Non Production Scrap Reduction in the DVD Manufacturing Process

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Abstract — *As well as many other manufacturing processes the Compact Disc (CD) and Digital Video Disc (DVD) manufacturing companies are in constant perused for price and scrap reduction. This research approach the reduction is non production scrap of polycarbonate by analyzing the major offenders and by implementing several countermeasure actions to reduce and eliminate non required use and generation of scrap of polycarbonate runners, melt and discarded substrates discs. The time zero scrap indicator was in 10% on non-production polycarbonate, the management goal was 3%. At the end of the research many recommendation were put in place and the goal was reached and exceeded.*

Key Terms — *Cost Reduction, Non-Production Scrap, Polycarbonate Reutilization, Re-Grinders*

RESEARCH DESCRIPTION

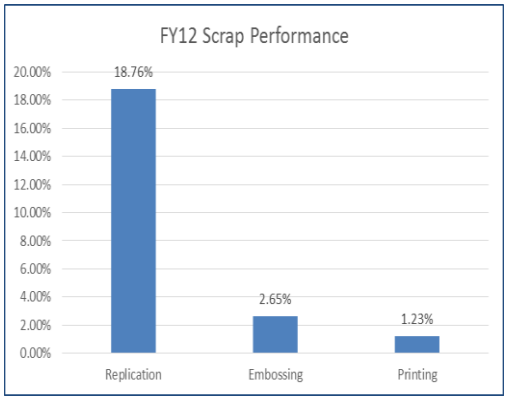
The CD's (Compact Discs) and DVD's Digital Video Discs) are physical media storage data devices. Originally known as CD-DA or Compact Disc Digital Audio was first presented by Philips and Sony Corporation in 1980 [1]. The media came with the promise to lower data storage cost by reducing unit cost to fractions against his predecessor the DAT (Digital Audio Tape), USB Flash Dive and 3.5" Floppy Disc. The estimated media cost of a DVD-R is $0.05/GB against $12.50/GB with 3.5" Floppy Discs format [2]. The manufacturing process of Compact Discs (CD's) and Digital Video Discs (DVD's) is under constant direct pressure from Quality, Manufacturing Volumes and Cost, among other indirect factors. Quality has a special meaning in Microsoft Corporation since the key objective in customer satisfaction is not only to have a happy customer but have a delighted customer with the product acquisition. It is a starting point in the development and implementation of the manufacturing process to create a system to deliver a level of quality capable of precisely that, a delighted customer. Manufacturing volumes is a requirement by any modern standard to guarantee site longevity and job security. Cost is the variable most watched and talked about in any corporation, and the main driver for improvement projects in almost any department. Keeping production on budget is the main goal of managers, engineers, and supervisors.

Scrap generated in the manufacturing process is one of the seven wastes and all companies assign resources to reduce and eliminate scrap at the source. The CD's and DVD's manufacturing generate scrap in all steps; Replication, Embossing (Anti-Piracy/Branding), Printing and Packaging.

CURRENT CONDITIONS

Replication is the process step responsible for the biggest part of the scrap, accountable for 18.67% on fiscal year 2012. Refer to Table 1, Scrap by Process Step on Fiscal Years 12. Also represent to represent 83% of total Scrap.

Table 1
Scrap by Process Step on Fiscal Years 2012



The scrap generated in the replication process could be in form of non-used discs (substrates), discarded runner or sprue (remaining section of plastic through which the melted polycarbonate flows, and then solidifies, it is inherent to the injection mold design. For every disc, two piece of runner are discarded as scrap. This sprue accounts for 0.39g or 5% of the total disc weight). The third one is melted polycarbonate purges from the molding equipment. All that is called non-production scrap or clear scrap since is translucent by the lack of the metallization process. Also additional scrap could be generated by the scanner at the end of the process and that's called process scrap. In the replication manufacturing process the scrap is divided in two categories, process scrap or metalized scrap and non-production or clear scrap. Process scraps represent a 55% from total scrap and non-production or clear represent a 45%. Refer to Figure 1.

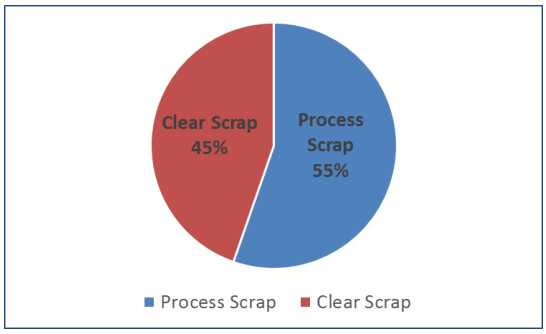


Figure 1
Replication process Scrap Breakdown FY2012

As of Fiscal Year 2012 the total value on raw material of the scrap material is nearly $302,000.00. Refer to Table 2.

Table 2
Total Production Scrap Cost on Fiscal Year 2012

Date	Production Scrap Quantity	Pounds of Resine 0.0355 pounds/DVD	Resin Cost ($1.56/pound)
July FY12	471,450	16,736.48	$ 26,109
August FY12	1,269,325	45,061.04	$ 70,295
September FY12	1,073,163	38,097.28	$ 59,432
October FY12	836,082	29,680.90	$ 46,302
November FY12	539,360	19,147.28	$ 29,870
December FY12	562,640	19,973.71	$ 31,159
January FY12	244,576	8,682.44	$ 13,545
February FY12	454,596	16,138.15	$ 25,176
		YTD Lost=	$ 301,887

OBJECTIVE

The purpose of the this project was to identify opportunities and develop countermeasures to reduce the clear scrap waste by developing monitoring systems, identify sources of scrap and establish strategies to reduce the generation of the scrap at the source.

METHODOLOGY

Methodology calls for a performance indicator as a first step to assess and follow on process improvements. The indicator was established based on process steps posted in Dynamics Ax MOPR (Microsoft Operations Puerto Rico) ERP (Enterprise Resources Planning) system. The posting will be presented in a bowling chart for the elements of Total Scrap, Production Scrap and Non Production Scrap. The staff of Microsoft Operation Puerto Rico establishes a goal of 3% for nonproduction clear scrap.

The clear scrap is generated by three sources: sprues, clear discs and by melted polycarbonate as stated earlier. Refer to Figure 2. Strategies were developed around the sources of scrap to reduce or eliminate the generation of the aforementioned non production scrap sources. Through the discussion of the methodology, it was noticed that regrinding equipment was available at the plant but it had been disconnected or not in-use. This equipment is designed to recycle (integrate) each sprue back into the material. The reconnection of the re grinders became apriority and the first improvement task.

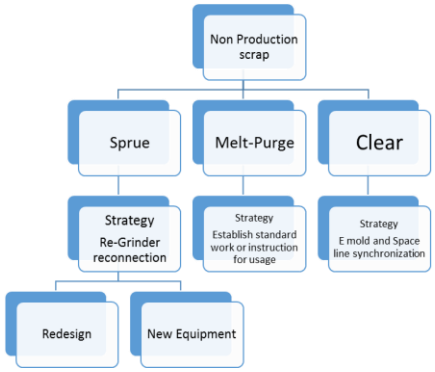


Figure 2
Replication Process Scrap Breakdown FY2012

RUNNER RELATED SCRAP

The re-grinders are equipment's designed to reprocess material and to reduce virgin material usage from 5% to 7% [3]. The re-grinder utilizes a screen and knife design with a low rpm drive to create a uniform sized pellet, without generating dust particles with minimum if any effect on the optical disc production yield. The system is positioned adjacent and in-line with the replicating machine. Refer to Figure 3. The material is constantly being reintroduced back into the injection molding process.

A session was held with operators, engineers and technicians to challenge the actual re-grinder design. It was early in the meeting that the group the reasons for the disconnection of the equipment were due to original design and integration problems. With the team, elements of product flow, hoses dimensions, connectors and line vacuums were challenged. Key equipment components were challenged and the following changes were identified and implemented;

- **Hose Diameter** - Hoses were changed from 1.5" to 2" to accommodate the 1.5" sprue size. These new hoses were clear and not corrugated allowing for an uninterrupted flow from the picking place of the sprue to the re grinder hopper.
- **Hopper intake** – Intakes were enlarged to fit the 2" hoses. Also the orientation of the intakes was aligned facing both entrances to the same side. The alignment of the intakes helps to eliminate hose close corners where the sprues have the tendencies to jam. A local machine shop was contracted to perform the modification.
- **Ventury Valves** - Vacuum valves were also increased to 2". The Ventury vacuum was also relocated and oriented as vertical as possible and as closer as possible to the sprue collecting point.
- **Knives** - The stationary knives was placed at a distance of 0.01 cm from the rotary knives as instructed in the equipment manual [4].

The re-grinder equipment installation began on February 2012 and finalized on August 2012 (FY13). A project plan was prepared to schedule the intervention one molding machine at the time. Also the procurement of new components parts as well as the modification of the equipment's added to the lead time. In each installation a special team was developed with the technicians to provide a close monitoring of the performance and a rapid intervention of any condition impacting the re grinder or the manufacturing process. One important consideration was to work around manufacturing priorities without impacting manufacturing up-time. One very important part was the development of an operational parameters list. The group proved that the factory programed parameters, did not always yielded the best performance. Refer to Table 3 Replication Equipment's Parameters List. Parameters were then optimized, taking in consideration equipment cycle time and hose measurements as key response elements. A parameters table was used to document the optimized parameters for each replication line.

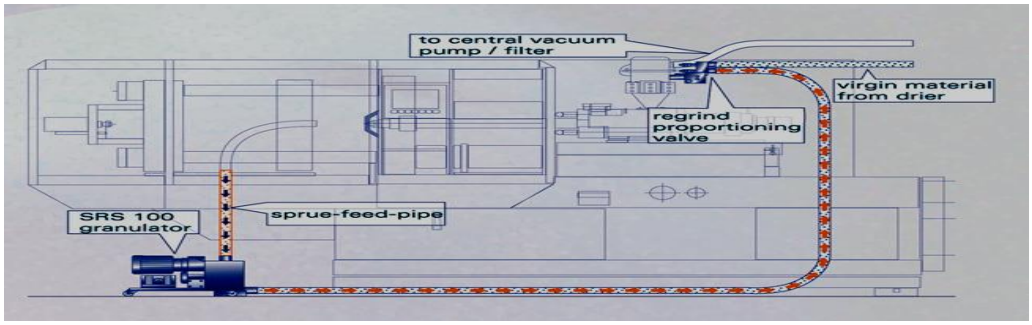


Figure 3
Pictorial of E-Mold and Re-Grinder System

Table 3
Replication Equipment's Parameters List

Parameters List										
E Mold	Line Vac blow PSI		Delay time to activate Line Vac.				Regrind material open valve		Line Vac Blow Time	
#	PSI C0	PSI C1	T1 (seg.)		T2 (seg.)		T3 (seg.)		T5 (seg.)	T6 (seg.)
			As Found	As Left	As Found	As Left	As Found	As Left		
DVD5	90	120	0.5	0.5	0.5	0.5	5	5	1.5	1.5
DVD6	110	105	0.5	1	0.5	1	7	7	1.5	1.5
DVD7	120	120	0.5	1	0.5	1	8	8	1.5	1.5
DVD8	100	100	1.7	1	1.7	1	6	6	1.5	1.5
DVD9	120	120	1.2	1.2	0.5	1.2	5	5	1.5	1.5
DVD10	150	110	0.5	0.5	0.5	0.5	4	4	1.5	1.5
DVD11										
DVD12	100	100	0.8	1	0.8	1	4	4	1.5	1.5

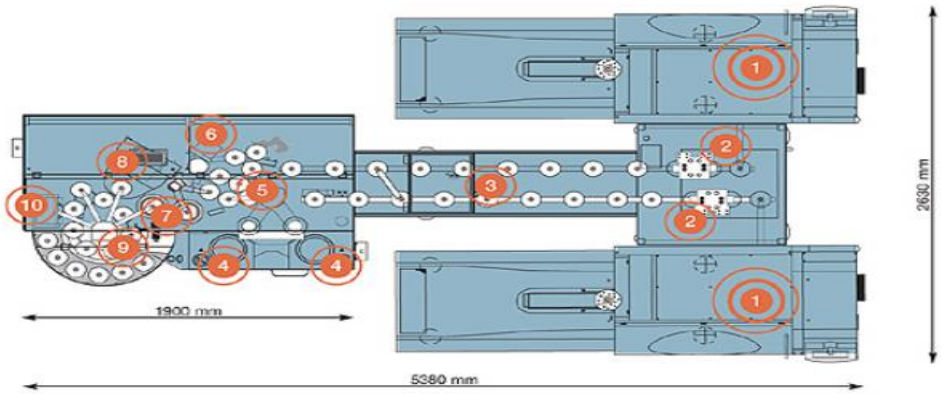


Figure 4
Pictorial of E-Mold and Re-Grinder System

CLEAR DISCS RELATED SCRAP

The Synchronization of E-Mold (Injection Molding Equipment) and Spaceline (Metallization/Replication) was a very powerful addition to the project perspective since it addressed the correct setting and performance of the E-Mold reducing and eliminating the generation of clear discs scrap from the source. One DVD manufacturing line work with three major components, two E-molds and one speceline. Refer to Figure 4 (1 - E-Mold Injection Molding; 2 - Spin Cooling Unit; 3 - Input Conveyor; 4 – Metalizer; 5 - Bonding Dosing; 6 - Bonding Station; 7 - Spining Station; 8 - Ultra Violet Curing; 9 - Final Cooling Conveyor; 10 - Scanner). Each E-mold generates one face of the disc (substrate) and the Spaceline bonds them together, performs the metallization and the final 100% visual/optical scan inspection. Both E-molds have to work with the same cooling and cycle times while synchronized with the Spaceline have to work with the same cycle time as the e-mold. If one E-mold is faster or slowest than the other the equipment takes the decision to discard the substrate produced in that side to wait for the other substrate and get back in sync again.

To correct that situation a daily monitoring and training program was initiated with the process operators and technicians to learn how to detect and fix the situation. As training material for discussion we used the E-mold controls pages to assess the cycle and cooling times. Daily Gemba walks was introduced to evaluate, detect and restore changes to the parameters summarized below (Table 4).

Table 4
Synchronization parameters for Replication Line

Date:					
Repl. Line	5		Comments:		
Layer 0		Layer 1			
Cooling Time		Cooling Time		Space Line	
Layer 0	□OK/□Not Ok	Layer 1	□OK/□Not Ok	Re-Grinder	□OK/□Not Ok

Also a quick verification process was performed with the help of the operator to detect and remove any disc, substrate or sprues in the slide chute area that may cause a jam. The operator communication was very important because their proactive intervention could save many minutes in down time to the re grinder and manufacturing equipment.

PURGE RELATED SCRAP

The purge or melted polycarbonate scrap is inherent to the molding manufacturing equipment, since it is required to clean the injector at the end of the shift. Also the injection and related systems are purged at the beginning of the shift to raise the equipment to the required temperature and polycarbonate viscosity. By the use of standard work measurements a defined quantity and time of purge was determined to prepare the equipment for manufacturing and at the same time use the smallest amount of polycarbonate possible. The amount of 2.5 to 3.0 pounds of polycarbonate was found to be the required quantity for the purge. It takes around 40 minutes to the operator and technician to execute the task of purging and warm up the equipment to the operational readiness. The standardization of this necessary task was a key factor to the project reductions of clear scrap to get closer to the goal by providing a predictive amount of scrap for startups.

The injection molding equipment needs to keep polycarbonate's temperature and viscosity constant. When idle, the machine has two different modes of maintaining these conditions: a Stand-by (warm) mode where the equipment is partially turned off without purging. The other is by programing a slow cycle where the equipment generate one substrate in each side of the E-mold every 3 minutes. This low cycle alternative is very effective to keep the equipment in operational condition. Because the operational status, it can be achieved immediately without the need of purging. However in the other hand this low cycle alternative is producing a clear scrap disc every 3 minutes as well.

By the standardization developed in the purge management a decision was made to leave the equipment's in Stand-by mode and not in slow cycle between shifts or whenever more than 60 minutes of idle time have gone by. The task was centralized in the technicians with information from the manufacturing manager. At the end of the shift the manufacturing equipment was placed in the standby mode. At the start of the day only the equipment's required to complete the daily schedule were purged and placed in slow cycle. This agreement helps in the elimination of the clear disc scrap generated over night or between prolonged hours of inactivity by the manufacturing equipment.

RESULTS AND DISCUSSION

Many positive results are credited to this project. From overall line cleanness to operator safety. The main task of the project was to reduce the accumulation of clear scrap in the CD/DVD molding process and the established goal was to take it to 3.0%. The result for the month of December 2012 is 2.93% of clear scrap produced. Refer to Figure 5. The Year to Date for the fiscal year 13 is 2.86% (Fiscal year from July 2012 to June 2013). The clear scrap indicator is under 3% for the last five months.

Other positive contribution in the reduction of clear scrap is related to the task of the manufacturing process operator who otherwise has to remove a bin from under the machine and discard the accumulated scrap. The reduction in scrap helps reduce the opportunity of an injury by reducing or eliminating the weight to be lifted by the operator from under the machine. Whit the re

grinders properly working the operator just collect by hand the accumulated disc in the bin without removing the bin. This was an unexpected contribution brought up by the operators.

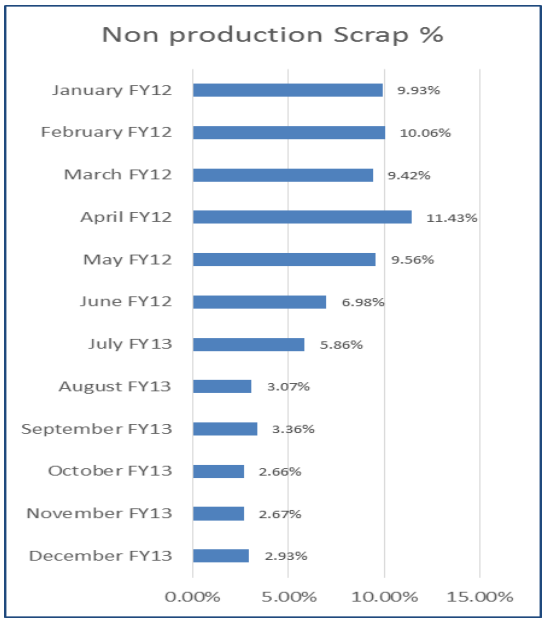


Figure 5
Implementation Results

The savings associated to the re grinder equipment implementation reached the $80,000.00 in the last seven months (Table 5). All this, with minimum expenditures, since the re grinder equipment was purchased five years ago and was already depreciated.

Table 5
Saving Due to Implementation

% Reduction	Less Disc Scrap	Less Pounds Polyc Used	Money Saved
2.20%	36,471	1,295	$ 2,019.75
3.32%	46,559	1,653	$ 2,578.45
6.11%	402,879	14,302	$ 22,311.44
5.82%	301,976	10,720	$ 16,723.44
6.52%	286,870	10,184	$ 15,886.83
6.51%	216,010	7,668	$ 11,962.64
6.25%	151,069	5,363	$ 8,366.18
		51,185	$ 79,848.73

From a financial perspective, if we use a straight Return On Investment (ROI) function to judge project benefit the equipment get paid already in the first seven months of implemented and are projected to bring a hard saving of $30,000.00 by the end of fiscal year 2013.

CONCLUSION

The methodology adopted was effective to reduce the non process clear scrap since it was implemented in different fronts, the source and the residual runner or sprue re integration. The re-grinder implementation proves to be a reliable method to re-integrate polycarbonate to replication process without impacting product quality and equipment up time. From the results observed the re-grinder equipment's meet the expectation of reduction the polycarbonate usage from 5% to 7%. Also the implementation of work standards to reduce and standardize the purging exercise and parameter list implementation help to reduce even more the scrap factor.

Recommendations

From the successful implementation of the re grinder equipment's another initiative was born to implement the technology to an additional there replication equipment's of DVD's recently acquired. The task is a bigger challenge since the re grinder to be used are designed for CD's replication equipment's and a retrofit for DVD replications equipment's is required.

Another pending task is to establish a manufacturing schedule of required equipment's base in equipment's capacity and sales requirements. This initiative will provide a more accurate amount of equipment's to be used by days or by weeks allowing the rest of the no required equipment's to be shut down.

REFERENCES

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