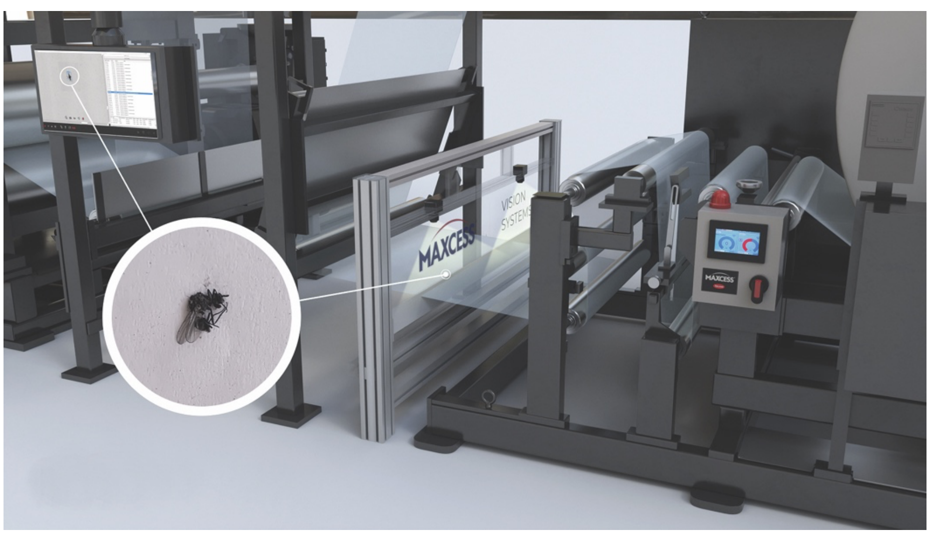
MAXCESS® | VISION SYSTEMS

Plastic Film Inspection



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Quality issues for plastic film extruders

Looking at the plastic film industry from the point of view of an inspection supplier can be quite narrow. I decided to look at those other measurement requirements often ignored by vision suppliers.

Here's a rundown of two of the major ways of measuring transparency in plastics (and other materials) the refractive index and optical clarity.

The Refractive Index

The refractive index is a measure of how much light is bent (or refracted) as it passes through a substance. It is defined by: n = sin i /sin r, where i and r are the angles of incidence and refraction respectively. The refractive index is also the ratio of the speed of light in a vacuum to the speed in the transparent material. The refractive index will vary slightly with the wavelength of the light used to measure the refractive index. If 'white' light (a mixture of various wavelengths) is used as the incident beam, then the variation in the refractive index for the various wavelengths will lead to splitting of light into the colors of the spectrum, a process known as dispersion. When light enters a dense material from a less dense material then the refracted ray is bent towards the normal. When light enters a less dense material from a dense material the refracted ray is bent away from the normal. When light passes through a transparent material with parallel sides, the refractions *'cancel out'* and the path of the light is displaced due to the presence of the transparent material.

Measuring optical clarity

So how do scientists measure clear plastic? The boundaries between *'transparent'* or *'clear'* and *'translucent'* or *'opaque'* are often highly subjective. What is acceptable for one observer is possibly not acceptable for another observer. It is possible to measure the degree of light transmission using ASTM D-1003 (Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics). This test method is used to evaluate light transmission and scattering of transparent plastics for a defined specimen thickness. As a general rule, light transmission percentages over 85 are considered to be *'transparent'*. The perceived transparency or optical clarity is dependent on the thickness of the sample used for assessment, and the optical clarity will decrease with increasing thickness. Standard glass can be relatively optically clear in thin sections but will show a green tint (due to iron in the glass) as the thickness increases. Optical clarity can only be achieved when the refractive index is constant through the material in the viewing direction. Any areas of opaque material (such as colorants) or areas of different refractive index, will result in a loss of optical clarity due to refraction and scattering.

Optical clarity is also dependent on surface reflections from the sample. The surface reflections at the air/plastic interface create significant transmission losses. For example, PMMA's transmission loss is around 93%, and PS's is around 88%. These surface reflections can come from two basic causes: specular reflection, which is the normal reflection from a smooth surface, and diffuse reflection, which is dependent on the surface flatness of the sample. The transmission loss as a result of surface roughness or embedded particles is more often termed 'haze', and this is generally a production concern and not a property of the material. In producing blown film, haze can be caused either by melt fracture at the surface or by interfacial instability between the layers of the film. An object's transparency is measured by its total transmittance. Total transmittance is the ratio of transmitted light to the incident light. There are two influencing factors; reflection and absorption. For example:

Incident light = 100% - (Absorption = -1% + Reflection = -5%) = **Total Transmittance = 94%**

Industry Standards

ASTM International (formerly known as the American Society for Testing and Materials) is the main body which works within the industry and develops standards for various tests/instruments. They dictate that the industry standard for the clarity meter entails the following;

- Reference beam, self-diagnosis, and enclosed optics.
- Built-in statistics with average, standard deviation, coefficient of variance, and min/max.
- Large storage capacity and data transfer to a PC.

The attribute of clarity of a sheet, measured by its ability to transmit image-forming light, correlates with its regular transmittance. Sensitivity to differences improves with decreasing incident beam- and receptor-angle. If the angular width of the incident beam and of the receptor aperture (as seen from the specimen position) are of the order of 0.1° or less, sheeting of commercial interest have a range of transparency of about 10 to 90 % as measured by this test. Results obtained by the use of this test method are greatly influenced by the design parameters of the instruments; for example, the resolution is largely determined by the angular width of the receptor aperture. Caution should therefore be exercised in comparing results obtained from different instruments, especially for samples with low regular transmittance.

Property Testing

Property testing is important for a number of reasons. These may include:

- Meet customer standards and specifications.
- Provide quality control; to verify the manufacturing process.
- Establish a history for new materials.

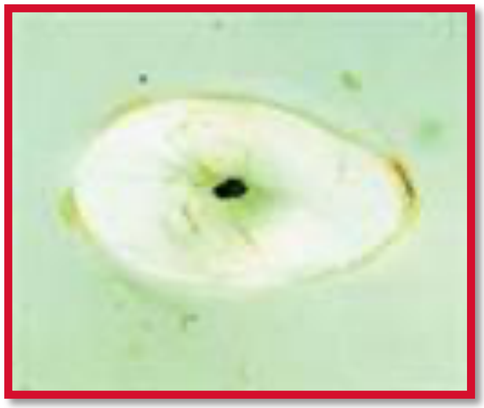
Testing often includes material evaluation such as density, and mechanical property evaluation such as tensile strength. The methods of testing often vary depending on the capabilities of the manufacturer. For example, testing the tensile properties of' bags may entail filling the bag with a weight rather than using the traditional tensile testing machine per ASTM specifications.

- ***Density.*** A materials characteristic, the specific density of the overall blend has an effect on end product properties. Lower density blends often have better mechanical properties in film applications. Density is determined by ASTM specification n D792 or D1505.
- ***Melt Index***. A materials characteristic, the melt index of the blend may affect the processing and melt mixing characteristics of the blend. Blends with lower melt indices may decrease throughput and require increased mixing in order to obtain consistent mechanical properties.

- ***Gel Count.*** A materials characteristic, gels are materials composed of oxidized or high molecular weight materials. The presence of gels in plastic films is objectionable due to appearance and to the problems associated with printing on the films. Gel count is determined by ASTM specification D-335 1-74.
- ***Tensile Strength****.* A mechanical property, tensile strength is a measure of the maximum stress a material will withstand when subjected to a load in tension. ASTM specifications for plastic films include D 88291. A simpler method is to load the fi lm or bag with a weight.
- *Tear/Shear Strength.* A mechanical property, tear strength is a measure of the maximum stress a material will withstand when subjected to a load in shear. ASTM specification for plastic films is D 1004-90.
- ***Dart Drop Impact Strength****.* A mechanical property, dart drop impact measures the toughness of the material by introducing a poly axial load. ASTM specification for plastic films is D 1709-91.
- ***Haze.*** An optical characteristic, haze is a measure of the clarity or transparency of the material. ASTM specifications for plastic films is D 1746-92 and ASTM D l003.
- ***Gloss.*** An optical characteristic, gloss is a measure of the reflectance of the material. ASTM specification for plastic films is D 2457-90.

In addition, there may be a number of other material or mechanical properties that are important to the manufacturer. These will vary depending on the performance requirements and customer specifications. Other characteristics that may be tested include: burst/seal strength, odor, freeze resistance, print quality, and modulus.

Gels and how to reduce them



Gels can come from several sources: HMW tails in a bimodal resin, crosslinked material caused by overheating, additives with poor thermal stability, fines from regrind, catalyst residue such as silica, and other organic or inorganic contamination. As a result of shear forces in extruders, gels usually end up as elongated ellipses. Those caused by contamination typically have a dot or "fisheye" in the center; gels caused by HMW material do not. When gels consist of HMW droplets, they are primarily a cosmetic problem. Gels caused by contamination, however, can produce a weak point in a tube or even start a hole in film.

If you have gels in an extruded product, it's important to know whether they originated in the incoming raw material or were created during extrusion. Gels formed during polymerization are called P-gels. They form in stagnating regions of the reactor where resin overheats. They may also be high-molecular-weight fractions created by a bimodal process or resin made when a reactor needs maintenance. P-gels are a common problem in polyolefin. Some non-olefins also have high gel problems. PVDF can pose severe gel problems from the manufacturer, especially if it's made shortly before a maintenance turnaround. So processors using a material that's prone to gels should be aware of reactor maintenance schedules.

Gels can also form during extrusion. These are called E-gels and tend to form as a result of high temperatures or long residence times. E-gels can be created by dead spots in the extruder e.g.) stagnating regions in the screw. Maddock mixing sections, for example, can create dead spots.

Preventing P-gels

The best defense against P-gels is to test incoming material for them and communicate clearly to resin suppliers that you do so. When resin suppliers realize they're dealing with a sophisticated user whose product requires low gel counts, they will try to send good material. Incoming QC for gels is especially important when running multi-layer film because you have more materials and extruders to check for gels. Testing for P-gels requires a thin plaque of the material. Plaques can be prepared several ways, such as by compression molding a few pellets' worth of resin. It's important to control the pressing temperature to make sure you don't create more gels in the test process. The number of gels per unit area in the plaque can be counted using an overhead projector and polarized light to project an image on a screen. Make sure you standardize gel-test procedures within your company. They should be written and followed consistently.

Preventing E-gels

To avoid making gels during extrusion, be sure the screw and die have a streamlined design. Also the screw, barrel, and die surfaces should be free of grooves, scratches, or gouges that might collect melt and cause degradation. It's also important to check resin feed tubes, blenders, feeders, hoppers, and other bulk-handling hardware for fines, streamers, or contamination from other plastics. Bulk-handling equipment should be

Gels and black specks can occur when PE Resin becomes degraded during the primary PE manufacturing process or the secondary conversion into a finished product. Such defects can seriously compromise the quality, aesthetics and performance of products manufactured from PE.

Benefits of inspection on plastics

The modern extrusion and converting/laminating lines now use surface inspection systems as standard. Your customers demand 100% quality control.

All plastic film include some level of contaminates, arising from the production process or due to the nature of Polymers. Therefore gels are only a question of resolution. Extrusion and converting lines classify many defect types such as gels, black specs, fish eyes, holes, oil stains, insects, scratches, coating voids, air bubbles etc. These all originate from different issues but most all can have an impact on the further processing.

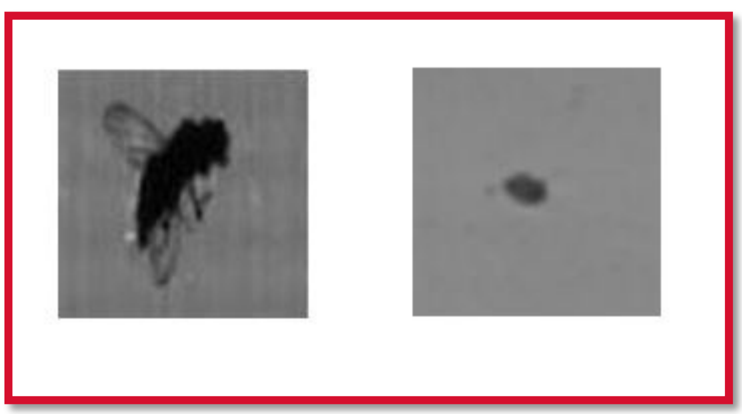
An extrusion line must control production using an advanced optical inspection system. These inspection systems locate all defects and identify the exact position, take a snapshot of the defect and alert the operator in real time. The end result is to avoid the production of waste. You can see benefits of deploying inspection in a number of areas including the film extrusion and converting process, the incoming raw material or at the final product especially during converting. By providing real time feedback on gel and black spec contamination, the machine downtime for die cleaning can be reduced and its capacity enhanced. In the extrusion and converting process a web inspection system can be used to monitor the raw material and allow you to choose the best raw material combination.

More about gels or fish eyes

Gels or Fish-eyes are small film defects are normally characterized by their area and protrusion above the film surface. A gel count is one of the standard film properties. Foreign polymeric materials that do not completely melt form gels. Contaminants such as dust from bulk containers, particles and foreign materials, e.g. from poorly cleaned silos, can also cause fish-eyes. During the transfer of PE pellets through pipes, some of the PE pellets melt and smear on the walls and form ribbon-like streamers (angle hair) that flake off into the pellet stream. While the streamers are still adhering to the walls, their large surface area comes into prolonged contact with atmospheric oxygen. This can form fish-eyes. Deposits on the inside wall of the extruder and prolonged thermal exposure during a stoppage can also lead to fish-eyes with brown spots.

Why film Inspection works?

The online measurement of film in a cast or blown processes provides real time data. Rinsing intervals can be optimized and the machine downtime reduced for die cleaning improving OEE. Other defects such as die/flow lines, oil stains, laminating defects, cracked coatings, air bubbles/inclusions, streaks, wrinkles, lack of adhesive or craters will also be detected. Classification of the defect is important, so that the operator can react.

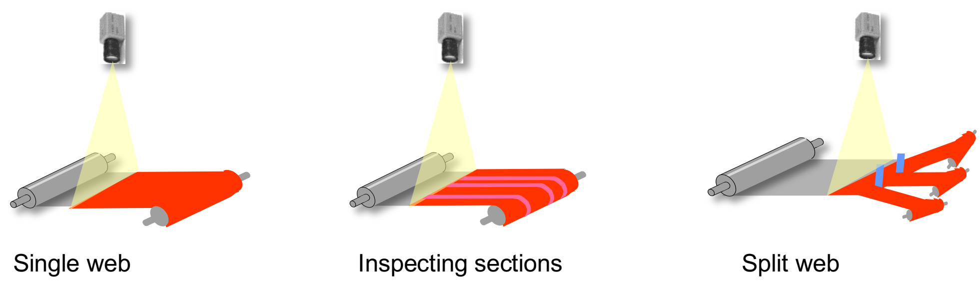


And pellet inspection will help

The inline measurement of pellets provide LAB color values, the Yellowness Index , detect dust and impurities and can measure the form and roundness . It's clear that a web inspection is a must to control quality. What is also clear is that it can also be used to minimize line downtime, optimize cleaning processes, identify the best raw material and improve the OEE of existing lines. Maxcess Vision Systems are experts at plastic film inspection and can offer advice on how to deploy your Capex to get the best value. Download our white paper to learn more and contact us to tell us about your issues.

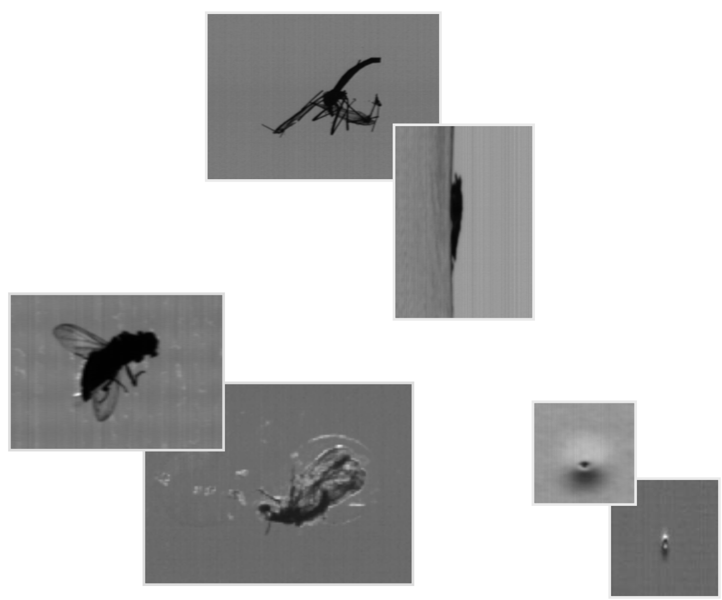
The Maxcess Vision Systems Solution

Our system enables the control of film quality during production. We analyze material defects and provide real time feedback for the operator. It documents the quality of the product and supports the operator with the optimization of the production process. It guarantees total quality control and monitors key metrics without contact.



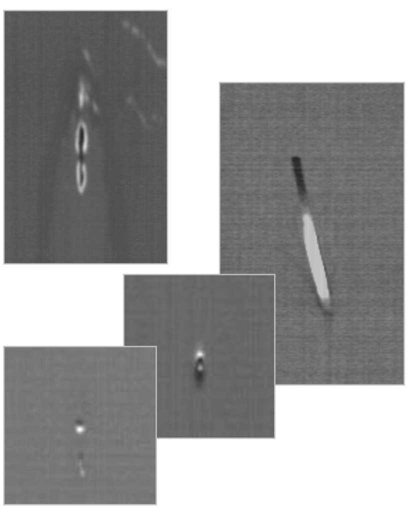
Maxcess Vision Systems will supply an effective solution that can be configured to meet your application requirement. Our software includes an extensive selection of software tools for each key user, production operator, quality manager and process engineer. The advanced surface inspection algorithm will detect and record the position and size of the following problems:

- Spots
- Gels
- Dirt
- Cracks and holes
- Lamination defects
- Coating defects
- Scratches
- Burned granulate
- Cords
- Streaks
- Contamination
- Insects
- Fisheyes
- Edge cracks
- Crow feet
- Grooves
- ....etc.



Easy to use operator interface with live feedback of all quality issues. It runs on a Windows 7 platform with an easy to use touchscreen interface. Warning messages inform users immediately about defective production or when tolerance levels are exceeded.

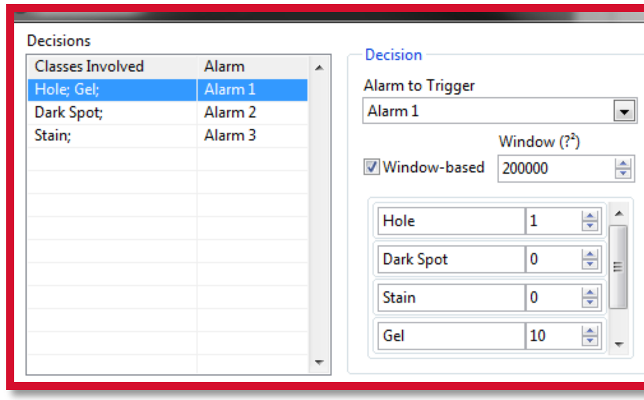
Imageflow supports any number of product recipes, and will store all defect images with the exact location and position.

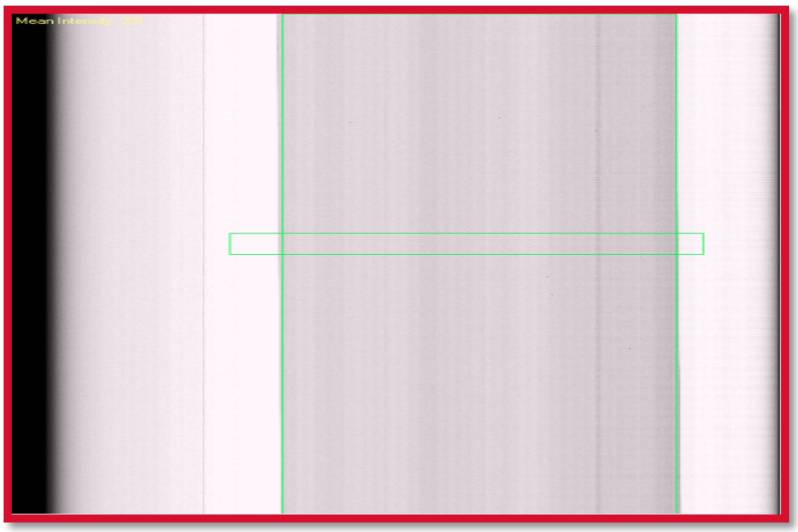


The key elements of the inspection system is the scanner mounted online. This includes the camera, the control box and the lighting. The image below shows a system.

Use the system to count gels and analyse according to a defined area, enabling real time grading of the film.

Create any number of standards and configure which ones should be alarmed.

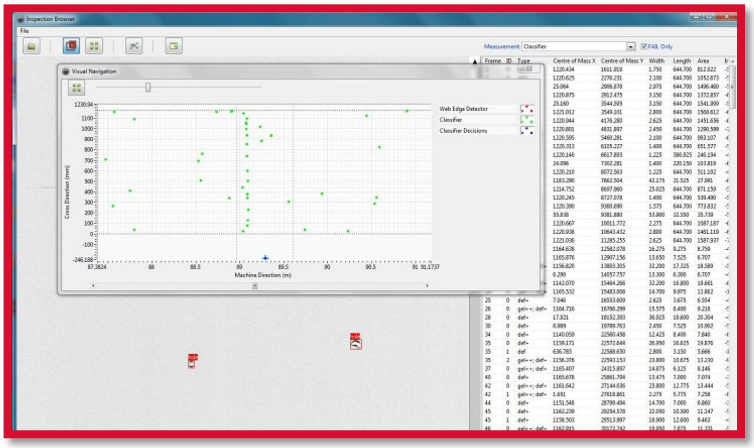




Measure width of the sheet. Use the caliper feature to make point to point measurements within the image.

Stream real time video of production to AVI files for later playback. Used for system validation, new recipe setup and machine troubleshooting.

Select as many areas as required for the system to monitor density.

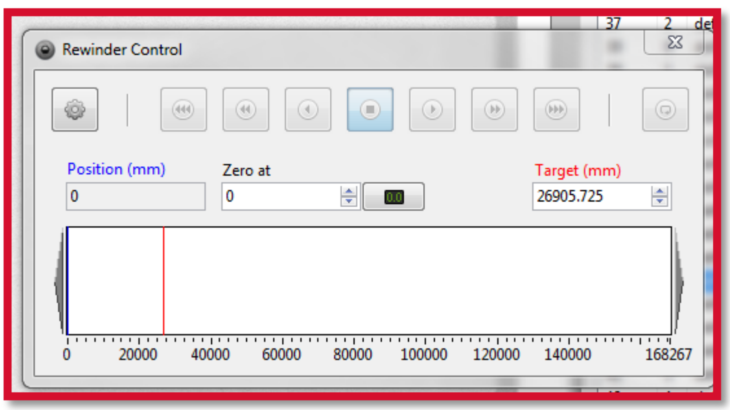


Defects of Images with locations are stored to support report generation and waste removal.

Filter defects according to class and size.

Export production run information to excel for reporting.

Automatically remove waste through the use of an optional module that supports a hardware interface to rewinders. Simply click on the defect on the graphical map and the system will turn on the machine, monitor the location using an encoder and stop the machine at the defect so the operator may splice out.



Five Benefits

1. **Reduce customer claims and increased productivity on rework** - Customer facing business benefits are probably the hardest to quantify and the most valuable. What price do you place on a lost contract? It can be part of any business strategy to include borderline product to fulfil a delivery. This is not a viable business strategy if the product quality has not been determined and stored. The cost of rework, if this product is returned, should be negated as the location of borderline issues will have been identified prior to shipping.
2. **Root cause analysis and process improvements** - reduce inline waste and increase asset OEE. Vision networks integrated with sensor historians enable this.
3. **Smart converting -** This is the use of data to optimize the follow on processes. An example of this is to rework a substrate roll prior to lamination. Why add the second layer to product that will be scrapped anyhow.
4. **Lower maintenance costs -** can be expected through root cause analysis. Assets that are run at a steady output without constant stops due to quality issues will require less maintenance.
5. **Increased Output** - Operators only deal with issues due to their process, there will be an increase in throughput.

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