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# Achieving Polyolefin Production Excellence with On-line Process Measurements

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## Introduction

In recent years, the polyolefin (PO) manufacturing industry has faced significant changes and challenges including large-scale mergers, rising energy costs, regional oversupply and inconsistent global economic growth. The impacts of these challenges have resulted in a more competitive environment for polyolefin manufacturers. This environment requires that manufacturers consider productivity improvements that will enable the profitable supply of specialized and commodity PO products into a regional or global marketplace.

Improvements in reactor process control, response time, inventory control and the ability to better utilize plant staff resources are all key to profitable operational success.

This paper outlines three areas where such improvement opportunities exist for PO manufacturers. These include the direct measurement of reaction performance including catalyst feeding, electrostatics monitoring and real-time online resin property analysis. Each one is an essential element for achieving polyolefin production excellence.

## Catalyst Mass Flow Measurements

Even before the polyolefin (PO) reaction, manufacturers clearly need to be sure that high purity feedstocks are available and advanced catalyst systems are chosen to result in efficient chemical reactions. Equally important is the ability to monitor and control the feeding of these constituents to a degree that enables optimum reaction performance.

In particular, the direct determination of the catalyst mass flow as it is fed into the reactor is one of the most critical parameters of a PO reaction. Yet given this critical importance, it is surprising that some PO manufacturing plants still do not have any means of directly measuring catalyst mass flow.

Poor control of catalyst feed will significantly impact production output and product quality. As seen in Figure 1 below, it is clear to see the impact of the catalyst feed on the overall production rate. In addition, unexpected variations in catalyst feed can wreak havoc on process control and polymer properties. Given the difficult nature of feeding catalyst in a multi-phase flow (solid in liquid or solid in gas), it is no wonder that this is a significant problem area for most PO reaction processes.

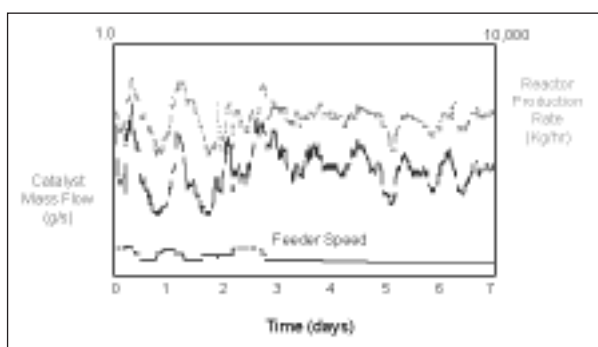


Figure 1: Production, feeder, catalyst and mass flow rate

**progression's** Correflow<sup>®</sup> Mass Flow Monitor (MFM) is designed specifically for the determination of catalyst flow monitoring in polyolefin processes. The MFM is well suited for implementation in-line in the catalyst feed system. With custom-built sensors, the MFM does not introduce any obstruction or additional pressure drop in the catalyst feed line. In addition, the non-contact analysis uses no moving parts so it is a proven reliable

technique for catalyst mass flow monitoring. Figure 2 shows where in a typical PO process the MFM sensor could be located.

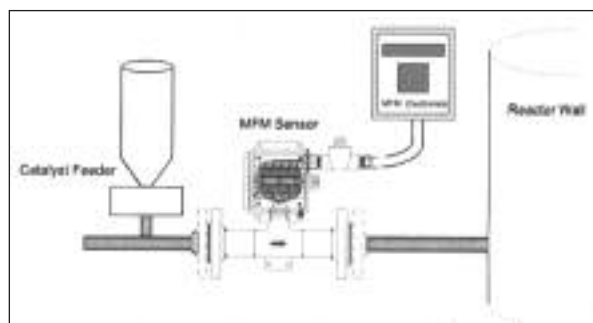


Figure 2: Correflow MFM for gas and liquid phase reactors

The graph in Figure 3 shows that a catalyst feeder system may often operate with less efficiency than expected. This can be caused by a range of problems such as clogging, leaking, partial filling or valve sticking. The ideal slope 1 shows that in the best case, the catalyst feeder rate is directly related to the catalyst mass flow. However, in many commercial scale plants, there is a lower efficiency resulting in slope 2 performance. The resulting "average performance" as shown will have adverse effects on productivity and create difficulty for operators trying to maintain tight PO quality specifications.

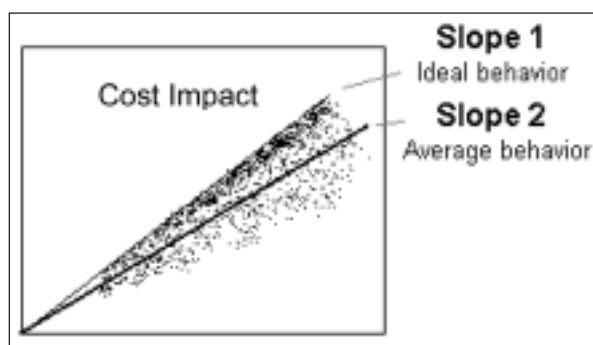


Figure 3: Catalyst mass flow versus feed rate

The use of MFM to perform closed loop control (as shown in Figure 4) can enable PO plants to approach an ideal catalyst delivery performing even with an inefficient feeder system.

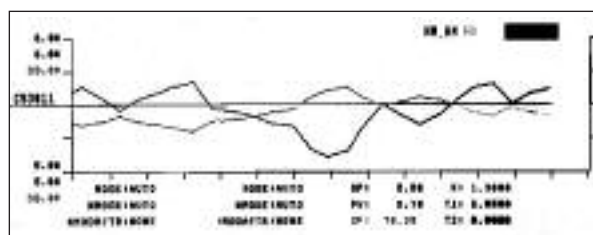


Figure 4: Closed loop control of catalyst feed rate

## Electrostatic Measurements

During the PO reaction process, manufacturers have a range of reaction conditions that are monitored. Parameters such as temperature, pressure, level and composition are commonplace on most plant DCS systems. In recent years, there has been an increased focus put on another basic reaction property: electrostatics. The development of newer high activity catalyst systems combined with advances in reaction technology and reactor size has created a growing need to monitor reactor electrostatic behavior.

In most PO reaction processes, the polymer resin particles will generate frictional triboelectric charges as they move and come into contact with each other and other materials. This activity results in the generation of electrostatic charges. Usually these charges will be generated and then dissipate via grounding paths in the reactor walls/pipes. However, under certain conditions, excess charge build up occurs in the reactor. This excess charging can cause a range of well-documented problems, such as fouling or sheeting on the reactor walls, generation of agglomerations, lower reaction rates, and quality problems due to inefficient heat exchanges. In extreme conditions, electrostatic problems will result in lengthy plant shutdown.

The ability to monitor real-time electrostatic behavior in PO reaction process is now possible in a range of configurations. **progression's** Correflow ElectroStatic Monitor (ESM) is the world's leading technology for the analysis of electrostatic behavior inside a PO reactors.

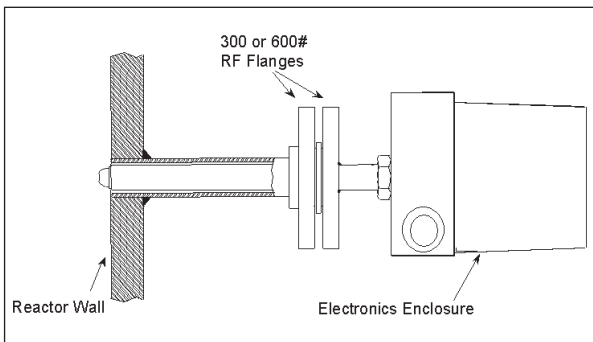


Figure 5: ESM reactor probe and reactor nozzle

Figure 5 shows how the ESM reactor probe would be inserted in a gas phase reactor. The Correflow ESM system is designed to allow up to eight electrostatic probes to be interfaced with one ESM transmitter. Figure 6 shows the corresponding data generated from two electrostatic reactor probes. It is clear that both probe 1 and 2 show an increase in electrostatic activity well before other indications such as temperature.

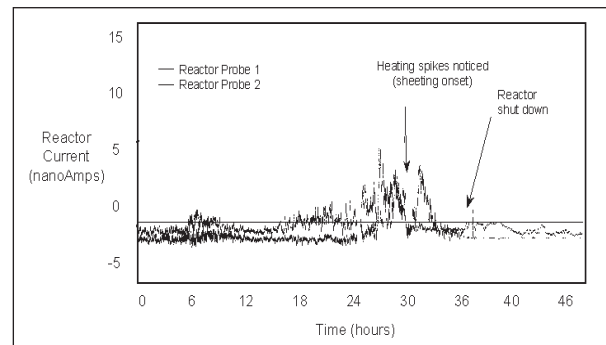


Figure 6: Static probe responses prior to sheeting event

Recent advances in ESM data processing have allowed even more insight into the electrostatic phenomenon in PO reactors. In Figure 7, raw electrostatic signals show an increase in activity, but this signal may be difficult for operators to fully interpret. Figure 8 shows the same ESM data after this signal is separated into AC and DC components.

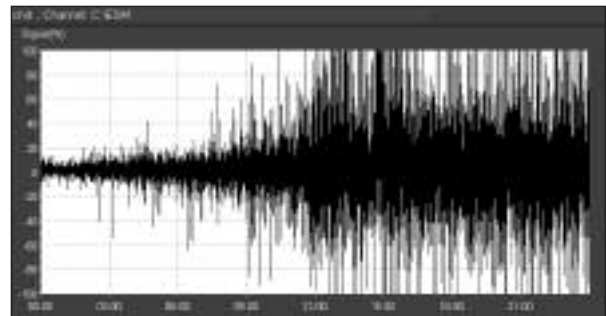


Figure 7: Real-time ESM Reactor probe data.

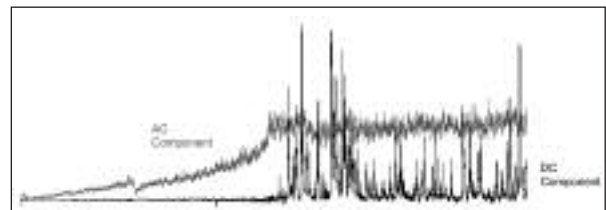


Figure 8: Real-time data de-convoluted

Note how the AC component of the signal changes significantly hours before the DC component varies at all. This same trend can be seen when reviewing data from other reactors.

## Resin Property Measurement

In PO applications, the Magneflow® process NMR system is used to measure chemical and physical properties of the powder or pellets such as density, crystallinity, melt index, xylene solubles, ethylene content rubber content, and melt flow.

In most applications, a small PO sample (<50 ml) is automatically collected by a **progression** supplied sampling system from a transfer line after the reactor, purge tank or extruder. This sample is then pneumatically conveyed to the Magneflow analyser for measurement. After the analysis, the sample is pneumatically conveyed back to the process. The multiple resin properties can be measured and directly reported to the DCS. The entire cycle is then repeated every 5 – 10 minutes. There is no wasted sample or consumable materials. The Magneflow is robust and designed for continuous operation in hazardous locations.

Figure 9 below outlines where the process NMR unit and sampling system would typically be interfaced to a PO plant.

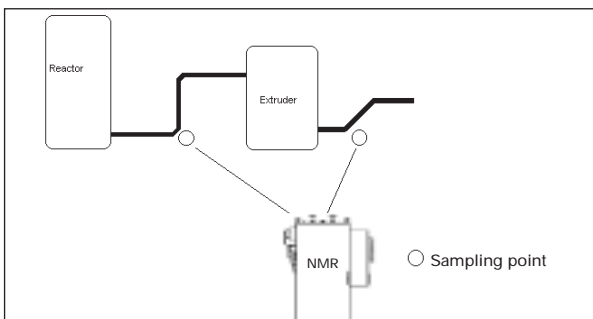


Figure 9: Magneflow sampling locations

### Improving Product Consistency

As noted previously, global and regional competition in the PO marketplace has increased significantly in recent years with the construction of many new world scale reactors. The ability to produce in-spec products consistently is now even more critical for PO producers to maintain key customers and grow market share.

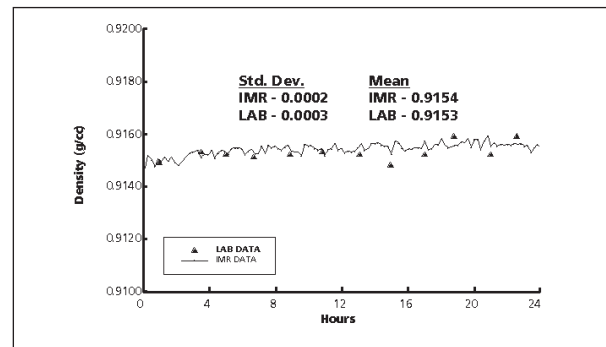


Figure 10: Steady state production results

The Magneflow process NMR system has repeatedly demonstrated the ability to measure in real-time PO resin consistency. The graph in Figure 10 above demonstrates how the on-line Magneflow density results provide continuous feed back to plant operators during this 24-hour steady state production run. The standard deviation as measured by the process NMR system is also slightly better than that of the more cumbersome lab density method.

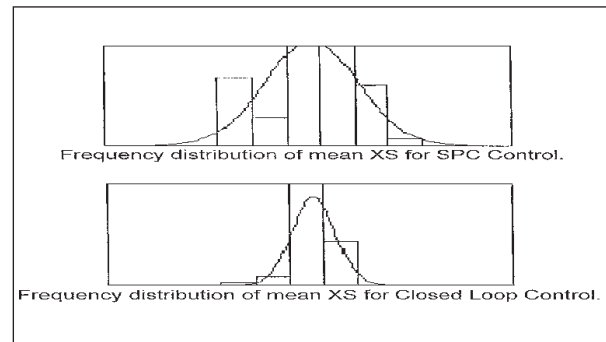


Figure 11

Many users have documented CpK improvements as a result of having on-line NMR analysis of resin properties. One example of such improvement in product consistency is shown above in Figure 11. The data were generated at the same facility with the same operators making the same resin grades. One can see the significant reductions in XS variations from the use of closed loop process NMR. In this example, the NMR distribution is about 3 times better than the lab XS and SPC. Similar CpK improvements have been demonstrated for melt properties as shown in Figure 12.

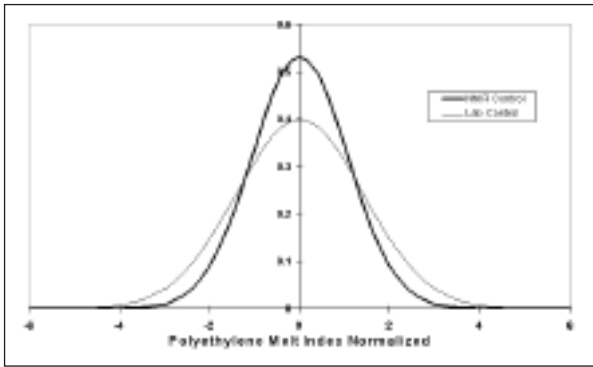


Figure 12: MI consistency improvement with NMR control

### Transition Control

As a result of the trend toward larger PO reactors and higher production rates, it becomes particularly important to have better transition control and better information to determine the start and end point of a product transition. PO resin producers using on-line process NMR have achieved tremendous benefit from the ability to better “mark” transitions and switch to on-spec silos sooner. The graphs in Figure 13 and 14 clearly show how the process NMR system continuously reports key polyolefin properties making it easy for an operator to decide the starting point and ending point of a grade transition. In addition, users of **progression** process NMR solutions have utilized advanced process control (APC) techniques to shorten the transition times by up to 50% in some cases.

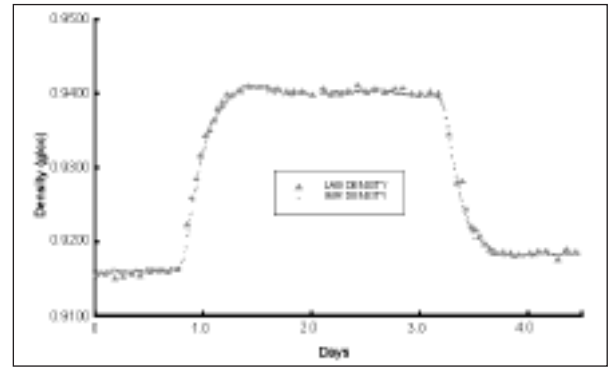


Figure 13: On-line density analysis by NMR compared with lab results

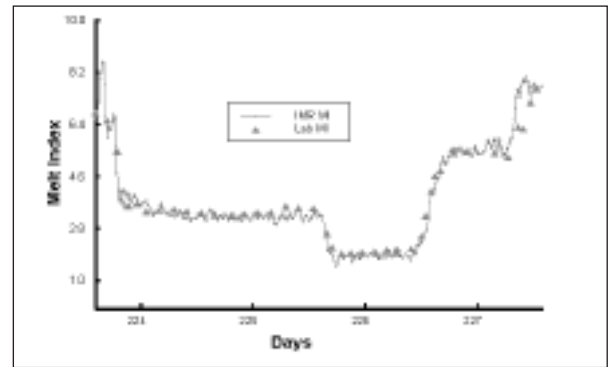


Figure 14: On-line melt index analysis by NMR compared with lab results

### Summary

This paper has presented three improvement opportunities for polyolefin manufacturers in different areas of the reaction process. The direct analysis of catalyst feed mass flow rate, reactor electrostatic monitoring and polyolefin resin analysis by process NMR. Each of these advanced techniques is a proven tool for adding value to a polyolefin manufacturing business.

Plant management must recognize and implement technology advances that will help to ensure increased plant efficiency and profitability.