

# **Quality Engineering**

## **Process Control Plan for PVC powder Moisture Content Control**

***JRL Consulting***

**Cross-Cultural Technology Management**

E-Mail : [tech@jrleeconsulting.com](mailto:tech@jrleeconsulting.com)

Website : [www.jrleeconsulting.com](http://www.jrleeconsulting.com)

## Summary:

The moisture content of PVC resin (powder) is an important factor for PVC grading. The better the grade of PVC resin can ensure the higher the profit for the manufacturer. The quality control of the moisture content is thus important along with other factors for example molecular weight, porosity, bulk density, and particle size distribution(PSD). The reason this moisture content analysis is selected in this study is because it has the potential to convert an off-line laboratory moisture measurement to on-line real time measurement. For laboratory analysis, usually a traditional microwave oven with a scale is the main equipment for the moisture measurement of PVC resin until the use of NIR (Near Infrared) spectroscopy as its potential replacement. The (simulated) data collected is based on the measurement from this NIR on PVC resin sampled every 3 hours for laboratory analysis. The process quality metrics is defined based on the old equipment, the data collection is manual and the data can be saved in a computer that makes the creation of the control chart plan much easier. The results show that NIR spectroscopy is a better and precise equipment for PVC resin moisture content measurement but more data needed to be collected for the on-line conversion. Since NIR spectroscopy is portable, we recommend a designate team to collect the sample and analyze the sample right in the dryer area every 30 minutes for a prelude the on-line NIR measurements that links the on-line to real time process control of PVC moisture quality control..

## Introduction:

There are three main processes can be used for the commercial production of PVC powders 1) Suspension 2) Emulsion 3) Bulk methods. The PVC produced by suspension process provides 80% of worldwide support. So, the process of PVC polymerization will be focused on the suspension method. In this study, the Chisso Process (reference) is used to produce PVC from vinyl chloride monomer (VCM) using suspension polymerization. The Chisso<sup>2</sup> process sequences are illustrated in Figure 1.

### PVC Suspension Process:

This process can be divided into 6 different steps from input of raw materials to the end products:

- a) Input Fresh VCM, additives and water into a stirring reactor (1), and maintaining temperature during the polymerization to control the grade of the PVC
- b) Discharge PVC powder after 85-90% VCM/PVC conversion to a blowdown tank (2) to flush off VCM gas and recover VCM gas to VCM gas holder (6)
- c) PCV slurry containing VCM is fed into the stripping column (3) continuously, most of the residual VCM will be recovered from this column
- d) The slurry will be de-watered with a centrifuge device (4)
- e) The slurry will be dried by the proprietary dryer (5). It is then passed to storage silos.

## PVC Process Inputs and Outputs:

Block diagram and process sequences can be seen from figure 1. This figure also identifies several needed raw materials and equipment for PVC polymerization. Many more inputs are needed to produce PVC resins.

### Inputs:

Capacity of the Reactor: 130 m<sup>3</sup>

Mixing speed with rotator : 120 r/s

Water Temperature in Jacket : 60 °C

Reaction time (with 85% conversion) : 6 hours

- Raw Materials:
- 1) VCM
  - 2) Purified Water
  - 3) Additives
    - a) PVC additives
    - b) Initiators
    - c) Inhibitors

Centrifuge Time: 10 minutes

Drying Time: 2 Hours

### Outputs:

PVC powders with different grading.

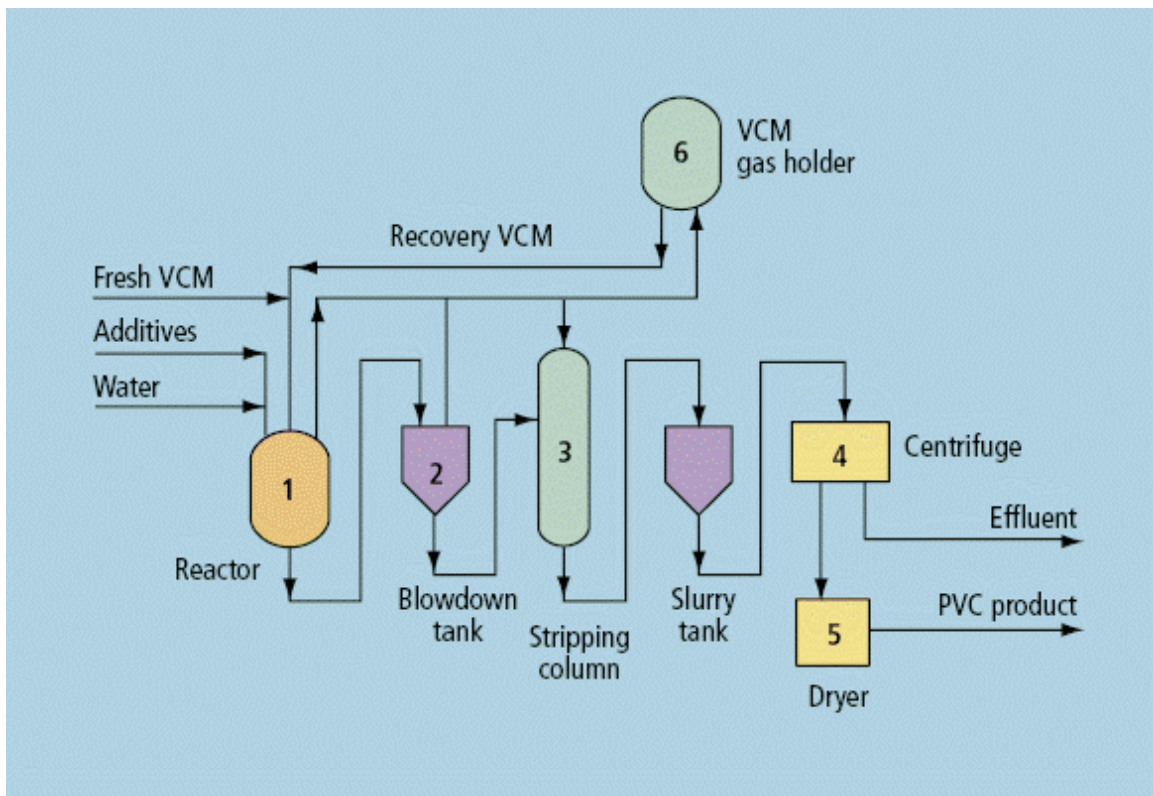


Figure 1 The Chisso Process for PVC suspension polymerization.

Process quality<sup>3</sup>/defect metrics on moisture contents:

For each grade of PVC resin, the plant applies a defined control plan which checks all necessary factors that impact on the PVC resin moisture content in order to guarantee the moisture content of specific grade upon delivery.

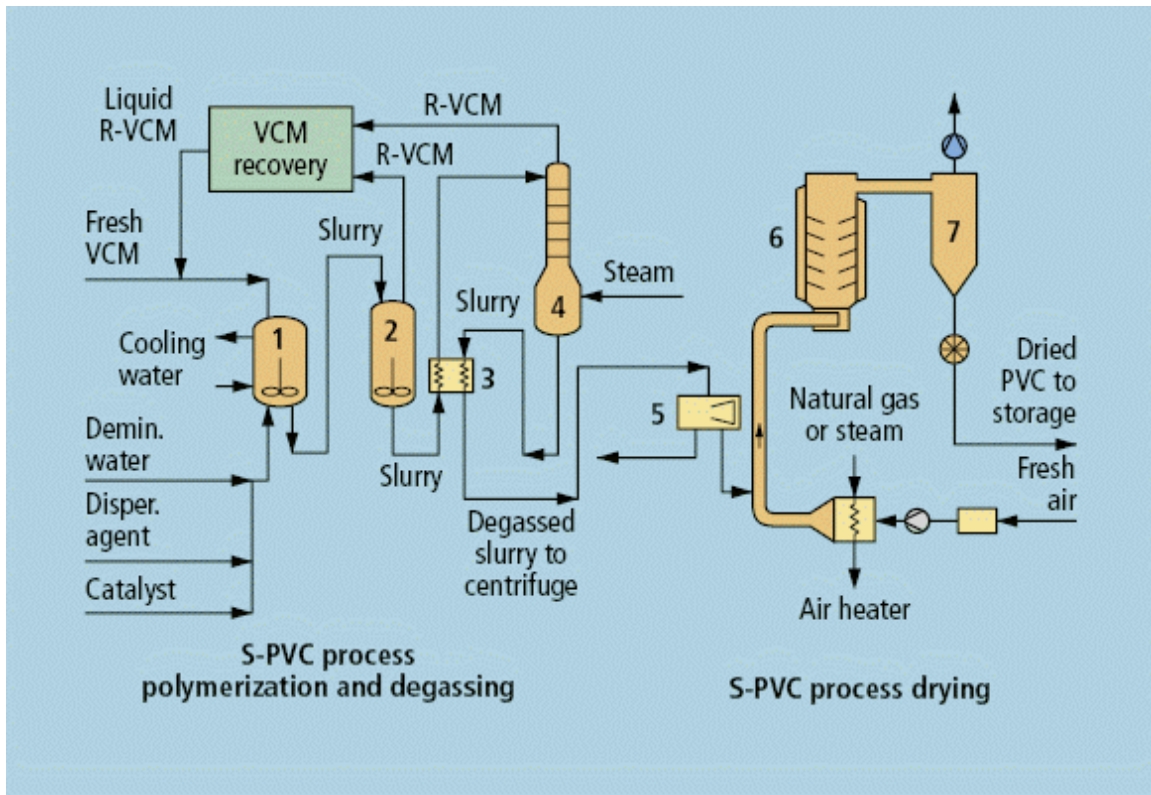


Figure 2 Production of suspension PVC resins and drying process using the Vinnolit<sup>2</sup> process.

These factors which are regularly controlled for drying purpose are:

- Stream pressure that regulates the temperature for drying
- Stream flow that regulates the temperature for drying
- Centrifuge speed
- RPM of dryer
- Speed of wet PVC slurry delivered to the dryer

PVC Resin quality control:

Root Cause analysis of potential defects as shown in figure 3 is the fishbone diagram that provides a cause-effect diagram for moisture control of PVC products.

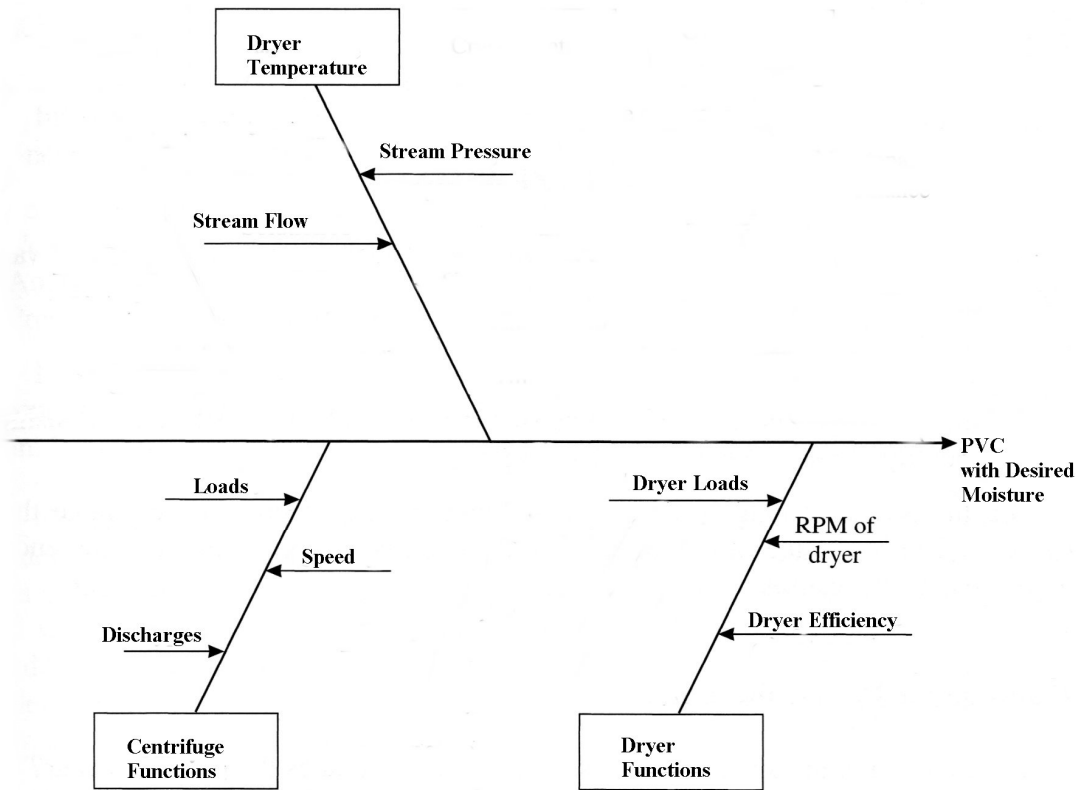


Figure 3 Fishbone diagram for PVC powder moisture control cause-effect factors.

### Plan for quality Control

Quality Categories	Moisture Content
Grade A	0.08% max 0.06% min
Grade B	0.2% max 0.16% min
Grade C	0.4% max 0.32% min

Table 1 Grade<sup>3</sup> differences with different moisture contents.

There are many PVC grade defined based on PSD, Molecular weight, and moisture contents as well as other factors. This control plan focuses on the drying process of the PVC manufacturing process. The moisture content in PVC becomes the key quality factor in this process. Several different grades of PVC resin based on the content of moisture are listed in table 1. The outcomes of these different grades are the combination effects of drying process attributes such as 1) Dryer Functional Capacities 2) Dryer's Temperature 3) Centrifuge Functional Capacities as outlined in figure 3.

Data Collection Plan:

The data collection process is quite straight forward. The dried samples were collected every 3 hours from the dryer then delivered to the laboratory for analysis. The samples collected will be divided into 5 sub-groups and measured using NIR spectroscopy.

NIR spectroscopy:

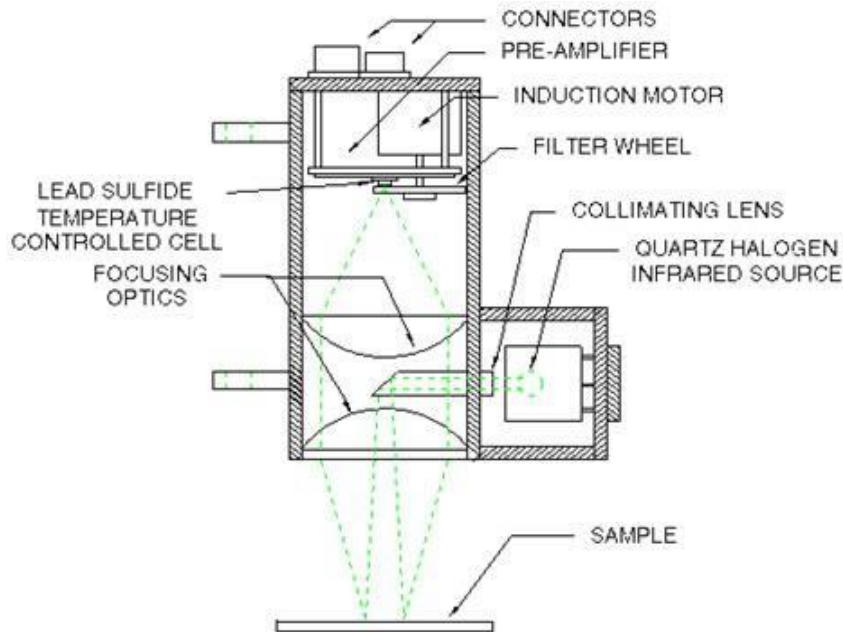


Figure 4 A typical NIR equipment.

Control Chart Plan:

Conclusion:

PVC production technology is now quite mature and seems little left to improve. But with baseline established for both the PVC quality (grade) and process cycle time, the cause-effect diagram can be used to identify potential problems and to propose the proper solutions. The metrics of both quality and cycle time for PVC were defined that allows the plan for both to be set with both the timeline and budget as listed in table 1 and 2.

## References:

1. "Polyvinly Chloride" by Michael W. Allsopp and Giovanni Vianello, retreated at <http://www.mindfully.org/Plastic/Polyvinylchloride/Polyvinyl-Chloride-PVC-Vinyl.htm> on July 31, 2008
2. "Polymerization VCM to PVC", retreated from <http://www.vinythai.co.th/aboutvinythai/ourplant/polymerisationofvcmtopvc/0,,1827-2-0,00.htm> on July 31, 2008.
3. "Manufacturing of PVC resin", retreated from <http://www.solvinpvc.com/faq/pvcresin/1,,55304-2-1,00.html> on July 31, 2008.
4. "polyvinyl Chloride-PVC", retreated from [http://nexant.ecnext.com/coms2/gi\\_0255-3041/Polyvinyl-Chloride-PVC.html](http://nexant.ecnext.com/coms2/gi_0255-3041/Polyvinyl-Chloride-PVC.html) on July 30, 2008.
5. How NIR works, <http://www.moistureregisterproducts.com/faq.htm>