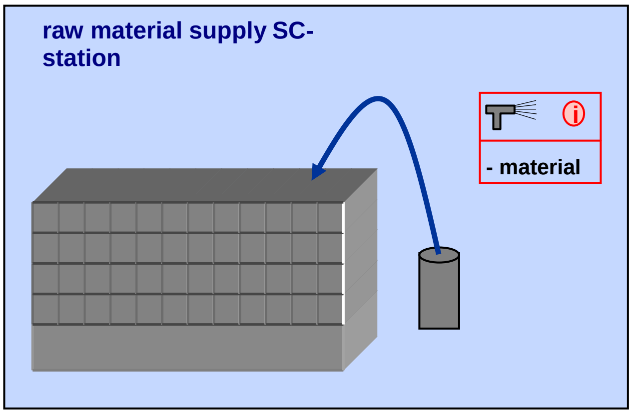

fig. 3: filling small chemical bin

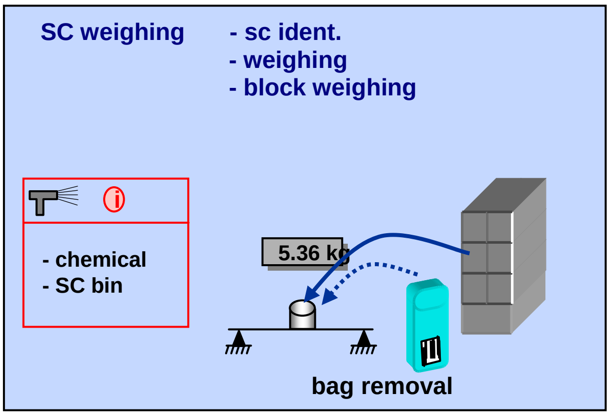

fig. 4: small chemical weighing

Filling control is done with a barcode-scanner, recognizing the supplied packaging and only opens or unlocks the charging door of that one relevant container of the small chemical site (fig. 3). When removing material, only that container door opens with the correct material inside. Just like with the filling, an interlocking system prevents opening of several doors at once.

If the material is filled into solid containers such as buckets or crates after weighing, an identification of these containers is done before (either by barcode or inductive transponders). Here, a unique marking of the container is sufficient (e.g. numeric). Allocation of the materials to the specific container is done during the weighing procedure and remains in the system until the content of this container is emptied into the mixer. Now the material data is allocated to the mixing lot. The empty container returns for reuse. If the chemicals are filled into PE bags, they can either be placed into labeled containers (buckets, crates) or labeled with modern printers and afterwards heat-sealed. Lately, printable labels made of low-melting polyethylene are used.

Generally, small chemicals are temporarily stored after weighing. Afterwards, the small chemicals, stored on pallets or in crates are allocated at the mixer platform. For this, the computer system produces an allocation report, which can be printed or displayed on a monitor in the intermediate storage room.

Material and data flow:

I. Filling of small chemical container:
- Identification of the delivered material: supplier, quantity, lot number, expiry date
- Release circuit to open the relevant charging door
- Filling of the small chemical container, saving raw material data, date and test date

II. Processing procedure:
- Release circuit to open the removal door/flap of the small chemical containers
- Removal of the chemical from the container (manually or automatically)
- Weighing (manually or automatically)
- Display on pallets
- Intermediate storage
- Allocation at the mixer platform
- Charging the mixer with a prior control (bag and total weight)

d) <u>Small chemical withdrawal directly from the suppliers packaging</u>

This type of weighing can often be found and the material is directly placed at the weighing station in its transport container. The procedure of material supply is computer-aided, as the demand is identified and listed depending on the order and the job position.
The raw material is identified by the operator prior to the weighing (fig. 4). In case of a conformity with the recipe, the weighing process can be started.

Material and data flow:

I. Accept material
- Recognition of supplied material by transfer of material code, lot number, test date

II. Handling procedure
- Release circuit „start weighing procedure“
- Manual removal of the material from the delivery packaging
- Manual weighing with saving and allocation of the data (quantity, lot number, bag or container number)

The process continues as described under c).

e) Weighing at the conveyer belt scale before the mixer

In general, weighing processes at the belt scale are done manually (elastomer, pre mixes), so that the procedure corresponds to the weighing process of small chemicals as described under pos. d) (fig. 4, 5). If a rubber sheet feeder exists, pre-mixes can be added and weighed automatically. All subsequent procedures are defined by the mixer control program. Feeding into the mixer is done automatically via the feeding belt. The emptied belt scale is available immediately for the weighing procedures of the next batch.

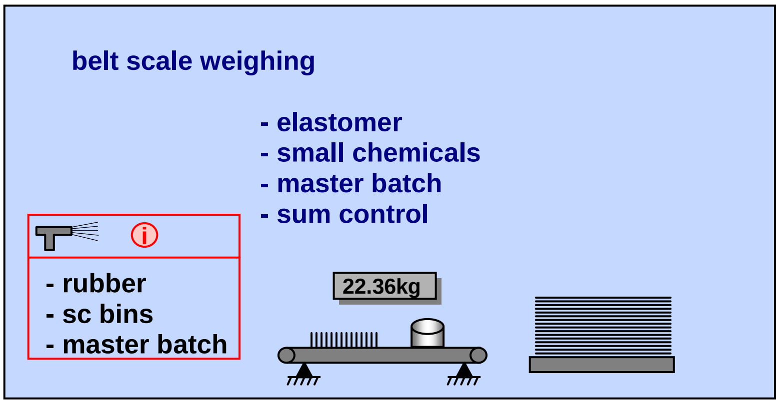

fig. 5: weighing procedures at the conveyer belt and sum control scale

Material and data flow:

I. Accept material:
- Recognition of the material that needs to be weighed (pre-mixes, elastomers)
- Recognition of the small chemical materials

II. Handling procedure:
- Release circuit „start weighing procedure“
- Manual or automatic weighing (rubber cutter, rubber sheet feeder)
- Sum control weighing of small chemicals
- Automatic allocation by the computer system of the data to the mixed lot, at the same time also documentation of the entry sequence

Mixing process

Prior to the compound production the mixer is supplied with process-related requirements in the form of step programs with step-forward criteria or – as possible in controlled operation – pre-settings in the form of master curves. At the same time, material pre-settings are transmitted according to the recipe and container pre-settings on the basis of previous procedure steps (i. e., small chemicals filled in bags). The sequence of feeding the materials into the mixer is determined by a procedure programme related to the recipe. Prior to the mixer input, all materials are identified by an identification system at the feeding belt of the mixer and allocated to the running mixing lot. To avoid any material loss, a sum control weighing of the small chemicals can be executed at the belt scale or any separate scale, depending on the weights.
During the mixing process, ongoing measures and calculations are taking place to control and document the mixing sequence. The recording rate of the values can be determined by the operator. Likewise, the parameters for controlling the process, links (and/or-links) and other mathematic functions can also be determined by the operator. In addition to the measured values, incident parameter and material data are saved for the exact documentation of the process [1].

After the procedure within the mixer, the compound is emptied into the open mill. Here, the compound cools down and a post-homogenisation is taking place. If further chemicals are meant to be added, they need to be controlled with a barcode-scanner, similar to the procedure at the belt scale before the mixer. The material data is automatically allocated to the batch by the computer system. All measured values are collected and saved for the documentation of the process, similar to the procedure at the mixer [2].

After the mixing procedure the sample piece for the laboratory tests is cut. The sample piece can be labelled with a bar code label. Here, a bar code writing device needs to be installed, printing a label containing the characteristic compound data (order, recipe, lot number). With adhesive compounds, the sample can be placed into a PE bag, which can then be labelled. The information on the label guarantees a definite identification of the compound in the laboratory and can be taken to generate the according test plan.
With some mixing facilities an online test of the compound is carried out at a rheometer installed next to the mill. Transfer of the characteristic measured values to the computer system serve as a first compound evaluation. These measured values are saved lot-related in the computer system in addition to all other arising process values.

After the mill (or the roller-die-extruder) the compound reaches the batch-off-facility for cooling down. Via a wig-wag installation the sheets are placed onto a pallet or into a iron-barred box. The compound scale determines the discarded amount. The printer, integrated in the system, prints out a compound data sheet, providing all relevant data of the compound, incl. the weight (clear text and bar code). The produced compound quantities are booked by the computer system and – if requested – transferred to a superior host system.

Master batches first reach an interim storage. Prior to the input into the mixer to produce the final compounds, they are identified by the compound data sheet and their usability is checked. Afterwards, the compound is produced and all data is allocated to the lots of the final compound.

Final batches, leaving the mixing room for further handling or despatch, are transferred via an exit-I-point, where a final examination is taking place before final approval. Despatch can be executed if allowed by a saved release note in the system. Furthermore, a coordination with the transport documentation can be done with regard to accuracy and completeness of the consignment.

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Possible interferences with the raw material backtracking

Interferences with the allocation of the raw material lot number are possible due to the facility construction and compound production:

Flow-cone and remaining quantities in major silos and small chemical container (fig. 6)
- Commingling of fluids filled into the container
- With multi-layer compounds, when returning batches and pre-mixtures into the mixing process.
- When discarding the compound onto pallets or into iron-barred boxes, as a result of splicing the sheets between open mills and batch off.

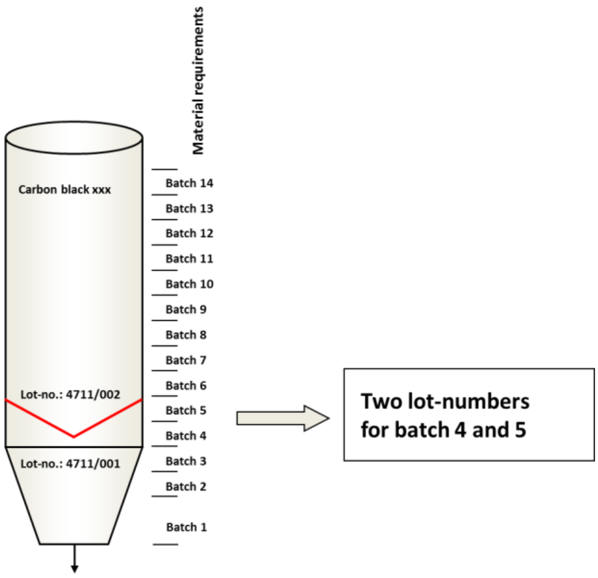

fig. 6: flow-cone in a silo

Interferences with the remaining quantities can be defined by the quantitative withdrawal and allocation of lot numbers following the principle first in – first out. This is provided by running two lot numbers. Plasticisers and oils are handled in the same way.

With multi-layer compounds it is always possible to dissolve again into the pre-mixes, again providing a definite allocation to the used raw materials.

Interferences when discarding the compound behind the batch-off cannot be totally avoided, as the material flow after the mixer transfers from a discontinuous lot production to a continuous process (splicing between open mills and batch-off).
Afterwards the sheets are placed on the pallet. Here, an exact allocation to the compound lot cannot be guaranteed, as the cutting is directed by the weight. Here, in general, containment with regard to the discarded compound batches is also possible.

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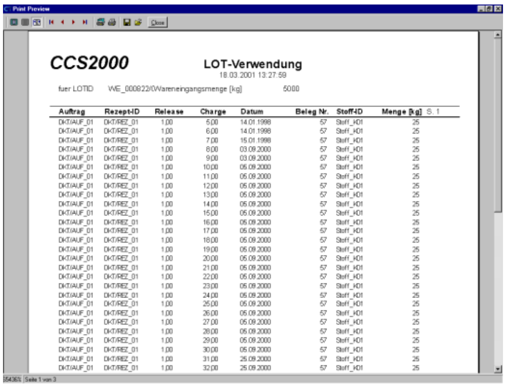
Different identification systems

As described, various identification systems can be used depending on the operation purpose. Generally, bar-code systems are used for the labelling of single-use containers, such as sacks, bags, or rubber bales. Circulatory containers, boxes, crates or pallets can be marked with both, bar-code or with other code carriers. For reading inductive code carriers the code carrier (chip) needs to be positioned approx. 20 cm away from the reading device in order to ensure a precise data recognition – which can be difficult to realise in some areas of the production process. Therefore, today in rubber production mostly bar-code reading and printing systems are used. For feeding procedures wireless scanners are well-proven. Wired scanners are often found at work places with a limited working radius.

Protocol and analysis

The two following analysis are serving as examples for the documentation of a raw material backtracking.
The protocol „lot-usage“ shows the disposition of a raw material with a certain lot number. On input of the relevant data (raw material name or code, lot number) an automatic search is started within the data base of the computer system resulting in the chart in fig. 7.


Print Preview

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LOT-Verwendung
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fuer LOTID WE_000822/0Wareneingangsmenge [kg] 5000

Auftrag	Rezept-ID	Release	Charge	Datum	Beleg Nr.	Stoff-ID	Menge [kg] S. 1
DKT/AUF_01	DKT/REZ_01	1,00	5,00	14.01.1998	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	6,00	14.01.1998	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	7,00	15.01.1998	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	8,00	03.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	9,00	03.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	10,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	11,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	12,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	13,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	14,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	15,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	16,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	17,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	18,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	19,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	20,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	21,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	22,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	23,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	24,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	25,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	26,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	27,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	28,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	29,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	30,00	05.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	31,00	25.09.2000	57	Stoff_K01	25
DKT/AUF_01	DKT/REZ_01	1,00	32,00	25.09.2000	57	Stoff_K01	25

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Fig. 7: order protocol with lot no. prove

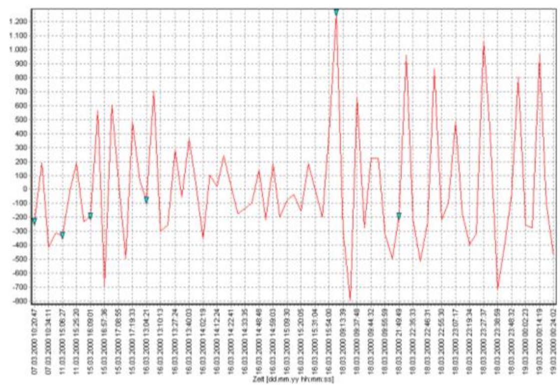

Fig. 8: diagram lot number exchange

Fig. 8 demonstrates the graphic recording of the weighing data of an automatic scale transporting and weighing the same raw material over a certain period of time. The markings show the transfer to the following lot number. Optionally, the lot number itself, the date of exchange or the order exchange can be displayed.

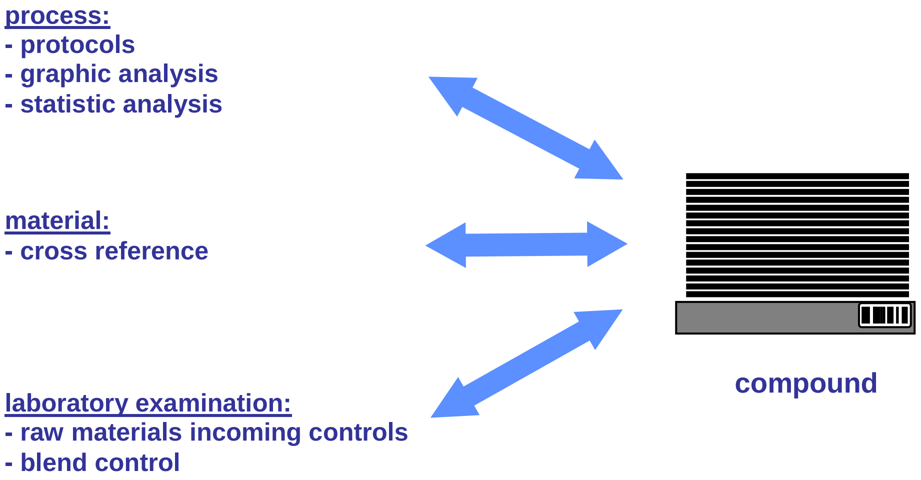

Fig. 9 complete QS documentation

Summary

Aim of a quality secured mixing production is a secured process and raw material guidance. All production procedures and the used materials are recorded and documented during the production process. Powerful databases provide a fast and selective evaluation of the quality-determining parameters, which can be displayed in protocol or graphic forms.

By using serial interfaces to the testing laboratory, production and material data are completed with the results of the compound test (fig. 9).

This ensures a process and material assured compound production resulting in mixtures only within the quality requirements are fed into the following production processes.

References:

[1] E.P. Jourdain, Computer Control of Internal Mixers for more Consistent EPDM Compounds. KGK Kautschuk Gummi Kunststoffe 51. Jahrgang, Nr. 2/98, Seiten 129 – 133.

[2] W. May, R. Dittel, J. Tessner, Ein Konzept zur qualitätssicheren Herstellung von Gummimischungen aus der Sicht der Datenverarbeitung. KGK Kautschuk Gummi Kunststoffe 48. Jahrgang, Nr. 7-8/95, Seiten 534 – 538.

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