AUTOMATIC MONITORING OF POLYMERS FLUX USING IMAGE PROCESSING

André Borin Soares
LAPSI – DELET – UFRGS, Av. Osvaldo Aranha 103, 206B
borin@eletro.ufrgs.br

Juan Carlos Sandoval Ortiz
LABMECFRAC / GPFAI – DEMEC – UFRGS, Rua Sarmento Leite, 425
juanca@mecanica.ufrgs.br

Thiago Rosa Figueiró
LAPSI – DELET – UFRGS, Av. Osvaldo Aranha 103, 206B
figueiro@eletro.ufrgs.br

Leticia Vieira Guimarães
LAPSI – DELET – UFRGS, Av. Osvaldo Aranha 103, 206B
leticia@eletro.ufrgs.br

Altamiro Amadeu Susin
LAPSI – DELET – UFRGS, Av. Osvaldo Aranha 103, 206B
susin@eletro.ufrgs.br

Abstract. *A polymer drying system requires constant monitoring due to the possible system fails, specially related to the material particles flux when they leave the conveyor belt to pass throw the funnel and arrive at the fuse. The problem consists on the natural tendency of the particles to aggregate to the fuse, obstructing the conduction duct. Nowadays, the monitoring is made by an operator that constantly observes the images deriving from a camera installed at the top of the funnel, which acquire images of transportation fuse. The problems of this method are the tiredness of the operators and the many attributions they have, observing many factory spots, which makes it difficult to quickly response at the beginning of the duct obstruction. The proposed system uses the camera signal already installed at the top of the funnel to make image processing in order to monitor the flux. In the image acquired is selected a Region of Interest (R.O.I.) and on it the system verify the variation of luminance due to the polymer pass. If the variation became smaller than a threshold and the quantity of polymer on the R.O.I. became greater then a second threshold, then is defined and obstruction. The system performs an automatic estimate the quantity of polymer that may characterize a obstruction and then generate an alarm sound to an operator fast enough to be able to control the flux.*

Keywords*: Flux monitoring, automatic supervision, industrial automation, image processing and motion detection.*

1. Introduction

Generally, industrial process control needs monitoring several sensors in order to take decisions to control several points of the process.

Lately, image sensors have been used for surveillance with manual monitoring and/or manual alarm. Also, in automatic security systems applying image processing as face, finger print or car plate recognition and identification, for example. Generally, industrial environment is very noisy for usual sensors as temperature, pressure that generate low energy signals that are very sensitive to noise. The usages of image sensors in industry have been encouraged by the improvement of their technology, that permit to use cameras in noisy environment as so as the decreasing of their size and cost allow to spread their application even in small places. Moreover, the image processing tasks already used in security systems can be adapted to industrial application successfully.

This work proposes an image processing technique to monitoring a material transport line of a polymers industry. Polymers particles are heated and pressed in order to take de water of dry the particle, after the washing process. The transport line is located between the heating and pressing process. The critical points of the material transport line to be monitored are the funnel that conducts the polymer particles from the heating location to the pressing location. The pressing is performed by a fuse that rotates inside of a pipe while the particles are located between the fuse and the pipe wall, so the particles ate pressed and transported to the next point of the process, at the same time. The pipe is often obstructing by the increasing of the number of particles transported by the line. Therefore, the flux of polymers must be controlled.

Nowadays, the flux of polymers is controlled manually. A technician monitors the transport line and the funnel state by images transmitted to the control section of the industry. The manual monitoring is not a trustworthy method because the technician monitors several process and sensors at the same time, moreover, the sight task is boring and causes eye fatigue, decreasing the capacity of fail detection.

We propose the capture of sequential images [Vezhnevets 2003, Soares 2004] of the critical points, digitizing them to a computer, then, process these images in order to estimate the particle flux and the funnel state. Finally, automatically generate alarms to provoke the technician on timely reaction. The experiments showed that the flux estimation and funnel state monitoring provided by the proposed system are effective in alarm generation to the transport line control.

2. The polymers drying system

The particles of polymers are cleaned and dried in order to be delivered to other factories that transform them into automotive or electrical manufactured devices. The schema in fig. 1 shows the flux of the polymers and the monitoring points on the washing and drying process. Where A is the heating block, B is the heating-to-transport line access funnel, C is the transport line, D is the transport line-to-pressing pipe, E is the pressing pipe, F is the monitoring camera, and G is the video monitor in the control room. Figure 2 shows the part of the transport line (C) and the funnel that connects the transport line and the pressing fuse-pipe.

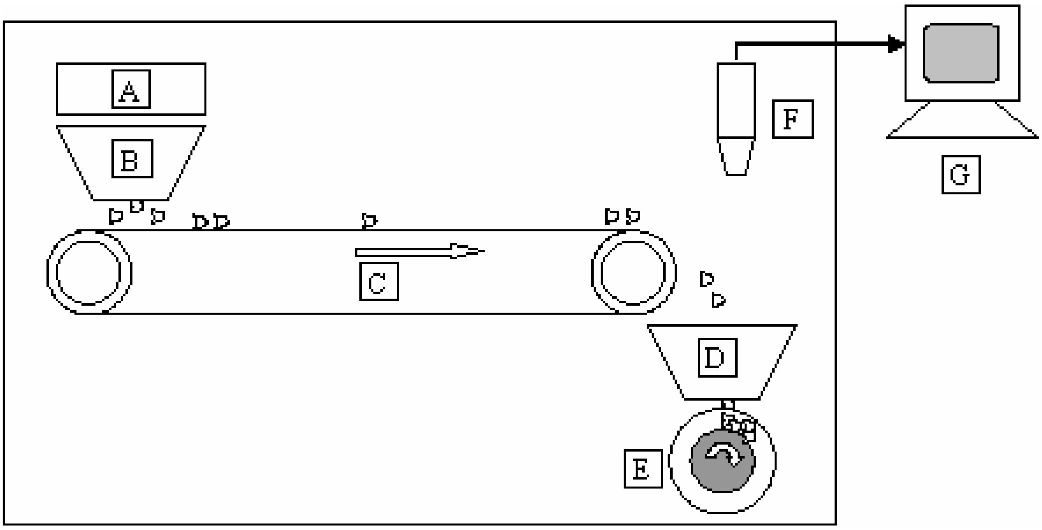


Figure 1. Schema of the polymers flux.

The drying process consists in heat the polymer particles near to 100º C, then, transported to the pressing pipe. During the transport the steam is liberated, helping the drying process. However, the steam covers the monitoring area introducing noise on the images.

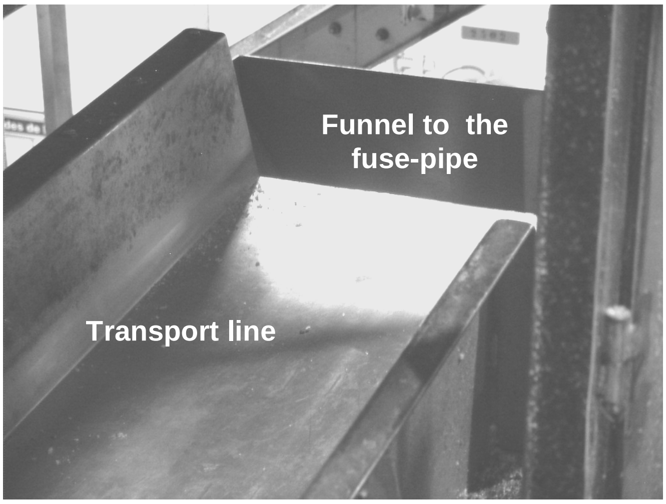


Figure 2. A photo of the transport line and the entrance of the funnel.

3. Visual monitoring

The visual monitoring is proceeded remotely in the control room by sighting a video monitor (G) connected to the camera (F). The operator looks the video monitor that presents the image showed in fig. 3. In fig. 3, the white particles are the polymers, in the bottom of the image there is the transport line (C) while the up the particles are falling to the funnel (D).

Figure 3. The view of the operator while monitoring the system throw the camera.

4. The automatic monitoring system

The proposed monitoring system is composed by hardware and software as shown in fig. 4. The hardware is composed by a camera, the ALTAvision [Figueiro 2003] and alarm devices. The software proceed the image data storage and management, polymer particles segmentation and counting and the volume of polymers inside of the funnel.

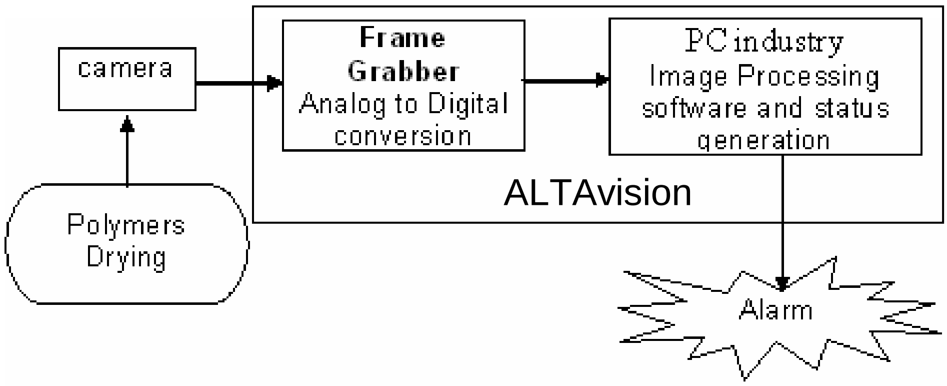


Figure 4. General block diagram of the proposed monitoring system

4.1. Hardware

The proposed hardware system is composed by a camera connected to the ALTAvision [Figueiro 2003, Schuch 2004] that is responsible to activate the alarm systems connected on it.

The camera is a VHS B&W, providing a composite video to the frame grabber by a coaxial cable (50Ω), with a BNC connector.

The ALTAvision is composed of by IBM-PC SBC PC 104 microcomputer with a 4-channel frame grabber (PXC200 Imagenation™ [1]) video camera and link network. The system process, stores images while communicating by standard interfaces (serial, parallel and VGA). Furthermore, the ALTAvision also has a LCD monitor for local user communication. The ALTAvision was packaged inside a metal box with dimensions: 48cm x 38cm x 15,5cm. Figure 5 shows the ALTAvision with the box open.

The alarm is activated by one of the output interfaces of the ALTAvision (serial, parallel or internet). The alarm device configuration permits to set a visual or sound alarm, according to the environment requirements.

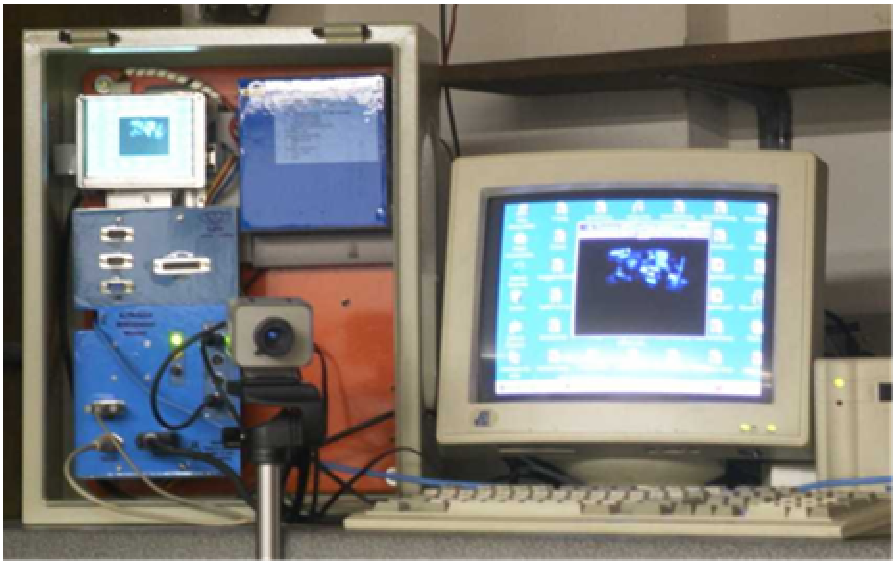


Figure 5. The ALTAvision at LaPSI

4.2. Software

The software was developed to proceed image processing functions at the ALTAvision, for Windows 98 or superior. The software programming language was C++ and the LaPSI Image Processing Library (*lili*) was used to implement the algorithms.

The image processing was divided in several steps [Figueiro 2004, Guimarães 2000, Guimarães 2001, Guimarães 2002]. First, we realize a Background Segmentation in order to generate a "empty" funnel and transport line. Second, we process a Particle Segmentation, which generate a map indicating where the particles are and the area occupied by them. Third, we determine a Region Of Interest (R.O.I.)., in order to evaluate if the particles are inside the funnel or in the transport line. Then, we analyze both Funnel Volume (R.O.I. - inside the Funnel) and the Flux at the Transport Line (R.OI. outside the Funnel). Last, we determine the activation of the alarm according to the parameters decision considering both the volume of particles at the funnel and the flux at the transport line. Figure 6 shows a general schema of this algorithm.

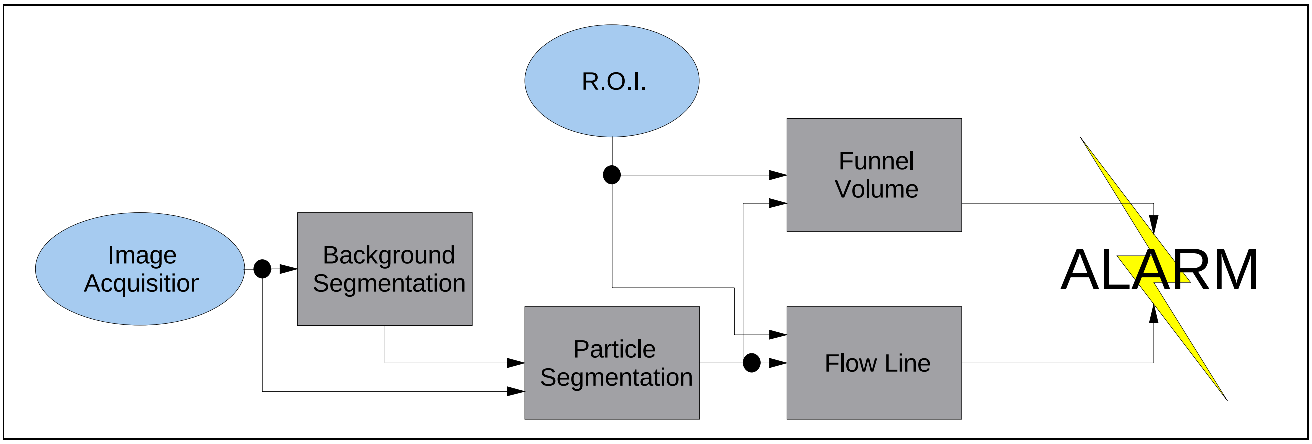
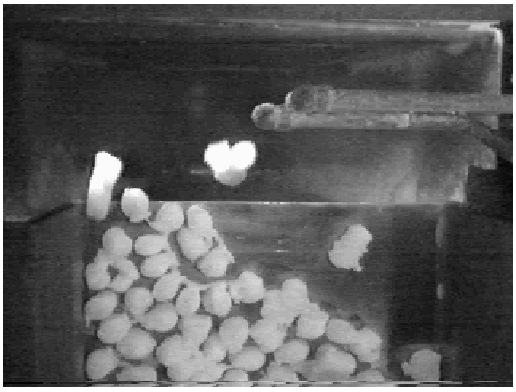


Figure 6. The general scheme of the software.

4.2.1. Background Segmentation

The background segmentation is used to aid the particle segmentation with a reference of what is the system environment and, for this reason, not a particle. The process uses a sequence of images acquired in a normal operation situation (no problems on the system) as a calibration. After performing the average of many images what tend to stay at the final image is only the things that were present in almost every image (background) and the moving objects (like the particles) tend to disappear because they are not always at the same point. Figure 7 (a) shows one image from the set used to generate the background while fig. 7 (b) shows the background generated.


(a)

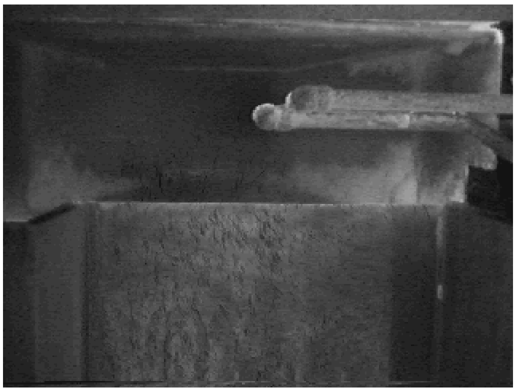

(b)

Figure 7. (a) An image from the set of images used to generate the background. (b) The background extracted from the set of images.

4.2.2. Particles Segmentation

The particle segmentation was performed using the background generated at the Background Segmentation and the acquired images. The method consist on subtract the acquired image from the background and evaluate the difference between the two images, as show in eq. 1.

$$\Delta I = |f(x,y,t) - f_r(x,y)| \quad (1)$$

where ΔI is the modulus of the difference between the image in time t (just acquired image) and the background.

Figure 8 shows the difference between fig. 7 (a) and fig. 7 (b).

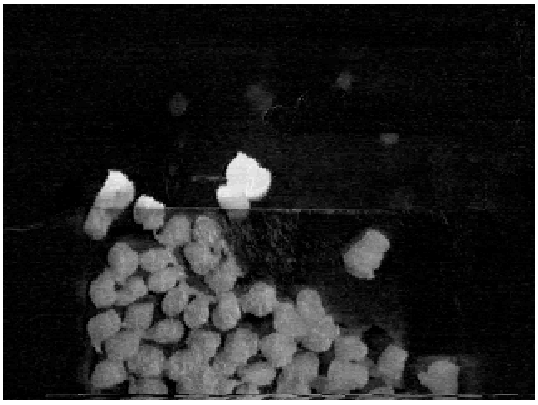
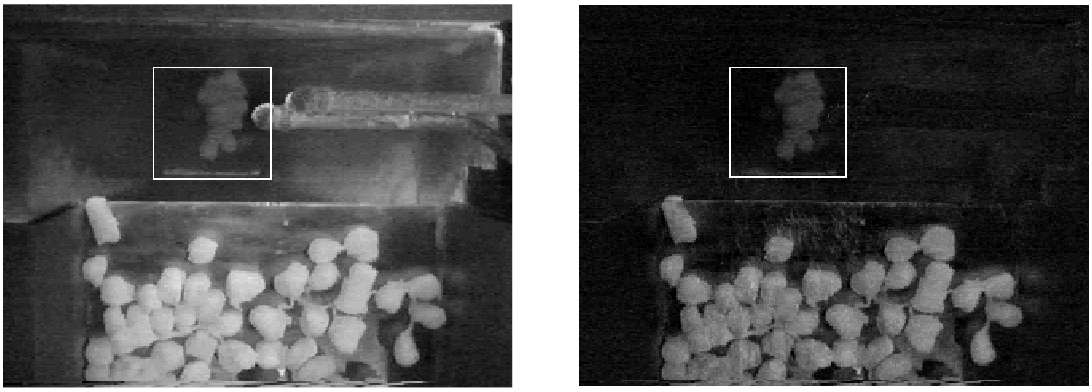


Figure 8. The difference between the acquired image and the reference background

4.2.3. Region of Interest

The Region Of Interest (R.O.I.) [Gonzales 1993] is important in order to verify the volume at the funnel and the flux in the transport line. This region is the cavity where the polymer particles pass in order to get in the fuse. This region is set only one time, when the system first installed and every time the camera is removed and reinstalled in order to calibrate the system. Figure 9 (a) shows the region on the original image while fig. 9 (b) shows in the difference image.

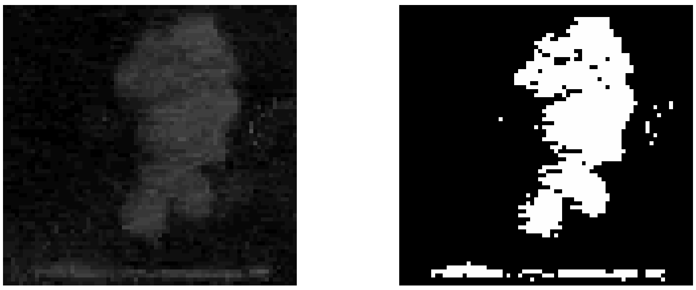


(a) (b)

Figure 9. The R.O.I showed in the original image (a) and in the difference image (b).

4.2.4. Funnel Volume

The funnel region, defined by the R.O.I., is evaluated in order to analyze the area of particles inside of it. The mean luminance of the objects inside the R.O.I. is different from the rest of the image, once the fuse in a different distance from the camera than the funnel entrance and the conveyor belt. A threshold was determinate in order to segment the particles. This threshold was used to generate a binary image. Figure 10 (a) shows the image inside the R.O.I. and fig. 10 (b) shows the result of the binarization [Lili 2005].



(a) (b)

Figure 10. (a) shows the original image R.O.I and (b) the binarization result considering threshold = 30.

There are established percent ranges of particles in the region. These ranges are divided in 0% to 10%, 10% to 30%, 30% to 50%, 50% to 80% and 80% to 100%. Each group activate a different kind of alarm, been able to aid the operator with visual (LEDs or Screen) or sound information of the system. One example is to display in a visible spot of the screen different colors according to the proportion of particles inside the funnel (example shown in tab. 1).

Table 1. An example of color alarm to the funnel particle volume.

Group	Example of Alarm	
0% to 10%		Green (Level 1)
10% to 30%		Yellow (Level 2)
30% to 50%		Light Orange (Level 3)
50% to 80%		Orange (Level 4)
80% to 100%		Red (Level 5)

4.2.5. Flux at the Transport Line

The flux is controlled by evaluating the particles area outsize the R.O.I.. This is done by considering that particles outsize the funnel will be on the conveyor belt. The analysis is important both for evaluate if the commands given by the operator are being effective and to allow a problem prediction. As in the funnel volume, there are established percent ranges of particles in the conveyor belt. The same ranges are proposed to the flux at the transport line. One example is to light LEDs in a system with different colors according to the proportion of particles passing on the conveyor belt (example shown in tab. 2).

Table 2. An example of LEDs alarm to the flux at the transport line.

Group	Example of Alarm	
0% to 10%		Level 1
10% to 30%		Level 2
30% to 50%		Level 3
50% to 80%		Level 4
80% to 100%		Level 5

5. Experiments

The images used to the experiments were acquired using the camera already installed at the top of the funnel, capturing the signal in a VCR. Then, the image from the VCR were converted using a frame grabber to a AVI file in order to digitalize the images. Some image samples from the AVI file were used to validate the algorithm. While acquiring the images, the conveyor belt speed was changed several times in order to change the funnel volume and the flux of polymer at the transport line.

6. Conclusions

The system had difficulties in determine the adequate proportion value of particles at the funnel and at the conveyor belt when the quantity of water steam in front of the camera. Once that the steam generate high intensity regions on the image, it may cause an false alarm, considering it as polymers regions. In order to solve this problem, the environment must be chanced to avoid the steam to get in front of the camera or even reduce the amount of steam.

The implementation of this system in a industrial plant is not expensive and really makes the difference avoiding that the factory to stop its production for two or more hours.

7. Future Works

The next step of this research is to develop a system to count the number of polymers. Also, evaluate the size of the particles and create software to automate the system in order to implant the proposed system on a factory.

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