

Cycle Time Reduction to Increase Productivity of DVD Production

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Abstract: *The prime objective of any enterprise is to earn profit by selling their goods in market and/or providing services to customers. These days, many firms are focusing on continuous improving in quality and customer delight. A continuous search for areas of improvement in the production system is needed to survive in the trend of globalization. To achieve this objective, the firms need to convert some inputs like manpower, materials, capital, energy, information, etc. into useful outputs like finished products and services in required quantity and quality. To profit as corporate goal the focus now is on good quality, customer satisfaction and improvement in the product and production system. Productivity is defined in term of utilization of resources, like material and labor. In simple term productivity is the ratio of output to input. Therefore, productivity can be improved by a) controlling input parameters, b) improved process, c) advanced technology. To increase the production quantity and reduce manufacturing cost in DVD manufacturing, the cycle time of DVD production was reduced by controlling some input parameters and its effects which have been discussed in this paper. This has considerably improved the productivity of DVD production.*

Keywords: DVD, productivity, cycle time reduction.

1. Introduction

Cycle time reduction is one of the most important parameters of the successful manufacturing process today. More and more customers desire that manufacturers quickly respond to their needs, deliver perfect quality product on time. This trend, which will continue, has lead companies to focus more attention on their order-to-delivery cycle time without compromising the quality. Order-to-delivery cycle time reduction is often a good place to start in the overall effort to improve operations because it can be done without large capital investment. Clearly, long cycle times cause large inventories, high cost and poor customer service. As a result, many manufacturers are streamlining internal and external supply operations to reduce overall order-to-delivery cycle time.

Customers generally evaluate a supplier's performance, on four factors: product performance (features), prices, quality and delivery within a reasonable time. In the past years, manufacturers made product and stored them into finished goods (i.e. time "make-to-stock" mode) and waited for customers to place orders to buy them. In this "push" production model, large runs of batches of products are proceed using highly inaccurate sales forecast. In contrast, today it is the customer who largely dictates what products are manufactured and when. The customer says "I will let you know what and how many I want; when I'm ready to buy; and then you ship it exactly as I want the product configured; and in a very short lead time:". Cycle time is the time required to complete a given process. Cycle time reduction is identifying and implementing more efficient ways to do things. Reducing cycle time requires eliminating or reducing non-value-added activity, which is defined as any activity that does not add value to the product. An example of non value added activity in which cycle time can be reduced or eliminated include repair due to defects, machine setup, inspection, test and schedule delays, reducing cycle time will have implemented. Reducing cycle time

gives benefits as reduced costs, increased throughput, improved communications, nominal process variability, scheduled integrity, and improved on-time-delivery.

2. Productivity

Productivity is a measure of output from a production process, per unit of input. For example, labor productivity is typically measured as a ratio of output per labor-hour, an input. Productivity may be conceived as a metric of the technical or engineering efficiency of production. As such, the emphasis is on quantitative metrics of input, and sometimes output. Productivity is distinct from metrics of allocative efficiency, which take into account both the monetary value (price) of what is produced and the cost of inputs used, and also distinct from metrics of profitability, which address the difference between the revenues obtained from the output and the expense associated with consumption of inputs.

There is considerable evidence that producer-level churning contributes substantially to aggregate (industry) productivity growth, as more productive businesses displace less productive ones. However, productivity has been limited by the fact that producer-level prices are typically unobserved; thus within-industry price differences are embodied in productivity measures. If prices reflect idiosyncratic demand or market power shifts, high "productivity" businesses may not be particularly efficient, and the literature's findings might be better interpreted as evidence of entering businesses displacing less profitable, but not necessarily less productive, exiting businesses. In this paper, we investigate the nature of selection and productivity growth using data from industries where we observe producer-level quantities and prices separately. We show there are important differences between revenue and physical productivity. A key dissimilarity is that physical productivity is inversely correlated with plant-level prices while revenue productivity is positively correlated with the prices. This implies that previous work linking

(revenue-based) productivity to survive has confounded the separate and opposing effects of technical efficiency and demand on survival, understating the true impacts of both. We further show that young producers charge lower prices than incumbents, and as such the literature understate the productivity advantage of new producers and the contribution of entry to aggregate productivity growth.

3. DVD

DVD-R and DVD+R discs can be either single or double-sided. A single-sided (SS) disc is composed of a recording side and a dummy side while a double-sided (DS) disc consists of two recording sides. The recording side of a DVD-R and DVD+R disc is a sandwich of a number of layers. First comes a polycarbonate plastic substrate containing a shallow spiral groove extending from the inside to the outside diameter of the disc. A DVD-R disc additionally includes pits and lands on the areas between the coils of the groove (land pre-pits). Added to this substrate is an organic dye recording layer (azo, cyanine, dipyrromethene or others) followed by a metal reflective layer (silver, silver alloy, gold). The dummy side of a single-sided disc consists of an additional flat polycarbonate plastic substrate (sometimes with an additional metal layer to obscure the bonding layer from view for aesthetic purposes). An adhesive, then bonds two recording sides (for a double-sided) or a recording and a dummy side (for a single-sided) together into the final disc. Some single-sided discs are also tapped on the dummy side with decorations or additional layers that provide surfaces suitable for labeling by inkjet, thermal transfer or re-transfer printers.

4. DVD Manufacturing Process

The first step in manufacturing a DVD-R or DVD+R disc is to fabricate the polycarbonate plastic substrates (incorporating the spiral groove and land pre-pits) using an injection molding process. The dye is then applied using spin coating and the metal layers by means of DC sputtering. After both sides of the disc are completed, they are bonded together using a hot melt, UV cationic or free radical process. Additional decoration or printable layers are typically applied using screen printing methods. A DVD-R (General) disc undergoes a further manufacturing step in which a specialized computer DVD recorder is used to “pre writes” information in the Control Data Zone of its Lead-in Area to inhibit direct copying of prerecorded DVD-Video discs encrypted with the Content Scrambling System (CSS).

Apart from this, and some minor differences in the configuration of the molding stumper used to create the substrates, the process for manufacturing DVD-R and DVD+R discs are virtually identical. To allow information to not only be written, but also re-written many times over, DVD-RW, DVD+RW and DVD-RAM (rewritable) disc construction is more complex than that of DVD-R and DVD+R (recordable). Just like a recordable disc, a rewritable disc can be either single or double-sided. The recording side of a rewritable disc also uses multiple layers beginning with a polycarbonate plastic substrate containing a shallow spiral groove extending from the inside to the outside diameter of the disc. A DVD-RW disc additionally includes pits and

lands on the areas between the coils of the groove (land pre-pits) and a DVD-RAM disc also inside the groove itself (land and groove). Next comes a dielectric layer (zinc sulfide and silicon dioxide), followed by a phase-change alloy recording layer (either indium, silver, tellurium and antimony or germanium, tellurium and antimony), another dielectric layer and a metal reflective layer (silver, silver alloy, aluminum). Additional layers may also be incorporated above or below the dielectric layers (germanium nitride, silicon carbide, silicon dioxide, silicon nitride, zinc sulfide, antimony telluride and others). The dummy side consists of a flat polycarbonate plastic substrate, sometimes with an additional metal layer. An adhesive, then bonds the sides together into a single disc. The exterior of the recording side may also be “hard coated” with a transparent material (indium tin oxide, silicon-based lacquer and others) designed to repel dust and resist fingerprints and scratches. Similar to a barcode in appearance, a DVD-RAM or DVD-RW disc can also contain near its inner diameter an optional Burst Cutting Area (BCA) or Narrow Burst Cutting Area (NBCA) to supply information required to implement Content Protection for Recordable Media (CPRM). Apart from the thinner substrates and tighter manufacturing tolerances, the most significant difference between writable DVD and CD manufacturing is the need to perfectly bond two DVD halves together to create a disc that is the same thickness as a CD (1.2 mm). It is imperative that the two disc halves have the same long-term mechanical behavior to ensure that the resulting disc maintains its thermo-mechanical stability. This is particularly important for high-speed discs where flatness and uniformity are paramount. Writable DVD disc manufacturing equipment and production steps (with the addition of the bonding stage) closely resemble those used to fabricate their CD counterparts. In fact, many media manufacturers have simply modified their existing CD-R and CD-RW equipment to produce writable DVD discs, although it is generally expected to become less feasible to do so (for productivity and product quality demands) as the technology and business evolves.

Table 1: Process conditions

Sl. No.	Parameters	Specification
1	Dye Volume	0.40 +/- 0.05g
2	Needle Height	1.8 + 0.6 mm
3	Airflow on the cup	0.9 to 1.2 m/sec
4	Dye cup exhaust setting	1.0 – 1.6 m/sec
5	Dye pressure	100 mbar
6	Humidity	40 ~45% + 1%Rh
7	Temperature	25-27.0°C+ 0.25°C
8	Needle Angle	15 degree
9	Needle diameter	0.8mm
10	Ionization Pressure	1.5 ~2.0 bar
11	Dye concentration	1.40 gm/100cc

4.1 Raw Materials for making DVD

- 1) Polycarbonate (PC): It is prime raw material.
- 2) Dye: Azo Dye (A Powder mixed with TFP or OFP Liquid Solvent).
- 3) Silver Target: A 4 kg. Silver target which makes 50,000 discs.
- 4) Methyl Lactate (ML): It is used for removing excess dye and silver particle from disc.

- 5) Bonding Bucket: A kayerd 750 bonding bucket is used for permanent joining of an active disc and a dummy disc.
- 6) Acetone: It is used for cleaning any part of the PLC machine (Bonding area, Dye area etc.).
- 7) IPA: It is used for cleaning any part of the PLC machine (Bonding area, Dye area etc.).

4.2 Operating Station

Active/dummy molding ⇒ Pre-cooler ⇒ Input conveyer ⇒ Cooler ⇒ Dye coating area ⇒ Printer ⇒ Q.C.1 scanner ⇒ Dryer ⇒ Metalizer ⇒ Edge washing ⇒ Bonding ⇒ U.V. Cooler ⇒ Q.C.2 Scanner ⇒ Receiver area.

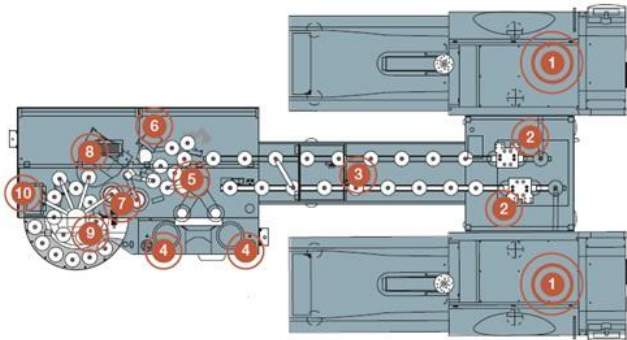


Figure 1: A Typical Layout of DVD Manufacturing Unit

In above fig. 1, (1) Injection moulding (active & dummy), (2) Pre-cooler, (3) Input conveyer, (4) Metalizer, (5) Edge washing, (6) Delay table, (7) Bonding zone, (8) UV cooler, (9) QC2 scanner, (10) Receiver.

4.3 Functions of different units in a DVD manufacturing unit

- 1) *Operation at Active and Dummy Molding:* At first Poly Carbonate (PC) is coming into the hopper of the active and dummy molding. The mould has one fixed side and other movable side. The PC comes to a movable part in granular form and melts at 320°C then molten PC come into the fixed side with the help of a nozzle. The active blank disc is made with grooves on the surface by stumper which is fixed at the fixed side of the active molding. In case, dummy blank disc, mirror is used in place of a stumper. So, there will not be any groove in the dummy disc. When fixed and movable mould is closed to each other the blank disc is made in the mould.
- 2) *Operation at the Pre-cooler:* From mould the blank disc is collected with the help of the robotic arm. Robotic arm puts the blank disc at pre-cooler pin. Pre-cooler is round shape with at least 8 pins. One robotic arm puts blank disc at pin No. 1 from mould and another robotic arm release blank disc from pin No. 7 to input conveyer. Pin 8 is always empty.
- 3) *Operation at Input Conveyer:* In input conveyer there are 23 numbers of pins. In input conveyer there are three numbers of fans for cooling the blank disc to avoid the tilting problem.
- 4) *Operation at Cooler:* Cooler has 70 layers (on each layer there are three carriers) in which blank disc come in the down words direction and 71 (on each layer there are three carriers) layers in which blank disc come in to

the up words. The main purpose of a cooler is to avoid the tilt of blank disc.

- 5) *Operation in Dye Coating Area:* The main function of the dye coating area is to fulfill the dye in active disc.
- 6) *Operation at Printer:* In the printer station print the line number, number of days, shift (A, B, C) and disc number at the hub of active disc.
- 7) *Operation at Q.C. 1 Scanner:* The main function of Q.C.1 scanner is to scan the active disc by a top and a bottom camera. After grading (A, B & Reject), Q.C.1 scanner rejects the disputed disc, then the active and dummy disc come in the dryer.
- 8) *Operation at Dryer:* Dryer has 70 carriers of down words and 71 carriers up words. The main function of the dryer is to control the tilt of the active and dummy disc.
- 9) *Operation at Metalizer:* The active disc comes in to the metalizer. In the metalizer 120 nm silver layer is coated on active disc to increase reflectivity.
- 10) *Operation at Edge Washing:* After silver coating of 120 nm on active disc, it comes into an edge washing area for removing excess dye and silver at the outer area of the active disc using methyl lactated.
- 11) *Operation at Bonding Area:* In the bonding area active and dummy disc joint together with the help of glue. After completion of bounding, disc reaches to spin the cup for removing excess glue.
- 12) *Operation at UV Cooler:* In UV cooler the complete disc is dried by the heat of ultraviolet ray and active and dummy disc joint properly.
- 13) *Operation at Q.C.2 Scanner:* The main function of Q.C.2 scanners is to scan the final disc. After scanning, scanner puts the ok disc in to “A-grade” spindle, middle quality disc in to “B-grade” spindle, disputed disc in to “Reject” spindle.

5. Attempt to Increase Productivity

Change in a cycle time of DVD production (from 2.5 Sec. per disc to 2 Sec. per disc) was done by changing parameter like molding, pre-cooler, dye conveyer, metalizer conveyer, bonding chuck, curing section etc., At molding, metal melting time was reduced. At pre-cooler, waiting time of the pre-cooler chuck and pre-cooler conveyer was reduced. At dye coating, waiting time at dye conveyer was reduced. At bonding and edge washing area, the RPM of bonding chuck and edge washing chuck were increased. At curing section, power was increased and processing time was reduced.

Reduction in melting time of polycarbonate at moulding by changing heat into the mould was implemented. Starting of the action molding team face lot of problems like silver stick, mount fuzi, and cloud on active, molding team adjusted the molding parameter and heat to combat this problem.

After molding, action was taken at the pre-cooler and cooler. Here waiting time of the pre-cooler and cooler was changed. In starting, scratch on active disc was found due to high speed disc touched on the conveyer. Next action was taken in the dye coating area. At dye coating area, the dye dispenses needle (0.8 mm dia to 1.0 mm dia) was changed and reduction in the processing time. After dye coating, action was taken on the dryer. The dryer is used to heat treatment of

disc. Here, speed of dryer conveyer was increased manually; here tilt problem was found. After dryer, action was taken on metalizer. Then, the process time of metalizer was reduced. After metalizer, action was taken on bonding area. Here, the R.P.M at bonding chuck and edge working check was increased. After bonding area, speed of receiver handle was increased.

6. Problems owing to increase in Productivity by Reducing Cycle Time

At the starting, lot of problems like machine breakdown, low quality of the product was found. At molding, the problem was found on mount Fuji, injection flow, silver stick, cloud, etc. To combat with this problem, molding team adjusted the temperature of melting polycarbonates and adjusts the molding parameter. From dye coating area, problem aroused in face dye cut problem (dye not fill up properly on the disc) and adjusted the parameter of dye coating area to overcome this problem. From bonding area, bonding glue did not reach up to cross mote area. Changed bonding glue and adjusted pressure and temperature of bonding area action were taken to remove this problem. Changed the UV lamp and increased the power of lamp to overcome wet bonding problems.

While numbers of problems were aroused in reducing the cycle time the problems, action taken and action done has given below in the table 2 below:

Table 2: Problems & action taken

Section concerned with the Problem	Nature of problem	Section initiated the action	Action taken
Molding	Injection flow	Molding Person	• Adjust mold temperature
	Mount fuzi	Molding Person	• Adjust mold temperature • Clean the stumper holder
	Silver Stick	Molding Person	• Adjust mold temperature • Clean the stumper
	Dent in inner hub	Molding Person	• Change the stumper holder
	Dent on active side	Molding Person	• Clean the stumper • Change the stumper
Pre-cooler and input conveyer	Dent in hub	Production and maintenance person	• Change the Pre-cooler pin
	Scratch on active	Production and maintenance person	• At first found where this touch, then adjust the height of disc and conveyer
Dye coating	Dye drop on disc	Production and process engineer	• A retro fill pipe is adjusted with dye dispense pipe. • Clean the dye cup with schedule
	Dye cut problem	process engineer	• Adjust the dye dispense parameter • Adjust dye density

Dryer	Scratch on active	Maintenance person	• Give Properly allocation at dryer. • Change career if it broken
Metalizer	Dent in hub	Production person & Maintenance person	• Change the Metalizer pin
	Crack at outer	Maintenance person	• Adjust temperature inside the metalizer
	Mass cut problem	Production person	• Change the mask
	Yellow band problem	Production person	• Change the silver target
Edge washing	Crack at hub	Production person & Maintenance person	• Adjust the needle position • Adjust the methyl lactate dispense
Bonding area	Bonding Glue not up to mot area	Production person & process engineer	• Increase Pressure of bonding glue • Increase temperature of bonding glue • Take needle position inside the disk
	Bonding Glue cross up to mot area	Production person & process engineer	• Decrease pressure of bonding glue • Decrease temperature of bonding glue • Take needle outside the disc
	Resign bubble at hub	process engineer	• Adjust the parameter • Adjust the pressure and temperature of bonding glue
U.V. unit	Wet bonding	Process engineer	• Increase the power of U.V. lamp • Change the U.V. lamp

7. Conclusion

As the cycle time reduction results in higher productivity, less-utilization of manpower, avoids the production delays, reduce inventory, higher customer satisfaction due to the high quality and increases overall efficiency of the plant.

Cycle time reduction has many positive efforts on the manufacturing process of reducing work in process (WIP) to increase output without increasing the resources required to produce the product.

Cycle time reduction plays an important role in improving the competitiveness of DVD manufacturing. Shortening the production cycle time improves the responsiveness to customer demands, and leads to significant profits from yield improvement and cost reduction.

The result showed that reduction of cycle time from 2.5 Sec. to 2 Sec. increases productivity resulting in cost reduction.

Table 3: Calculation

	<i>DVD Production when cycle time 2.5 second per disc</i>	<i>DVD Production when cycle time 2 sec. per disc</i>
<i>DVD Production per hour (1 Hour= 3600 sec)</i>	= $3600/2.5= 1440$	= $3600/2.0= 1800$
<i>DVD Production per day (1 Day= 24 Hours)</i>	= $1440 \times 24= 34560$	= $1800 \times 24= 43200$
<i>DVD Production per day (if there is 150 PLC machine in a company)</i>	= $34560 \times 150= 5184000$	= $43200 \times 150= 6480000$

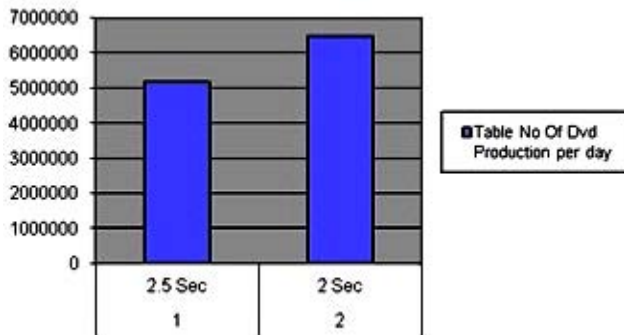


Figure 2: Comparative chart for DVD production w.r.t time

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Author Profile



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