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MACHINE VISION MAPS DYEING AND FINISHING DEFECTS – REDUCING SCRAP AND COST

Dyeing and finishing, being an end of the line process for a textile, traditionally bears a large proportion of the cost of faults. In order to minimise customer rejections and returns dyers and finishers are forced to suffer the high labour costs associated with detailed manual inspection. And manual inspection is not always a guaranteed solution to the problem.

The small size of the defects, which need to be detected, can only be seen by a human if the textile is travelling at a slow speed. This slow throughput of an individual inspector relative to production speed requires several inspectors working in parallel. With each batch being inspected by different people the inspection standard will vary from batch to batch. And with the inspectors attention waxing and waning throughout the shift inconsistencies will be found in individual batches.

The inconsistencies can be further aggravated by labour turnover that will add further variation to the outputs.

Utopia would be an inspector that never sleeps, applies consistent inspection criteria and does so at the production speed of the process. There are a number of vision systems on the market, some being capable of inspecting textiles. Of those that are capable of inspecting textiles, the majority can inspect either texture defects or colour, but not both texture defects and colour.

Computer vision systems are large and complex, typically involving multiple planes of cameras with several cameras on each plane and numerous lighting arrangements. The operation of such machines has, in the past, been an unwieldy task. Traditionally, the process of setting up such systems has been long and arduous with multiple sets of parameters needing to be set for each differing material, colour, customer or batch number.

The technologies available on the market today vary widely. Using the lower technically specified systems still requires a considerable amount of set up and manual interaction. At the higher end of technical sophistication the vision systems have self-learning and the ability to run and re-run webs or cloth in a simulated fashion thus reducing the need for manual interaction and set up times.

One of the high specification systems is the Shelton family of vision system platforms. The Shelton webSPECTOR[®] family includes *Lite*, *Standard* and *Plus* versions of the system concept. Each module tackles a different area of the automated vision inspection arena: -

webSPECTOR[®] *Lite* is designed for measurement and gauging operations where the features being looked for are a priori and exist to some extent in a controlled way.

webSPECTOR[®] *Standard* tackles defect finding tasks where the feature being looked for is not known but simply differs from what should be there.

webSPECTOR[®] *Plus* offers enhancements such as self-learning, data base management, defect libraries and the webcorder utility.

The webSPECTOR[®] family uses MMX technology in most of its processes. This means there is considerable power available to undertake the different image process requirements that identify the subtle defects that would otherwise be missed and sent to customers. The webSPECTOR[®] *Standard* and webSPECTOR[®] *Lite* systems use nine different defect detection algorithms that can run simultaneously. Six of these use types of filtering which are very “process-hungry” operations but give the accuracy that is required. The other three processes are image stabilisers and cancel out external effects such as

variable lighting and factory temperature. This gives better reliability so that the system can inspect to the optimum sensitivity.

A typical example of how the vision systems can benefit, with rapid pay back, is illustrated by a Shelton installation at W. L. Gore and Associates, where they manufacture a range of fabrics with high performance PTFE membranes, including 'Goretex'. W. L. Gore and Associates have installed two webSPECTOR[®] *Plus* systems consisting of three planes of cameras each looking across the full width of the fabric. Each unit is installed at the end of a production line where it is inspecting a vast range of surface types and finishes on laminated fabrics for all types of defect such as holes, slubs, and streaks. The size of defect to be detected is application dependent, but 0.5 mm is not unreasonable.

The detected faults are used to operate a tagging system, marking the faults for processes further down the production line. Data regarding fault position, type and severity is also interfaced with the factory data logging system. The completed bulk rolls are still sent to the inspection area for separating into individual rolls, but inspectors can now fast forward to the tagged faults and carry out any cutting or mending without inspecting tens of metres of perfect fabric. As a result, throughput is greatly increased.

Since the inspection takes place online, in real time the data is also used by the process operators to provide feedback of the process state. If large quantities of faults are being produced then remedial action can be taken or the process shut down, potentially cutting down on the waste produced by the plant.

The W. L. Gore system has three planes of cameras each looking across the full width of the fabric but at different combinations of lighting and viewing angle. The multiple planes are required because different fault types become visible under different conditions. This approach is simply a parallel application of the lighting and viewing techniques applied by the manual inspectors one after the other.

The camera images, after processing, identify all features that differ from the normal view. The features extraction utilises up to 48 algorithms due to the diverse and sometimes subtle nature of textile faults. The features from each camera plane are then combined to ensure that no feature is reported twice resulting in a better understanding of each fault. This process outputs 56 independent properties for each fault that are analysed in a classification stage to see what type of fault it is. This provides a basis for acceptance or rejection of the fault. The fault criteria are subsequently adjustable so that the final declaration of a feature as a fault can be framed as a particular set of values. These values can vary depending on the intended customer, or grade of the product.

At W. L. Gore there are several thousand products, each requiring 56 algorithms to be set at the optimum sensitivity level. The webSPECTOR[®] *Plus* system used by W. L. Gore has an automated training process, webTrainer, which is capable of setting these levels on fabric it has never seen before. Consequently, the operation of the machine is very much simplified, and does not require an in-depth knowledge of machine vision principles.

The webTrainer module, which trains the system sensitivity settings for all products, works in an unsupervised fashion. It does this by assuming most of the material passing through the system is good product and then trains itself to expect that. It is also possible to input current manual inspection knowledge into the auto training module, so that it can be more or less sensitive depending on customer wishes.

For each located fault the webSPECTOR[®] *Plus* system records multiple features such as position, size and severity along with an image of the fault. This information can be used by subsequent processes in the form of a roll map showing the roll and the position of the defects contained within it.

To prove the reliability of their vision system platforms Shelton developed the WebCorder module. This is part of a concept designed to ensure the inspection system is operating as expected and is especially useful where quality is critical and there is little tolerance on faults. The entire web can be recorded at

production speeds to disk. It can then be replayed as though the material were being run through the system again.

During validation of the system's abilities for each application, the webCorder is used to compare manual and automatic inspection results. If the manual inspectors see a fault not seen by the system, the webCorder can be moved to this position and the inspection system's settings adjusted to ensure the fault is detected. These settings can then be incorporated into the auto-training module to ensure subsequent products are also inspected properly. It is more common that the inspection system sees genuine faults not picked up by inspectors. The webCorder is also useful in ensuring that false alarms are not picked up, where the system sees something that is not considered a real fault. By recording the material, it is possible to re-try the same product without having to re-run it through the machine. Physically re-running material often imparts more faults and can cause material to be scrapped unnecessarily.

Stuart Speake of W. L. Gore said, "We have thousands of different styles, which have to be set up to run. Without the tools provided by the webSPECTOR® *Plus* self-learning system it would be a mammoth task to introduce new products.

The software is user-friendly and the fault tracking and statistics generator are useful because they enable us to control quality very tightly. The error mapping

allows us to look at and analyse exactly what is happening in our production process. It takes out the subjectivity and de-skills the process”, he added.

The Shelton vision system capabilities can be further reinforced by the installation example at the Owens Corning Veil fibreglass plant at Liversedge. Owens Corning have also installed a webSPECTOR[®] *Plus* system to inspect their fibreglass product as it emerges from the curing ovens. In addition to using the fault information ‘in house’ to reduce defects and wastage they take the information produced by the webSPECTOR[®] *Plus* one stage further. To increase customer confidence Owens Corning supply the fault information to their customers in the form of a roll map. This enables the customer to plan their cutting before any material is actually handled.

The webSPECTOR[®] *Plus* has a defect library which is used to store and supply images of all faults found on each roll. Levels of work in progress can be cut down or removed as product is removed from the end of the line fully inspected and mapped. If no remedial work is necessary, the roll can be shipped straight out to the customer and not be left as work in progress awaiting inspection.

The throughput of 175 metres/min, on the Owens Corning line, would require considerable resources and manpower to inspect each roll manually. Before the inspection system was installed, the rolls were inspected on a sample basis. This resulted in delays between inspection and detection of the faults allowing

further operations to be performed as defect material proceeded through the system. The automated system ensures each roll is completely inspected. This has realised a considerable saving in defect material and increase in customer confidence.

Commenting on this issue Subir Chandra, Manufacturing and Six Sigma Engineer at Owens Corning said, "Vision systems can also give added value above simple inspection tasks. This is demonstrated at the Owens Corning plant where the system is being used to improve the production process.

The webSPECTOR[®] *Plus* system gives us early warning of production problems which we can rectify before wasting considerable amounts of raw materials. In particular, the recently introduced classification of the faults helps us to analyse the line conditions over time, and drive down waste even further."

When tailoring a vision system to particular applications the most important considerations are the resolution and the data rate requirements of the system. The data rate is defined by the system resolution - how many pixels image each millimetre of fabric and the processing capacity required to convert the acquired images into fault information. A narrow width inspection task looking for very small defects in a highly structured fabric can require as much hardware and processing power as that looking for large faults in a non-structured fabric of several metres in width.

The dyeing and finishing phases of textile production are areas that require particular attention. At this stage, the textile has a large amount of investment to be lost by faulty production. Colour and geometry are particularly important. The more sophisticated vision systems cater for the inspection of these parameters.

There are a number of bench top, spectrophotometer inspection, solutions on the market that are used to inspect the colour of the textiles being produced. These remove samples from the production run to test in an on site lab. Such equipment has now been superseded by current vision system technology. The Shelton vision system removes the need to take samples to the lab for testing. It makes colour measurements at three points across the fabric width at varying points along its length, up to one metre in distance, depending on fabric speed. The measurements are presented as a series of data values detailing $L^*a^*b^*$ at several hundred points through out a typical roll (depending on length and measurement frequency). Each sample is compared to an ideal measurement and the colour difference, in the form of ΔE , is presented as a map of the roll. The system is able to report colour differences between each sample area and the reference measurement to less than 1 ΔE .

Geometry inspection is aimed at checking the dimensions of the fabric.

Measurements can be made of basic dimensions such as the width, length,

pattern repeat, bow and skew. For more structured fabrics it is possible to measure the relationship between groups of particular pattern features such as radii, area, hole centres or other datum points.

A particularly good example, of the need for geometric measurement, is that of an automotive air bag manufacture. The results from the measurements performed were fed back into the webSPECTOR[®] *Plus* system to ensure the correct dimensions of the components being produced and that no bow or skew was being introduced in the final finishing and coating process.

The webSPECTOR[®] *Plus* system has also been adapted for the stentering of lace. The system being used to measure the pattern repeat at input and output stages for assistance in controlling the stenter. It has also been able to measure the bow, width and skew of the lace.

The significant advantage offered by all proven computer inspection systems lies in the consistency of operation and applied standard allied to the speed at which they can operate. They give the user access to inspection data in real time at a point in the production cycle that can minimise costs, waste and customer rejections by lowering overall defect rates.

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Notes: -

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