White Paper

Optimally Adjusting Filling Processes

How Checkweighers Increase Profit

Contents

METTLER TOLEDO

1 Actively Develop Solutions

Value creation demands integrated solutions. Global competition, the variety of technological development, and short product life cycles are among the driving forces behind changes that make continuous optimization of the production environment essential. Quality that contributes to value creation only comes into being when every part of the production process is tuned to every other, allowing them to mesh seamlessly together.

Companies need partners who can think for them. For company managers and those responsible for production, this means that their own production depends significantly on others' solutions. It is the skillful solutions developed by partners that contribute in large measure to the development of one's own solutions, ensuring survival in the market.

Dynamic weight control of products must be integrated into the manufacturing process. Again and again it can be seen that far too little attention is paid to checkweighing as part of the manufacturing process. Companies that employ it appropriately – with the entire production process in mind – and so consciously avoid weak links in the overall production chain, can make an additional contribution to their own value creation.

2 Checkweighers – Critical Control Levers in the Production Process

Within complex production processes, some of which comprise many hundred production steps, it is always possible that one small step does not receive the necessary attention. This can have a negative effect on the overall result.

Quality assurance within manufacturing processes is becoming more and more important. The importance of modern checkweighers is growing rapidly. Checkweighers, through their ability to weigh 100% of products even within a rapidly operating, round-the-clock production process, make an important contribution to successful production. The days are long gone in which the only purpose of a checkweigher was to determine the weight deviation of a product. On the contrary, a checkweighing program matched to the production process now has a comprehensive protection and safety function – and therefore huge commercial significance.

Modern checkweighers perform a wide range of tasks. Added-value programs such as the statistics programs are capable of employing statistical evaluations of their measurements in order to control filling systems in such a way that production automatically remains within very tight tolerances. In this way, the optimum utilization of product and resources is achieved and secured in a systematic weighing process. Expensive reworking resulting from incorrect filling, or even recall actions that damage a brand's reputation, can now be avoided through a checkweighing program implemented in the production site.

Effective production site programs for checkweighing also secure:

- The compliance with official regulations (e.g. national and international food safety laws – FDA/FSMA, GFSI)
- The observance of industrial standards (e.g. national ISO 9001, international ISO 2200, GMP, HACCP)
- The observance of codes of conduct (e.g. trade organizations such as FDA, BRC, IFS)
- The provision of customer benefits (e.g. avoiding recall actions, encouragement of trust, due diligence etc.)

3 Sources of Error and Stumbling Blocks That Matter

Only a checkweighing system that satisfies the demands of modern production lines is able to contribute to cost reduction and optimizing product quality. Companies often only have the observance of statutory regulations and standards in mind when they purchase a checkweigher. However, there is a wide range of other important aspects that can be overlooked all too easily. Not infrequently these have a significant influence on the design and configuration of the new checkweigher, and as a result the design can have a critical impact on the user's survival against global competition.

3.1 Production risks and chances

It is by no means certain that a production process that runs without interruption is working optimally and economically. Only production processes that are able to operate within closely specified tolerances can fully utilize their expensive resources. Even very small savings can often lead to cost reductions that are crucial to survival against global competition.

Recall actions or halted production are the nightmare of every production manager. If you can only take random samples, there is always a risk that the production process will have to be halted for correction, or, in the worst case, that product must be recalled from suppliers or from the marketplace. The consequences range from changes to the production timetable and unexpected additional costs, right up to cancelled contracts and a damaged reputation.

The world of modern production needs predictive checking systems. Ideally the active feedback control built into the checkweigher is used to control filling processes. Thanks to continuous analysis of the measured weights, it is able to automatically adjust the filling head of a filling installation, resulting in comprehensive regulation along the production chain. The efficient production not only yields optimized levels of manufactured goods, but also minimizes the cost of the control process.

3.2 Rules and regulations

A major feature of global trade is the expanding range of specifications and statutory regulations that must be observed in the manufacture of products. The enormous pressure to produce quickly and to overcome the competition demands systems that are flexible and reliable. One of the requirements of modern checkweighing systems is that their operators can quickly make the specified adjustments, and can change them when needed. It is also necessary to prepare and archive documentation relating to the tests for Weights and Measures authorities and for other administrative offices. In addition to its reliability, a checkweighing system must be simple and secure in operation, particularly bearing in mind that it will have different operators.

3.3 The consumer and brand quality

Often the little things are the most annoying – and this also applies to filling processes. Products that are short on content have already done lasting damage to consumer attitudes to more than a few manufacturers and brands. The loss of a commercial relationship can affect the company just as badly as the loss of brand image that stops new customer contacts. Companies must here emphasize the need for a degree of care that has precisely the opposite effect to what has just been described: that is to say an optimization of product quality from the end consumer's point of view, generated through reliability that characterizes the brand quality. Consumer protection, and the protection of the company's market reputation and its customer relationships, are the result.

3.4 The product quality

Checkweighing has a crucial role to play in the control of quality and methods – provided it covers 100% of production. Every product manufactured must be weighed. Integrated checkweighing systems are now capable of doing this. They document the entire production, monitoring it in real-time, so that accurate control of the amount of product dispensed by filling installations is therefore possible at any time.

But the checkweigher can do more than just weigh. It is increasingly becoming the central point of quality assurance, as a result of the option of interlinking with other testing procedures. By connecting sensors, scanners or identification systems, barcodes can be applied, for instance, or products with missing or incorrectly positioned parts can be rejected. With just one central user interface for all the components employed, quality assurance gets a significant boost. Multilingual operator guidance not only reduces costs, but also saves valuable personnel resources.

4 Checkweighers That Are as Accurate as You Need

Programs must satisfy clear criteria. The analysis of practical operation can clearly demonstrate that quite specific factors are responsible for the success of a production site's checkweighing program. These include the unchanging accuracy of the checkweigher, the ability to make necessary adjustments quickly and easily when the produced items change, and the reliable rejection of products that do not meet specification.

Accuracy pays! When purchasing a new checkweigher system it is therefore crucial to bring the requirements of the particular application into a proper relationship with these factors. Greater precision of measurement can, for instance, initially entail a higher investment cost; fewer instances of under or overfilling, savings in rework or minimization of product wastage, can over time lead to a reduction in costs and in a long term consideration of profitability can justify the initially high investment. This always demands comprehensive knowledge of the particular application. In the tug-of-war between costs and benefits, it is necessary to discover the right compromise for the required precision of the checkweigher.

5 Checkweighers in Filling Processes

Anyone who invests wants to be sure that the capital used will pay out. That is also true when evaluating and purchasing a checkweigher system. Reliability, efficiency and the proper design are the key parameters. Very often, only the observation of specifications and statutory regulations receives full attention, since failure here can result in sanctions. But there is a whole range of important aspects that can have a significant effect on reducing costs and increasing product quality. These should also be included in the purchase calculation.

5.1 Avoid commercial damage

Only if 100% of the products coming off the production line can be weighed, the company can be certain that they are good enough for market requirements and up to modern production standards. It also avoids infringing the wide range of standards and regulations applying to both national and international trade. An effective checkweigher program therefore automatically supports the good name of a product brand or a company. Faulty products that get into the distribution system and reach the end customer have already put an end to a few business relationships.

Accuracy is also a question of costs. Checkweighers that operate within a quality assurance process are capable of working within very close tolerance bands. As a result, numbers of incorrect rejections and cases of wrong sorting are reduced! On the one hand this improves the quality of the manufacturing process, on the other hand it reduces product wastage and the need for rework - a point that clearly weighs on the side of cost reduction. A vital argument in favor of a checkweigher system is feedback control for filling heads. Intelligent weighing technology provides predictive monitoring of the filling heads in the filling installation. Accurate control adjustments then ensure that overfilling or underfilling are avoided. Feedback control ensures seamless regulation that can lead to enormous savings (cf. Page 6 / calculation example).

5.2 Maintain an overview

The requirements of a company and its manufacturing processes are the measure for an effective checkweighing program. This requires clear operating targets to be set for the flow of production, knowledge of the metrological regulations to be observed, as well as an understanding of how limit values are specified. Measuring 100% of the products provides information about the availability of an item of equipment as well as about its performance and quality. It affects the total effectiveness of the plant, and therefore is an important control lever for profitability.

Your operating requirements also provide the measure for the selection of the right supplier. A serious supplier will always want to know about the particularities of your operation. Ideally, the supplier's experience is reflected in a wide range

of products, from the entry-level model for use in a stable environment through to high-performance systems for tough production conditions – every solution calls for clearly defined pre-sales and after-sales advice along with comprehensive service. And the rule here, as in ordinary life, is that bargain prices call for caution!

6 Every Gram Counts, in Particular for Filling Processes

Precision makes itself very noticeable, above all in modern, high-performance filling installations. Every bit of product wastage – caused through overfilling, for example – can turn into an expensive waste of resources when large quantities are being produced in multi-shift operations.

The basic rule is that the greater the precision, the smaller is the loss of product. The consistency of the product is the result of two considerations: one is the checkweigher, and the other is the filling machine. It is only if a highly accurate checkweigher is used in combination with optimum control and filling precision in the filling machine that the process can be guaranteed not to waste resources.

Note: Checkweighers are subject to environmental influences (e.g. air temperature), the packaging or the application itself, and these can lead to variations in weight. A changed fill weight can, however, always be traced back to the filling installation that controls the filling. Reasons for these variations can be found in changes in the environment or in the properties of the product, but malfunctions in the equipment itself can also often be the cause.

6.1 The overfilling/underfilling problem

Checkweighing involves both specifications and mathematics. Legal regulations require filling companies to ensure that the mean weight of a defined production quantity is equal to or larger than the weight quoted on the packaging. Individual products must also not weigh significantly more or less than stated on the packaging. There are a number of influences that can affect the checkweigher and the filling installation, regularly leading to deviations in the fill quantity. It is therefore necessary to take account of these deviations in the control process, i.e. in the equipment controller. If they are random, and occur with the same probability, these deviations follow the standard deviation pattern. This corresponds to a mathematically defined normal distribution, and can be calculated exactly.

Definition: The standard deviation is a measure of the way values are spread around a mean value in a normally distributed series of observations.

If the standard deviation is very small, all the weights are in fact very close to the target weight. If, however, it is large, underfilling or overfilling to a degree that cannot be tolerated will occur, ending in rejected product.

If the waste of resources caused by overfilling in the production process is to be restricted, and if the number of items that have to be rejected because their weight is wrong is to be reduced, it is necessary to achieve a reduction in the standard deviation of the filling machine.

Note: What you can do to reduce the standard deviation of your filling machine:

- ☑ Use a filling machine that is appropriate for your product.
- ☑ Make sure your filling machine is in optimum condition.
- ☑ Make sure that there is a steady flow of product to your filling machine.

The calculation example below shows how small variations in weight can give rise to large effects.

What's a gram worth?
If the overfilling of product packages is reduced by 1 gram per pack through the application of 100% weight control, or by replacing an existing and less accurate checkweigher by a more accurate and more capable weighing solution, remarkable savings can be made. A simple example for a product that is worth just 0.1 cents per gram is shown below.

Packing and production	Saving resulting from 1 g waste reduction per pack
Nominal product weight = 450 g	0.1 cent saving per pack
Material costs = 0.1 cent per gram	20 cent saving per minute
Throughput = 200 packs/minute	Over $13.00 saving per hour
Production line utilisation = 65 %	Over $136.00 saving per day
Working shift = 8 hours	Over $31,303.00 annual saving
Shifts per day = 2	
Production days per year = 230	

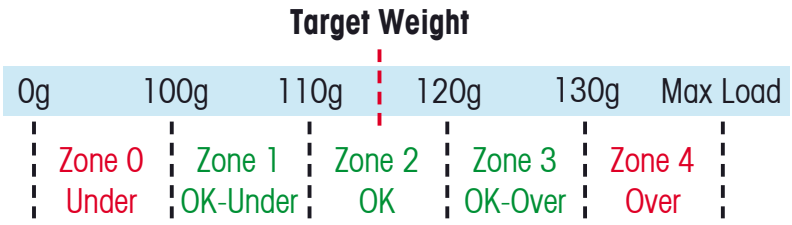
In addition to which there are 60,000 further product packs (with the associated profit) that could have been produced from the material saved.

7 Limit Values Are The Pointers on The Checkweigher for Quality and Productivity

"What it says on the package must be what is inside." This, in simple terms, is what the law says about content weight i.e. fill quantity of packages. There are, of course, tolerances and limit values that are clearly defined in the relevant regulations. Companies must implement this consumer protection, which is, at the same time, a mark of quality.
For any given product setup there are upper and lower weight limits, defined as the tolerance limits on what each individual product must contain. These tolerance limits, which are also known as classification limits in the context of checkweighers, are preset in the checkweigher for when particular specifications are to be followed. They can also be individually adjusted by each operator.

The classification limits define the range of weights which, when the product is weighed, will be considered "good", meaning the item will remain in the production process. Modern checkweighers normally have 3 or 5 or even 7 weight zones for classifying the products weighed.

For example: tolerance limits on a checkweigher with 5 weight zones:



Products that fall within the outer two zones are rejected, as their weight is no longer acceptable.

Note: Checkweighers are normally preset: The programming already takes into account the permitted variations in the weight in accordance with the OIML guidelines, NIST manual or local packaging regulations. The statutory tolerance limits are thus shown automatically.

7.1 Adjustment is everything

The process of adjusting the tolerance limits is oriented around the precision of the checkweigher and the variations in weight that are acceptable for the particular product. Practical experience shows that products tend to be wrongly classified when narrower tolerance bands are set. Improved measuring techniques can help in these cases. They have the effect of optimizing the process control of the filling, and therefore improve quality, since the filled weight of the products has less variation.

Step 1: The first step required to control the filling process is to define the nominal weight and the tolerances. In practice, the quantity dispensed by filling machines is a little bit higher than the weight indicated on the package. This usually ensures that the mean value of the weight dispensed by the overall production process is not below the indicated weight – the manufacturer is then "on the safe side".

Step 2: The legal regime applying in the particular region specifies the maximum permitted deviation from the nominal weight upwards and downwards. This is used in the second step to specify the tolerance bands. In Germany, for instance, it is the "Fertigpackungsverordnung" (FPVO / Finished Packaging Ordinance http://www.bundesrecht.juris.de/fertigpackv_1981/index.html) that specifies the maximum permitted deviation for various product categories.

In addition, the OIML guidelines (Organization International de Métrologie Légale) regulate the weight variations permissible in various countries. The "slight inaccuracies in weighing" caused by environmental influences, to which every checkweigher is subject, can be compensated for by specifying the tolerance in such a way that the limiting value for the "good" weight class is made "tighter" by the precision of the checkweigher.

7.2 Fine tuning thanks to the latest technology

The potential of modern checkweighers is far from being exhausted. They can do far more than merely weighing and indicating tolerance limits. Using special software and additional options they can contribute to improving production processes, and can increase productivity.

The documentation and recording of production processes, to provide evidence to government offices or to trading partners, is enormously important for modern production companies. Nowadays, software programs cannot only join together different checkweighers and control them, but also offer versatile options for documenting their results. Preset adjustments for different items can be stored, and country-specific versions can be recalled. Certification obligations can be satisfied easily and reliably. Modern data management software can even join different product inspection systems together such as metal detection, X-ray inspection, optical inspection and checkweighing systems from the same supplier.

The performance of the filling head is the crucial point for filling processes. So is the rule of thumb. Environmental effects and the condition of the filling installation contribute to unavoidable variations in the weight. In the worst case this ends in tolerance ranges being exceeded, to rejected product and to the machine being stopped – potentially a commercial disaster. Checkweigher systems with special software are capable of monitoring the performance of the filling head, and readjusting the filling machine in such a way that filling proceeds within the specified tolerances. By analyzing the changes in the weight distribution, they can detect the trends in filling the product, and can correct the filling behavior appropriately. This automatic "feedback control" supports optimum process control.

8 The Particular Application Determines the Control Method

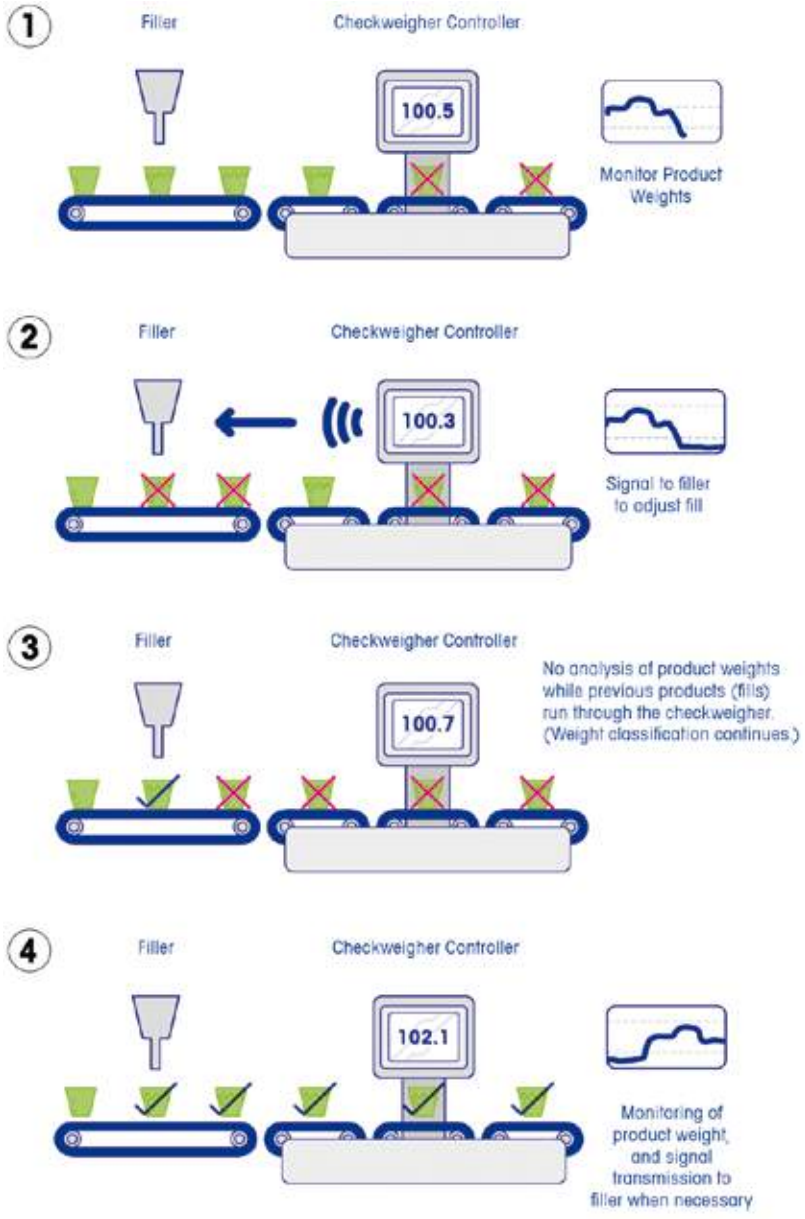
One effective way of optimizing filling processes is to maintain closer tolerance limits. This brings a reduction in scrap product and requires less rework, since the filled products should already be within the specified weight range. An accurately operating checkweigher with its control possibilities thus performs an important task.

Equipped with special programs for detecting weight trends, a checkweigher connected with the filling machine can react to such trends with a "correction process". Control systems that permit rapid and accurate fine-tuning of the filling head make this process possible.

8.1 The standard feedback control

The filling heads are automatically adjusted when necessary. The checkweigher directly controls the filling installation to which it is connected. A figure for the mean weight is continuously calculated in a continuous process. As soon as this varies from the set weight, a correction signal is sent to the filling installation, and this adjusts the filling quantity.

8.1.1 Feedback control in brief:



Step 1: The checkweigher detects a downwards deviation. If this trend continues, the deviation in the filling weight will increase, leading to underfilling.

Step 2: The checkweigher sends a signal to the filling system to regulate the fill level. A pause then follows, during which the checkweigher does not send any signal to the filling system.

Step 3: This pause corresponds to the time required for weighing the packages that were filled before the change in the fill weight was signalled.

Step 4: The downward trend in filling weight has been corrected automatically by the feedback control.

The greater the distance between the filling system and the checkweigher, the more incorrectly filled packages there will be between them. In the ideal case, the filling machine and the checkweigher are immediately next to one another, in order to permit the fastest possible reaction to changes in the fill weight.

Standard feedback control: Advantages at a glance:

- ☑ It optimizes filling processes and leads to a reduction in rejects.
- ☑ It results in less overfilling and underfilling.
- ☑ It generates cost savings, through lower unnecessary product wastage.
- ☑ It ensures that statutory specifications regarding the net package contents are observed.

If you would like more detailed information about feedback control visit:
www.mt.com/cw-app and request application note 04

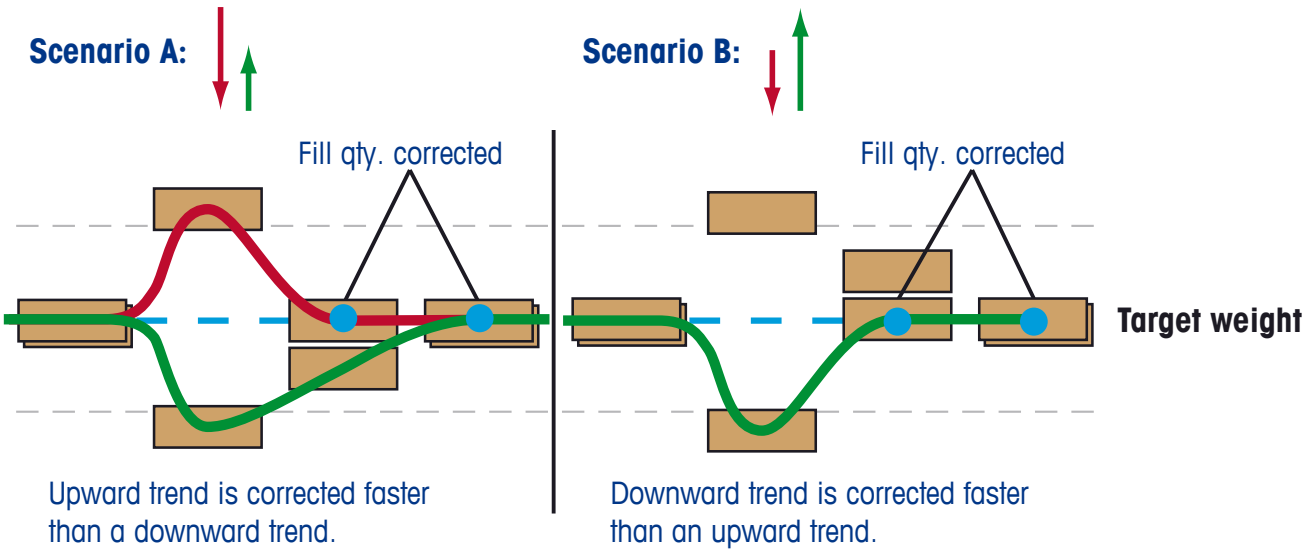
8.2 Extended feedback control

The best way to avoid errors is to see them coming and take the right measures to avoid them. This proactive approach becomes a reality with extended feedback control. The statistical interpretation of the weight distribution as the product is filled permits automatic adjustment of the filling head so quickly that products with the wrong weight and material wastage are reduced to a minimum.

The adjustment is even more accurate than it is with standard feedback control. Thanks to more refined control algorithms the approximation between the target weight of the feedback control and the nominal weight is even closer, therefore reducing both underfilling and overfilling more quickly and more effectively. In addition, the behavior of the control system can be adjusted in such a way as to be more closely in tune with the particular product and its properties.

In scenario A "overfilling" is corrected significantly more quickly than "underfilling". In this case, emphasis is placed on the fastest possible reduction of *over*filling – with the aim of reducing rejects. This model would be suitable when product that is rejected through being underfilled is not lost, but can be reused or returned to the process.

In scenario B "underfilling" is corrected significantly more quickly than "overfilling". In this case the emphasis is placed on the fastest possible reduction of *under*filling. This model is appropriate when product that has been rejected once as a result of underfilling cannot be reused, as would for instance be the case when processing frozen food.



Extended feedback control: Advantages at a glance:

- ☑ It ensures a perfect match between the control behavior and filling process. As a result, product wastage is minimized.
- ☑ It is directly linked into the statistics program, and ensures continuous monitoring of the mean value from the production system as a whole.
- ☑ It causes the actual weight (product) to automatically come closer to the indicated weight.
- ☑ It makes it even easier to maintain statutory regulations regarding the net pack content.
- ☑ It does not require the fill level to be readjusted manually at the end of the production run.
- ☑ It contributes to extremely high, consistent product quality.

If you would like more detailed information about extended feedback control visit:
www.mt.com/cw-app and request application note 03

8.3 What can be done about environmentally triggered weight variations?

There are also solutions for creeping weight variations. It can sometimes happen that product properties change quite slowly as production continues. In the case, for instance, of paper tissue, the external temperature and humidity can cause variations in weight as they affect moisture content. Special software is needed if this change is to be taken into account by the checkweigher. This software for gliding limits (also referred to as mean value tracking) looks at the measured trends in both short-term and long-term mean values, and it deduces from them how the preset nominal weight value and the tolerance limits must be moved in order to compensate for this change.

If you would like more detailed information about gliding limits visit:
www.mt.com/cw-app and request application note 05

9 Future-oriented – It is the Integrated Process That Matters

A continuous improvement in manufacturing processes is indispensable for survival against global competition. It is becoming increasingly important to simplify process steps and to combine them. Against the background of rising staff costs and foreseeable shortage of skilled workers, it becomes important to organize more functions through a workstation.

Modern checkweigher systems can be combined with a large number of further inspection options, that can communicate through one user interface that allows the parameters to be adjusted together. Multi-language systems make instruction and operation easy. They lower both costs and failure rates. The work required to maintain and clean combination systems is relatively low in comparison with multiple pieces of separate equipment. In this way, modern checkweigher systems are increasingly turning into a central control point.

9.1 What you should do

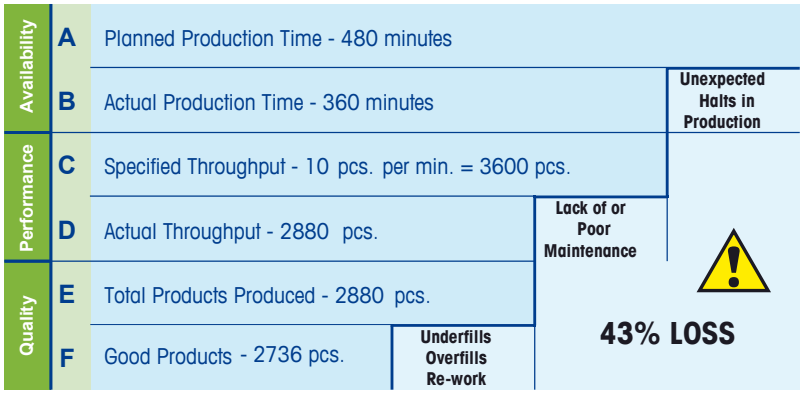
Nowadays checkweighers are a crucial instrument for profitable filling. They weigh, provide statistics, and automatically control other systems. This functions only as well, of course, as the rest of the elements involved. Only checkweighers that are regularly serviced can truly measure accurately, and even the best system will not function adequately without regular training of the operating staff. Powerful software programs that can carry out statistical analysis and feedback control are a hallmark of suppliers who continuously develop their systems further and update them. This demands expert knowledge together with experience over multiple industrial sectors and countries – suppliers who continually offer solutions, even after years, which not only meet statutory requirements but often even exceed them.

10 Tracking Solutions

Increasing market requirements, new statutory specifications and changes to the commercial environment demand both continuous performance and continuous performance increase.

It is critical here to make a comparison with previous production runs. The analyses and statistics from the checkweigher are of key significance to this task. Many companies make use of overall equipment effectiveness (OEE) as a yardstick of their efficiency. A factor is calculated on the basis of availability, performance and quality, providing a clear indication of performance on the production line. The OEE also therefore shows how well a solution works in the company. If the overall equipment effectiveness is greater than 85 %, your production line is world-class!

An example of an OEE calculation:



11 References

Further information, application examples and white papers relating to checkweighing can be found at:

www.mt.com/pi as well as

The Organization for Machine Automation and Control (OMAC) – www.omac.org

Organization International de Métrologie Légale (OIML) – www.oiml.org

Fertigpackungsverordnung (FPVO) – http://bundesrecht.juris.de/bundesrecht/fertigpackv_1981/gesamt.pdf

German Federal Institute of Physics and Technology (PTB) – www.ptb.de

EHEDG – www.ehedg.org

GFSI – www.mygfsi.com

FSMA – www.fda.gov

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The Product Inspection Division of METTLER TOLEDO is a leader in the field of automated inspection technology. Our solutions increase process efficiency for manufacturers while supporting compliance with industry standards and regulations. Our systems also deliver improved product quality which helps to protect the welfare of consumers and reputation of manufacturers.

Checkweighing

Metal Detection

Track & Trace

Vision Inspection

X-ray Inspection

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