FEEDER RELIABILITY IN THE EXTRUSION PROCESS FOR POLYCARBONATE

by

Stephen Wallace

May 2015

Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree Master of Science in Industrial Management in the Department of Engineering of the Pott College of Science and Engineering at the University of Southern Indiana

ACCEPTANCE AGREEMENT

Accepted by the Graduate Faculty of the University of Southern Indiana,

in partial fulfillment of the requirements of the degree of

Master of Science in Industrial Management

Dr. Thomas McDonald

Assistant Professor of Engineering

Dr. Marco Lara Gracia

Associate Professor of Engineering

Scott Campbell

Scott Campbell

Senior Asset Operations Manager

SABIC - Specialty Sheet and Film

ABSTRACT

The research paper looks at upgrading the feeder reliability in the extrusion process for polycarbonate. Using three of the Lexan Finishing feeder systems as an example for the other feeder systems, the study discusses the process of extrusion, the proposed changes, and justifications to demonstrate the needs for feeder control upgrades. Moreover, the paper also describes each feeder control items that are proposed to be purchased from Acrison, Inc. The description provides all features of the five items that need to be purchased.

Keywords: Extrusion Process for polycarbonate, Feeder control upgrades, Extrusion process,

ACKNOWLEGDEMENT

I would like to express my special thanks of gratitude to my many professors along the way for guiding, encouraging, and giving me an opportunity to learn so many different paths to success. Each one took the time to work closely with me and help me develop into a stronger leader. I will cherish their abilities to drive a change in me. I would like to especially like to highlight the contribution that Dr. David Schultz made to so many of us by seeing in each of us what could be and not what were, and taking the time to push us each to success. Lastly, I would like to thank Dr. Thomas McDonald for all of his efforts to ensure my success on this Feeder Reliability in the Extrusion Process for Polycarbonate study, which also helped me understand the practical application of so many skills that I have learned. Finally, I would like to thank my family for all the sacrifices that they have made over the years.

TABLE OF CONTENT

List of Figures

List of Tables

Feeder Reliability in the Extrusion Process for Polycarbonate

Introduction

A successful and reliable extrusion process for polycarbonates requires modern equipment with stable conditions as a way of ensuring the approximation of narrow limits that are improved to their actual conditions. The extrusion of polycarbonate requires careful and accurate addition of each raw material required to produce a successful finished product. As such, the quality of the equipment as well as the skill level of the operators impact the quality of the end product.

Literature Review

The understanding of the process of plastic extrusion is critical to lay down the research groundwork. "The plastic extrusion process begins with a predefined recipe that can include plastic resin, colorants, impact modifiers, ultraviolet (UV) inhibitors being fed into an extruder. The ingredients are added at different levels of concentration to reach a finished product that meets a customer specification" (Giles et al., 205). A blend can be made to reach the desired recipe mix, but often times each ingredient is metered into the process through a loss-in-weight feed system. The raw materials are fed into the process in the form of beads, pellets, powder, or flakes as discussed by Vogler (1984). After the proper proportions of raw materials have been fed into the extruder, the mixing process begins as demonstrated in Figure 1.

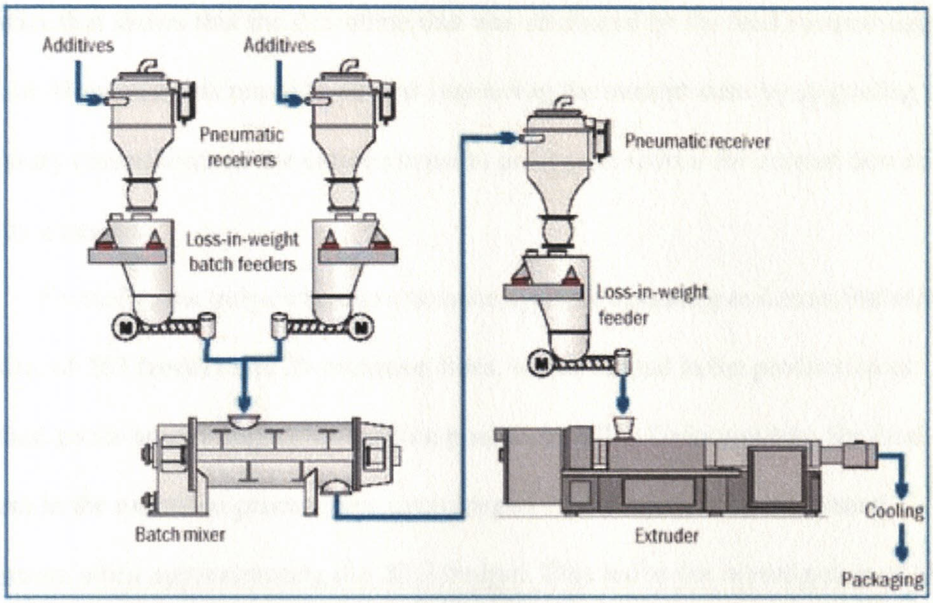


Figure 1 Extrusion Process for Polycarbonate

"A screw, or set of screws, convey and mix the raw materials inside the barrel of the extruder" (Tadmor & Gogos, 2006). Inside the extruder cavity, the temperature profile can range from 400°F (200 °C) to 550°F (288 °C). Different screw designs allow the molten plastic and additive ingredients to homogenize and provide a constant pressure and flow at the output of the extruder. The output of the extrusion process is strands of plastic that must be cooled in a water bath. The strands are then cut into small pellets, which are the finished goods that are sold to customers for molding into everyday products.

However, the purpose of this research study was attributed to the constant downtime failure of the extrusion process for polycarbonate. Therefore, this study aims at investigating the issue of downtime failures of the extrusion processes in order to propose the solutions to the feed systems that focuses on the quality production process. As such, the study aims at providing the detailed proposals for upgrading the Lexan Finishing feeder as an example of maintaining the production rate for polycarbonate extrusion process. The basis of this research study takes root from 2012 statistics that shows that the downtime that was attributed by the feed system was 11 percent. However, this research aims at improving the current state by upgrading the necessary components of the entire extrusion process to reduce the current downtime rate by 2 percent.

Factually, the polycarbonate extrusion systems operating in Lexan Finishing consists of 263 feeders and 25 extrusion lines, which helped in the production of finished goods amounting to 330 million pounds in 2012. Unfortunately, the feed system in the extrusion process was overcharged 11 percent for the unplanned downtime when approximating the 2013 budget. This led to the investigation of the 11 percent downtime that was attributed by the feed system. This investigation includes identifying the trends and operational attributes of the feed system that causes the largest impact to downtime in the extrusion process. Moreover, the research paper also focuses on providing action plans for improvement areas identified, which include recommending changes of equipment and raw material handling as a way of increasing the reliability and productivity of the feed systems.

The focus on upgrading the Lexan Finishing feeder systems, is started by describing the features and the level of quality and reliability to have a successful extrusion process for polycarbonate. The current Lexan Finishing feeder system has 263 loss-in-weight feeders that are responsible for metering the ingredients that can produce the required 330,000,000 lbs of the finished pellets. The 2012 analytical results confirmed that the feed systems were not performing their duties with the desired accuracy and repeatability, thereby decreasing the reliability of the whole extrusion process. Moreover, various factors also contributed to the needs of a research study on the Lexan Finishing feeder system in order to minimize the impact.

They include maintenance downtime, customer complaints, in-lot stops, and internal rejects, among other issues as earlier highlighted by Rauwendaal (2001).

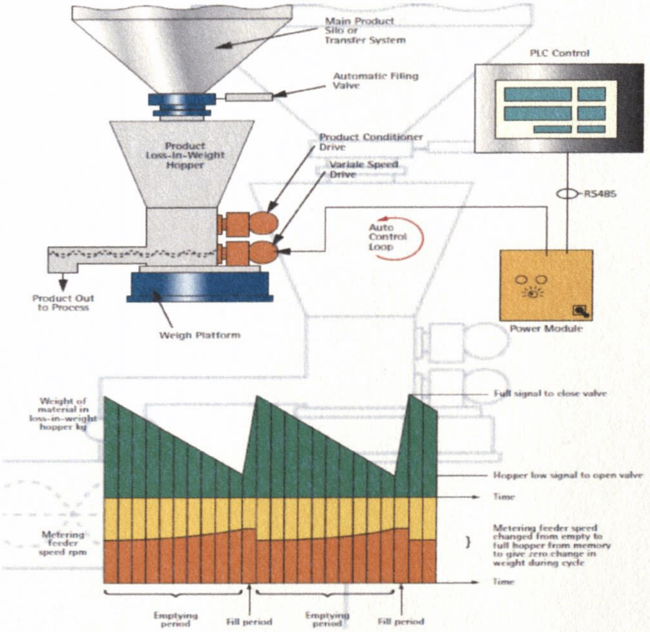


Figure 2 Loss-in-weight Feed system

Lexan Finishing extrusion process for Polycarbonate has the loss-in-weight feed system that is designed to control and weigh the output of various types of products in order to ensure accuracy level is increased to about ±0.25% to ±1% (Ancheh 2008). The loss-in-weight feed system illustrated in Figure 2 works well based on the outlined general principles of operations as stated below:

- The loss-in-weight hopper is rapidly filled via an automatic filling valve.
- The metering feeder starts and feeds product into the process; thus, the weight in its product hopper gradually falls.
- The falling weight is measured every few milliseconds and this information is averaged and stored by the microprocessor as a falling weight per unit time.

- Any difference in the actual loss-in-weight and the desired loss-in-weight is processed and the product feeder is sped up or slowed down in order to make the loss-in-weight identical
- At a pre-set hopper low weight, the metering feeder speed will be locked onto its last averaged value and the filling valve will signal to open, and rapidly filling the hopper.
- When the hopper is again filled, the feeder will be brought back onto automatic control
- Thus the cycle will repeat, with the microprocessor going through a continuous learning curve which will get more accurate with each cycle.
- The cycle time will be approximately 10:1 running to filling e.g. 10 minutes run to 1 min fill, or 5 minutes to 30 seconds fill.

Unfortunately, the Lexan Finishing Feeder system faced various issues that affected its results since the year 2012. The Figure 3 illustrates the current state of feeder downtime in terms of hours.

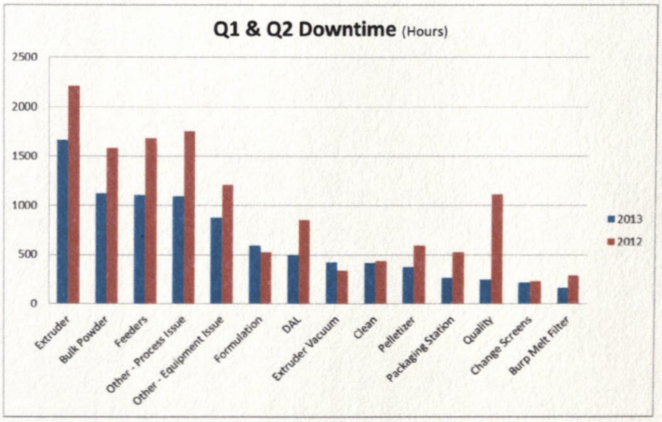


Figure 3 Current State: OEE (AA/AAO)

Table 1 Current State: Feeder OEE (AA/AAO)

Line	OEE Rate	2012 Hours Downtime	2012 OEE Pounds Lost	2013 Hours Downtime	2013 OEE Pounds Lost
14	2,840	148	419,931	172	488,514
20	2,614	99	258,436	134	350,222
23	1,701	122	207,393	40	68,024
24	3,909	259	1,013,298	318	1,243,189
25	4,019	274	1,099,401	252	1,012,889
27	8,160	183	1,494,084	170	1,387,166
28	5,773	243	1,401,190	182	1,050,650
29	5,205	94	488,911	46	239,439
30	4,402	325	1,431,915	110	484,242
31	3,357	105	353,972	98	329,006
C7	891		0	10	8,910
C14	1,428	41	59,006	46	65,679
C16	3,084	29	88,250	46	141,882
C22	6,028	126	760,650	30	180,840
Totals		**2,048**	**11,531,199**	**1,654**	**8,633,772**

In addition, Table 1 provided the current state of the amount lost by the whole feeder system due to downtime. The estimated total amount lost in the 2012's production process was 11,531,199 pounds while 2013 production loss amounted to 8,633,772 pounds.

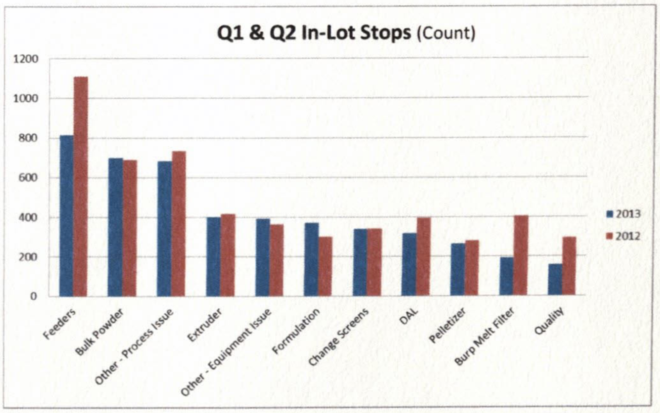


Figure 4 Current State: In-Lot stops (start-up recycle)

Figure 4 illustrates the effects of the in-lot stops due to the loss-in-weight feed system while Table 2 describes the effects of in-lot stops to entire extrusion process. The table illustrates that the total amount of recycle generated because of in-lot stops was 1,726,233 pounds in 2012 and 1,533,740 pounds in 2013.

Table 2 Current State: FEEDER In-Lot stops (start-up recycle)

Line	OEE Rate	2012 Number of Stops per Line	2012 Start-Up Pounds Lost (.25 Hours Runtime)	2013 Number of Stops per Line	2013Start-Up Pounds Lost (.25 Hours Runtime)
14	2,840	143	101,537	182	129,229
20	2,614	74	48,352	88	57,499
23	1,701	104	44,216	50	21,258
24	3,909	116	113,373	226	220,881
25	4,019	153	153,742	208	209,009
27	8,160	118	240,714	106	216,235
28	5,773	149	215,037	150	216,480
29	5,205	69	89,790	40	52,052
30	4,402	141	155,178	70	77,039
31	3,357	83	69,662	58	48,679
C7	891		0	8	1,782
C14	1,428	37	13,207	30	10,709
C16	3,084	26	20,049	42	32,386
C22	6,028	71	106,997	20	30,140
Totals		**1,755**	**1,726,233**	**1,628**	**1,553,740**

As such, the estimated 1628 in-lot stops is critical issue to the functionality and reliability of entire extrusion process since each stop requires a re-stranding of the line as illustrated in Table 3.0.

Table 3 Scope: Feed Systems by line

Line Impacted	Controls Upgrade	Feeder/Scale Upgrade	Tube/Auger Upgrade
14	X	X	
20		X	
23		X	
24		X	
25	X	X	
27		X	X
28	X	X	X
29		X	
30		X	X
31		X	
C7			X
C14			X
C16			X
C22		X	

Proposed Changes

The main action plan is to upgrade focus on three extrusion lines within Lexan Finishing and target the feeder controls, stainless steel concentrate feeder, Teflon tube and auger replacement, and a replacement feeder. Among the features to be upgraded is the feeder whose electronic components are based on old technology that is no longer available. The completion of the three feeder control system upgrades will allow a multi-year obsolescence plan to be developed. This plan is required due to 16 of the 22 feeder control systems in Lexan Finishing were found to be at very high risk due to obsolescence by the manufacturer. On the Stainless Steel Concentrate Feeder Upgrade, the existing carbon steel concentrate scales are corroding and at a high risk of failure. The failure can be intermittent and could affect the metering of raw material without any indication to the system. Teflon Tube and Auger Replacement (with end bearing) is due to the existing equipment does not have an end bearing. The auger becomes distorted and damages the Teflon coating (Sue et al. 1999). Finally, the Replacement Feeder is designed for the Line 28 UV 542 application. A new type of feeder has been designed by the manufacture to handle the raw material in a predictable and repeatable manner. Table 4.0 provides the estimations of project costs for upgrading the Feed System.

Table 4 Project Cost - Feed System Upgrade

Line	Feeder Type	Serial Number	Tube (Teflon Coated) With End Bearing	Scale	Controls Upgrade	Engineering	Installation	Replacement Feeder	Engineering	Installation	Costs
14	Controls				$23,000	$15,000	$30,000				$68,000
14	Concentrate	95182-03		$15,000							$15,000
14	Bulk1	95182-01		$15,000							$15,000
14	Bulk2	95182-02		$15,000							$15,000
20	Concentrate	87422-02		$15,000							$15,000
23	Concentrate	87478-01		$15,000							$15,000
24	Concentrate	88144-02		$15,000							$15,000
25	Controls				$57,000	$15,000	$65,000				$137,000
25	Concentrate	88144-04		$15,000							$15,000
27	UV	89293-01	$7,500								$7,500
27	Concentrate	88144-06		$15,000							$15,000
28	Controls				$61,000	$15,000	$65,000				$141,000
28	542	92458-02		$15,000				$36,000	$15,000	$55,000	$121,000
28	528	92310-01	$7,500								$7,500
28	Concentrate	86188-01		$15,000							$15,000
29	Concentrate	91352-01		$15,000							$15,000
30	542	93297-05	$7,500								$7,500
30	Concentrate	92168-02		$15,000							$15,000
31	Concentrate	86224-01		$15,000							$15,000
C14	528	98011-04	$7,500								$7,500
C16	528	04394-01	$7,500								$7,500
C22	Add1			$15,000							$15,000
C7	528	98102-05	$7,500								$7,500
											$707,000

Justifications of the Upgrading Process

There were several aspects used in the justification that determined the features to be changed in the Feeder System. Among the strong facts were justified by the lines impact that led to several issues in the functioning and production of the feeder.

Table 5 Justification: Lines impacted (Feeder Issues)

Line	2012 OEE Pounds Lost	2012 Start-Up Pounds Lost (.25 Hours Runtime)	2012 Pounds Rejected Internally
14	419,931	101,537	68,164
20	258,436	48,352	3,184
23	207,393	44,216	7,303
24	1,013,298	113,373	35,625
25	1,099,401	153,742	2,489
27	1,494,084	240,714	52,162
28	1,401,190	215,037	2,648
29	488,911	89,790	1,436
30	1,431,915	155,178	
31	353,972	69,662	
C7	0	0	
C14	59,006	13,207	
C16	88,250	20,049	1,760
C22	760,650	106,997	5,280
Totals	**9,076,438**	**1,371,852**	**180,051**

2012 Total pounds Impacted **10,628,340**

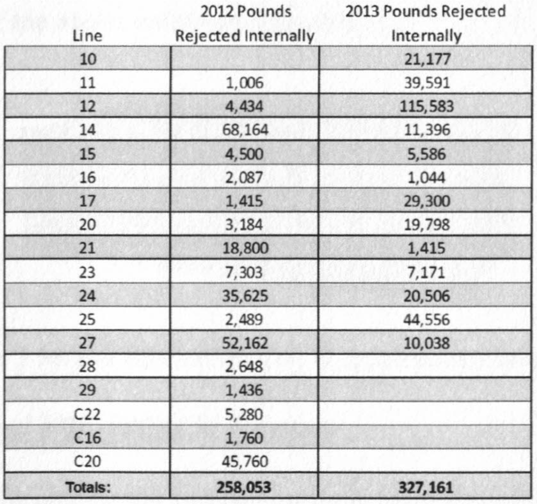
Line	2013 OEE Pounds Lost	2013Start-Up Pounds Lost (.25 Hours Runtime)	2013 Pounds Rejected Internally
14	488,514	129,229	231,166
20	350,222	57,499	58,600
23	68,024	21,258	2,830
24	1,243,189	220,881	14,342
25	1,012,889	209,009	41,012
27	1,387,166	216,235	89,112
28	1,050,650	216,480	20,076
29	239,439	52,052	0
30	484,242	77,039	0
31	329,006	48,679	0
C7	8,910	1,782	0
C14	65,679	10,709	0
C16	141,882	32,386	0
C22	180,840	30,140	0
Totals	**7,050,652**	**1,323,377**	**457,138**

2013 Total pounds Impacted **8,831,167**

As presented in Table 5, the Overall Equipment Effectiveness (OEE) pounds have influential force towards the current upgrade research study. In 2012, the total amount lost was 9,076,433 pounds while the loss of production in 2013 was 7,050,652 pounds. Moreover, the In-Lot Stop also played a crucial role in steering Feeder system upgrades since the total amount of recycle generated as a result of in-lot stops 2012 was 1,371,852 pounds. The 2013 recycle generation of 1,323,377 pounds. The 2013 1628 in-lot stops is critical because each stop involves re-stranding the line and finished goods cut-offs (EHS and Quality).

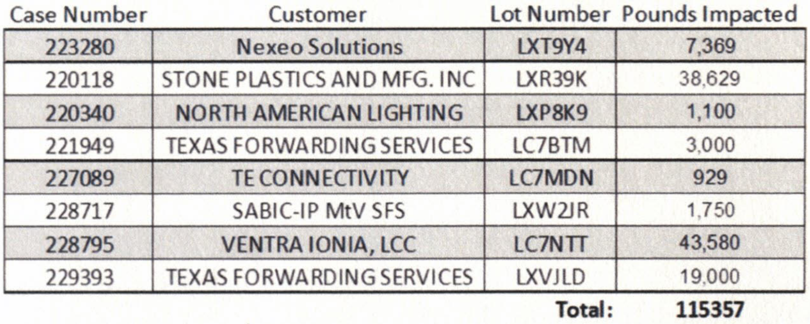
The other justification is the external rejects where clients complained about the quality of the finished goods offered as a result of the extrusion process for polycarbonates. However, this research project has an objective of reducing the customer complaints as well as internal rejects that are directly attributed to the feed system by over 50 percent in the year 2015. Table 6 and Table 7 illustrate the internal and external rejects, respectively caused by the fault features of the Feeder system.

Table 6 Internal Rejects



Line	2012 Pounds Rejected Internally	2013 Pounds Rejected Internally
10		21,177
11	1,006	39,591
12	4,434	115,583
14	68,164	11,396
15	4,500	5,586
16	2,087	1,044
17	1,415	29,300
20	3,184	19,798
21	18,800	1,415
23	7,303	7,171
24	35,625	20,506
25	2,489	44,556
27	52,162	10,038
28	2,648	
29	1,436	
C22	5,280	
C16	1,760	
C20	45,760	
Totals:	**258,053**	**327,161**

Table 7 External Rejects



Case Number	Customer	Lot Number	Pounds Impacted
223280	Nexeo Solutions	LXT9Y4	7,369
220118	STONE PLASTICS AND MFG. INC	LXR39K	38,629
220340	NORTH AMERICAN LIGHTING	LXP8K9	1,100
221949	TEXAS FORWARDING SERVICES	LC7BTM	3,000
227089	TE CONNECTIVITY	LC7MDN	929
228717	SABIC-IP MtV SFS	LXW2JR	1,750
228795	VENTRA IONIA, LCC	LC7NTT	43,580
229393	TEXAS FORWARDING SERVICES	LXVJLD	19,000
		Total:	**115357**

Proposed Controller Upgrades

The research project has identified several items that should be adopted as a way of upgrading the feeder system controls. Therefore, this section aims at providing the description of every product that needs to be purchased for the upgrade. The research study has found all the following upgrading materials as listed and described by the Acrison, Inc.

Item 1 -- Model SBC-2000 Cm Weigh Feeder Controller (For Weight-Loss Feeders)

The Model SBC-2000 Weigh Feeder Controller (shown in various size VME racks) is offered for control of the above referenced feeder(s):

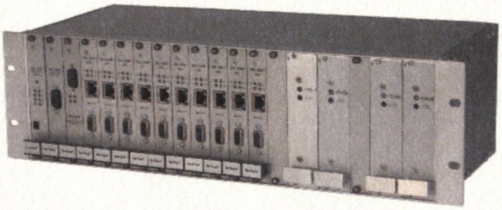


Figure 5 Model SBC-2000 Cm Weigh Feeder Controller

Standard and Optional SBC-2000 CM Features

The SBC-2000 CM Weigh Feeder Controller is designed to control weigh feeders in a panel-mount configuration. It can be furnished as an individual VME rack-mounted Weigh Feeder Controller or a number of SBC-2000 CM Modules that can be supplied VME rack-mounted in a NEMA rated enclosure. Another alternative is to supply the VME rack for installation in a user's enclosure. The SBC-2000 CM is designed as a "minimal hardware" controller used in central control systems, although it does not include display unit or keyboard. The options and features are listed in Appendix 1.

The standard hardware arrangement is as follows:

- SBC-2000 PM CARD RACK TO BE COMMON MOUNTED:
- SBC-2000 Full Size PM Card Rack with MB and Power Supplies
- SBC-2000 CM Controller(s), Rack Mounted (1 for each Weight-Loss Feeder)
- Hard Contact Relays on Standard Outputs, DIN Rail Mounted (Four for each Weight-Loss Feeder)

Item 2 -- Model SBC-2000 DSP Weigh Feeder Indicator

The Model SBC-2000 DSP is a self-contained, single Weigh Feeder Indicator is offered to control the referenced feeders in a panel-mounted configuration.

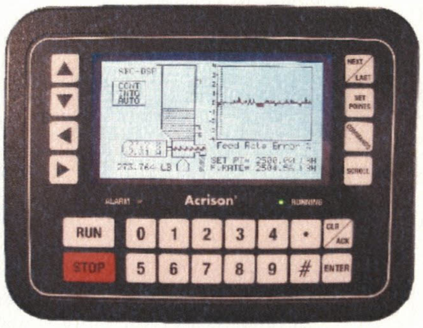


Figure 6 Model SBC-2000 DSP Weigh Feeder Indicator

The SBC-2000 DSP can be furnished as an individual Weigh Feeder Indicator in a NEMA rated enclosure or alternately, multiple controllers may be furnished in a common enclosure. The controller can also be supplied loose for installation in a user's enclosure. It has a state-of-the-art design featuring virtually all CMOS logic, including non-volatile storage of all operating data and set points. The standard and options features of the SBC-2000 DSP are listed in Appendix 2.

ITEM 3 -- Model 060 SCR/DC Motor Controller

This Model 060 Motor Controller (1 HP version shown in both its standard enclosure and less the enclosure when provided in a common enclosure with a weigh feeder controller) is offered to control the above referenced feeders. The standard and optional features of the Model 060 SCR/DC Motor Controller are listed in Appendix 3.

Figure 7 Model 060 SCR/DC Motor Controller

Item 4 -- Common Plate Mounting For Controls

The electrical controls will be mounted on a common plate (a typical common plate mount is shown in Figure 8) with options and dimensions as described in detail. This detail will be provided to meet the unique application and will vary depending on the application. This will require an onsite survey of existing equipment as well as drawings of existing installations.

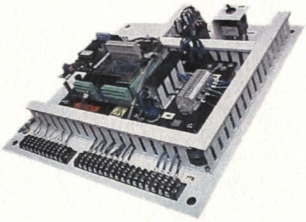


Figure 8 Common Mounting Plate

CONCLUSION

The research study has discussed the manufacturing drivers for the upgrade efforts of the Feeder Control System in order to improve the production, quality, and reliability of Extrusion Process for Polycarbonate. A review of the 2012 and 2013 potential benefits in Table 8 and Table 9 will demonstrate the financial impact of executing this project.

Table 8 Project Impact at 2012 Level of Performance

	2012 Pound Impacted	Contribution Margin	Potential Savings	Predicted 25% Impact	Projected Cost Impact
2012 OEE	9,076,438	$0.60	$5,445,863	0.25	$1,361,466
2012 Start-Up (.25 Hours Runtime)	1,371,852	$0.05	$68,593	0.25	$17,148
2012 Pounds Rejected Internally	180,051	$0.05	$9,003	0.25	$2,251
				Total:	**$1,380,864**

Table 9 Project Impact at 2013 Level of Performance

	2013 Pound Impacted	Contribution Margin	Potential Savings	Predicted 25% Impact	Projected Cost Impact
2013 OEE	7,050,652	1	$4,230,391.20	0.25	1,057,597.80
2013 Start-Up (.25 Hours Runtime)	1,323,378	0	$66,168.90	0.25	16,542.23
2013 Pounds Rejected Internally	457,138	0	$22,856.90	0.25	5,714.23
				Total:	**$1,079,854**

Table 10 Cost/Benefit Summary

	Annual Benefits	**Costs**
Tube (Teflon Coated) With End Bearing		($45,000)
Scale		($210,000)
Controls Upgrade		($346,000)
Replacement Feeder		($106,000)
Contingency 10%		($79,000)
Construction Management 6% of Contract Work		($28,000)
Cap Engineering		($10,000)
2013 OEE	$1,057,598	
2013 Start-Up (.25 Hours Runtime)	$16,542	
2013 Pounds Rejected Internally	$5,714	
Total	**$1,079,854**	**($824,000)**

This study has provided adequate information to establish need and benefit to upgrade the feed systems in Lexan Finishing, Table 10. The recommended action is to proceed with the funding of the project implementing in phases following Acrison's condition based recommendation. The information clearly shows that the expenditure of the $824,000 will provide a payback of less than one year. This coupled with the increased availability of the lines to produce more products will allow Lexan Finishing to be in a positive position to take advantage of future business growth.

BIBLIOGRAPHY

Ancheh, Vahid. *A Study of Polycarbonate/poly (butylene Terephthalate) Compounding in a Twin Screw Extruder.* Waterloo, Ont.: U of Waterloo, 2008. Print.

Giles, Harold F.; Wagner, John R.; Mount, Eldridge M. *Extrusion: the definitive processing guide and handbook.* William Andrew, 2005, p. 151, ISBN 978-0-8155-1473-2.

Rauwendaal, Chris. *Polymer Extrusion, 4th ed*, Hanser, 2001. ISBN 3-446-21774-6.

Sue, Hung-Jue, Hector Dilan, and Chris K.-Y. Li. "Simple Shear Plastic Deformation Behavior of Polycarbonate Plate Due to the Equal Channel Angular Extrusion Process. I: Finite Element Methods Modeling." *Polymer Engineering & Science*: Vol 39(12), 1999. Print.

Tadmor, Zehev. and Gogos Costas. *Principles of Polymer Processing.* John Wiley and Sons, 2006. ISBN 978-0-471-38770-1

Vogler, John. *Small Scale Recycling of Plastics.* Intermediate Technology Publication, 1984 pp. 6–7.

Zuiderduin, W.J.C., and Gaymans R.J. "Polycarbonate Modified with Crystallisable Bis-ester Tetra-amide Units in a Reaction Extrusion Process." *Reactive and Functional Polymers*: 2008, Vol. 68 (2)527-34. Print.

APPENDICES

Appendix 1

Model SBC-2000 CM Standard and Optional Features

- State-of-the-art design featuring virtually all CMOS logic, including non-volatile storage of all operating data and set points
- Time-proven software encompassing many of Acrison's proprietary weigh feeder control algorithms.
- Gravimetric and volumetric control mode selection, including ratio/proportioning and master/slave configurations
- Continuous or batch weighing operation, user selectable
- Automatic compensation for many external factors, including such items as product-bulk-density variations and hopper loading head effect
- Loss-in-weight or gain-in-weight batching capability, as well as volumetric mode of operation
- Deviation alarms for both feed rate and batch amount fed.
- Dual totalization in either continuous or batch modes with non-volatile storage to prevent loss of data; password protected.
- Delayed run/delayed stop feature for special applications.
- Programmable ramp time to set point
- Unique Acri-Lok® and Batch-Lok® features ensure optimum performance should the feeder's weighing system (scale) experience an unexpected disturbance during operation.
- Standard Deviation, Mean, CpK and CV of feed rate.

- Four hard contact relays suitable for direct connection to external devices, in lieu of the open collector digital outputs, are available as an option (see Specific Equipment and Accessories).
- Four additional hard contact relays are available for a total of eight digital outputs (see Specific Equipment and Accessories).
- Dedicated control channel to communicate with a weigh feeder's scale (Weight Resolver Computational Module), a variety of A/C variable speed drives (VFD), and optional analog and digital expansion modules.
- Built-in scale emulation for user training and testing parameters
- Standard certification to UL, CSA and EC specifications in its standard enclosure.
- Serial Communications Channel to interface with various host devices and protocols are available as an option (see Specific Equipment and Accessories).
- "Hot swap" module replacement for quick repairs.
- Power requirements: 115/1/50-60, 75mA; 230/1/50-60, 35mA (DC powered version also available).

Appendix 2

Model SBC-2000 DSP Weigh Feeder Indicator Standard and Optional Features

- Time-proven software encompassing many of Acrison's proprietary weigh feeder control algorithms.
- Gravimetric and volumetric control mode selection, including ratio/proportioning and master/slave configurations.
- Continuous or batch weighing operation, selectable from the keyboard.
- Automatic compensation for many external factors, including such items as product bulk density variations and hopper loading head effect.
- Loss-in-weight or gain-in-weight batching capability, as well as volumetric mode of operation.
- Deviation alarms for both feed rate and batch amount fed.
- Dual totalization in either continuous or batch modes with non-volatile storage to prevent loss of data; password protected.
- Delayed run/delayed stop feature for special applications.
- Programmable ramp time to set point
- Native Ethernet port supports Modbus TCP and Ethernet/IP protocols. Standard serial port is configurable for most industry standard protocols such as Allen-Bradley PLC-5, Honeywell TDC-3000, Modbus RTU or ASCII and others.
- Native Profibus DP channel is standard, and will provide for communication between a Profibus master device such as a PLC and the SBC-2000 DSP.
- Four digital outputs (open collector) and four digital inputs (dry contact) for customer use, user-selectable from over 35 conditions

- Four hard contact relays suitable for direct connection to external devices, in lieu of the open collector digital outputs, are available as an option (see Specific Equipment and Accessories).
- Four additional hard contact relays are available for eight digital outputs (see Specific Equipment and Accessories).
- Dedicated control channel to communicate with the weigh feeder's scale (Weight Resolver Computational Module), a variety of A/C variable speed drives (VFD), and optional analog and digital expansion modules.
- Built-in scale emulation for user training and testing parameters
- Standard certification to UL, CSA and EC specifications in its standard enclosure.
- Serial Communications Channel to interface with various host devices and protocols are available as an option (see Specific Equipment and Accessories).
- Power requirements: 115/1/50-60, 275mA; 230/1/50-60, 230mA.
- Reference Design Specification 1-200-0601.

Appendix 3

Model 060 SCR/DC Motor Controller Standard and Optional Features

- SCR/DC motor controller for DC motors ranging from ¼ to 5 horsepower. For use as a volumetric feeder controller or as the motor controller for use with a weigh feeder controller such as Acrison's MD-II-2000.
- 0-90 VDC armature and 100 VDC field with 115/1/50-60 input or 0-180 VDC armature and 200 VDC field with 230/1/50-60 input.
- Available with either armature or tachometer feedback.
- Speed range: 30:1 (armature feedback); 50:1 (tachometer feedback).
- Load regulation: ± 2% (armature feedback); ± 0.5% (tachometer feedback).
- Digital thumbwheel speed selector for precise speed setting and repeatability.
- Automatic electronic current limiting.
- Adjustable minimum and maximum speed settings (armature feedback).
- Adjustable IR Compensation.
- Optional Console Plate when supplied in a common enclosure, typically as part of a Weigh Feeder Controller.
- Integral circuit breaker in power switch (standard enclosure only).
- Hand/Auto switch (standard enclosure only).
- Overcurrent indicator (standard enclosure only).
- Optional speed indicating meter (standard enclosure or optional Console Plate).
- Optional analog input and/or output: 0-6, or 0-10 VDC; 4-20, or 10-50 mADC; 0-10 kHz (input); selectable.
- Optional serial and data link interfaces, which support most industry standard protocols such as Allen-Bradley PLC-5, Honeywell TDC-3000, Modbus RTU or ASCII and others.

- All steel standard enclosure (shown) is dust-tight and watertight.
- 1 HP enclosure measures 11.8” high x 6.6” wide x 4.7” deep. 5 HP enclosure measures 11.8” high x 11.3” wide x 6.1” deep.
- Available in optional enclosures, plate-mounted, multi-unit/common-mounted, or loose.
- Reference Design Specification # 1-200-437.