2019 TOCICO International Conference

THE PRODUCTIVITY JOURNEY

Extreme Drum-Buffer-Rope and Extreme Buffer Management

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Agenda

A quick review of T-DBR vs S-DBR

→

Two Extreme DBR Examples

→

Our Approach to Improving Flow using X-DBR

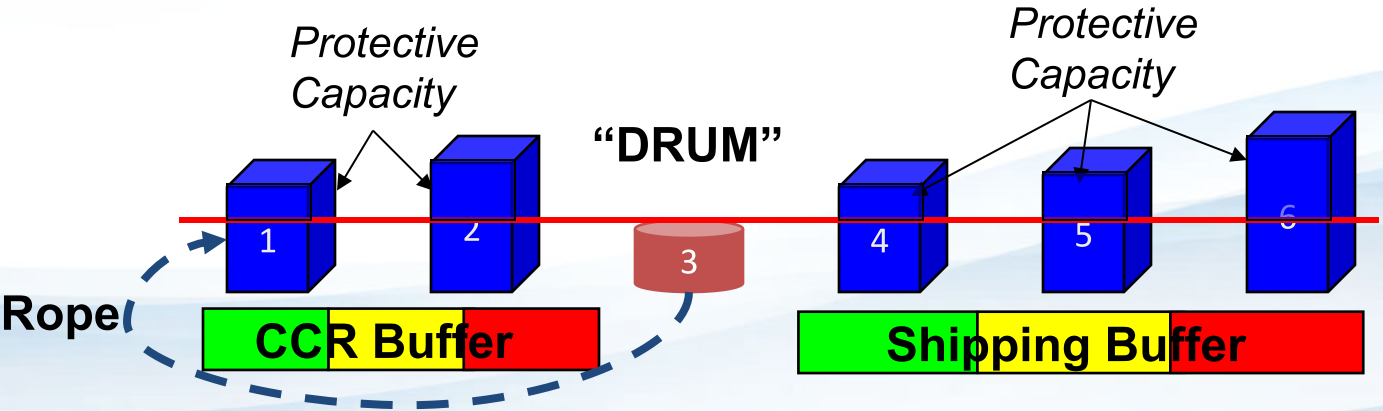
The Evolution of Drum-Buffer-Rope (DBR)

Traditional DBR

- Developed in mid 80s as a relatively simple, yet effective, production planning methodology
- Focuses on detailed finite capacity scheduling of the capacity constrained resource (CCR)
- Sometimes up to 3 buffers – CCR Buffer, Shipping Buffer & Assembly Buffer
- Creates a sequence that exploits the CCR – sequence often changes after the Drum to follow due date

Traditional DBR

- The Drum, or Control Point, defines the system output and sets the pace for a specific flow stream
- The Buffer is the right amount of work released to the drum to ensure its continued operation and set its priorities
- The Rope controls material release



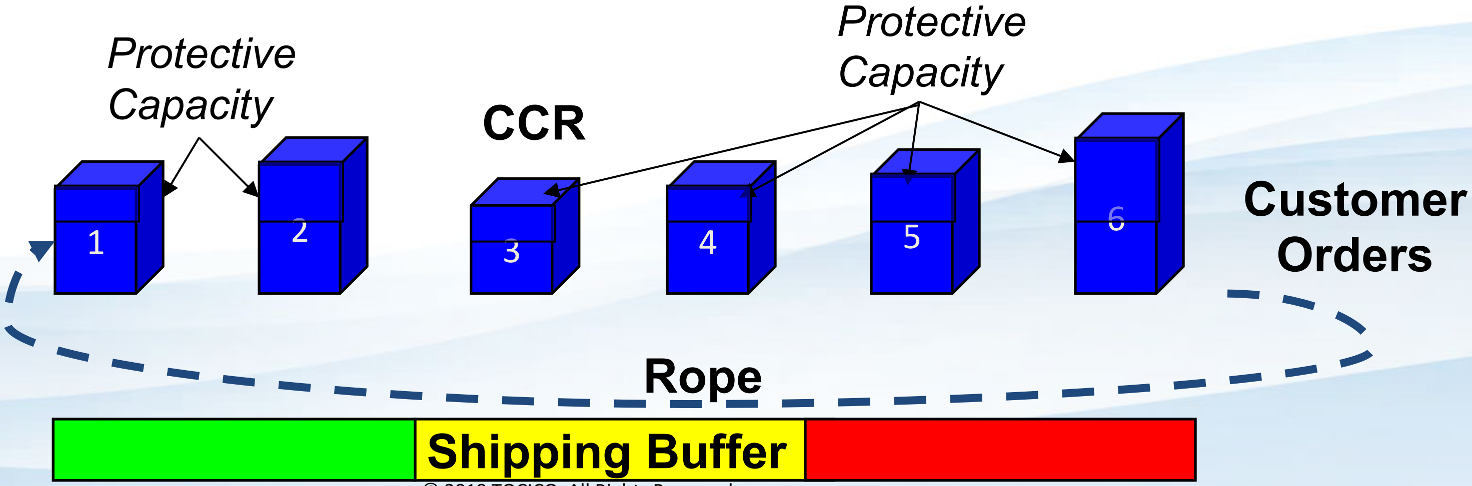
The Evolution of DBR

Simplified DBR

- Developed in early 2000s to extend the benefits of T-DBR and make it even simpler to implement
- Focuses on prioritizing to due date throughout the plant
- Only 1 buffer – the shipping buffer
- The sequence at the CCR is not planned – although the sensible decision of which order to do next depends on the state of the buffers
- Delivery dates are promised based on the planned load on the CCR

Simplified DBR

- Orders are scheduled according to due date – dates are committed according to the CCR Planned Load
- The Buffer ensures every order is given enough time to flow through the shop floor
- The Rope ensures that only orders to be delivered in the shipping buffer time are released to the floor



The Basic Assumptions behind S-DBR*

The market is always a constraint

The CCR is generally insensitive to small changes in processing sequence

Such changes don't usually have much impact on the overall performance of the system

*Schragenheim & Dettmer, Manufacturing at Warp Speed, St. Lucie Press, 2001

The Basic Assumptions behind S-DBR

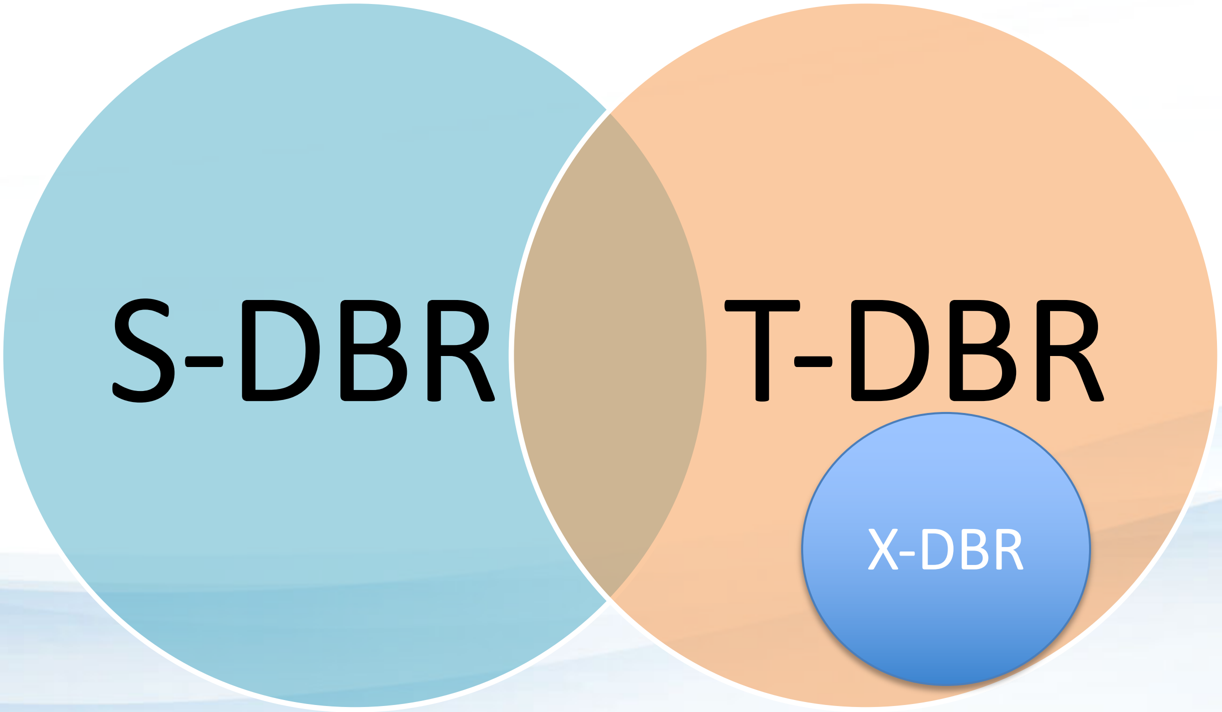
The market is always a constraint

If short lead times are a competitive advantage and the sales backlog is increasing (and therefore lead times are increasing) then we should consider the constraint to be internal

The CCR is generally insensitive to small changes in processing sequence

If there is at least a 40% capacity utilization difference between sequencing the orders for the Drum and not sequencing, then we should pay as much attention to sequencing as possible

Extreme DBR is a subset of T-DBR



What makes it Extreme is the massive degree of dependence between orders and / or the number of variables to consider when scheduling

Two Extreme Examples

Large dependence between orders

- Heat Treating

Large number of order variables to sequence

- Aluminum Extrusion

Heat Treating

The constraint is internal – running 7x24

Order sequence matters

Material availability is a not critical issue

Flow is an I plant

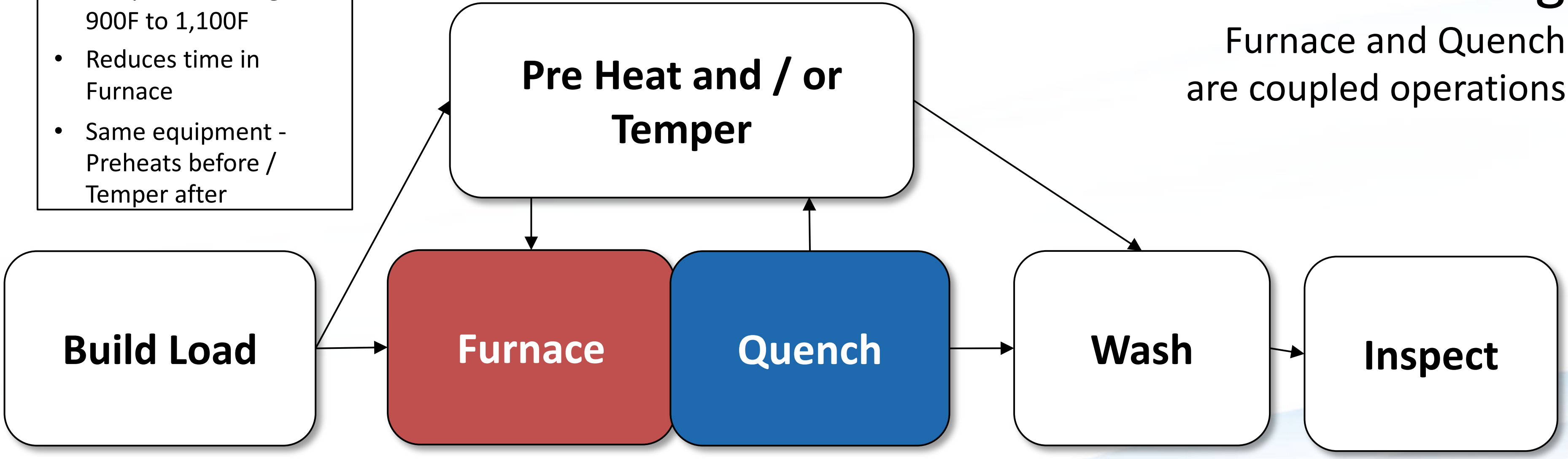
Scheduling to customer demand was already done well

Keys to exploitation are sequencing orders to maximize machine utilization, due date performance, load factor and basket rotation

Heat Treating

Furnace and Quench are coupled operations

- Temperature ranges - 900F to 1,100F
- Reduces time in Furnace
- Same equipment - Preheats before / Temper after



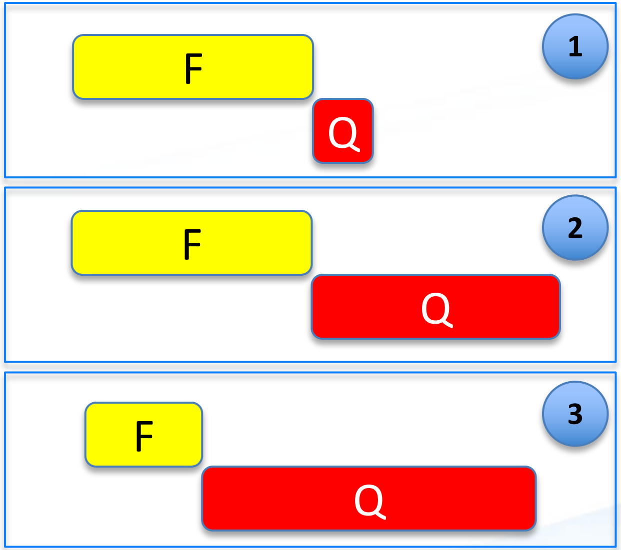
- Temperature ranges - 1,450F to 1,700F
- Temp ramp up time based on load weight and surface area
- Time spent at temperature varies according to alloy and hardening requirements

- Temperature ranges - 350F to 750F
- Bath of liquid salt
- Key is rate of cooling and holding time
- Duration can be shorter or longer than furnace duration
- Significant time required to change the Quench temperature

Heat Treating

Basic Profiles of durations needed to be sequenced

1. Long Furnace / Short Quench
2. Equal Durations
3. Short Furnace / Long Quench



- The challenge is to fit the ‘Tetris’ Blocks together to minimize the time where either the Furnace or the Quench is Empty

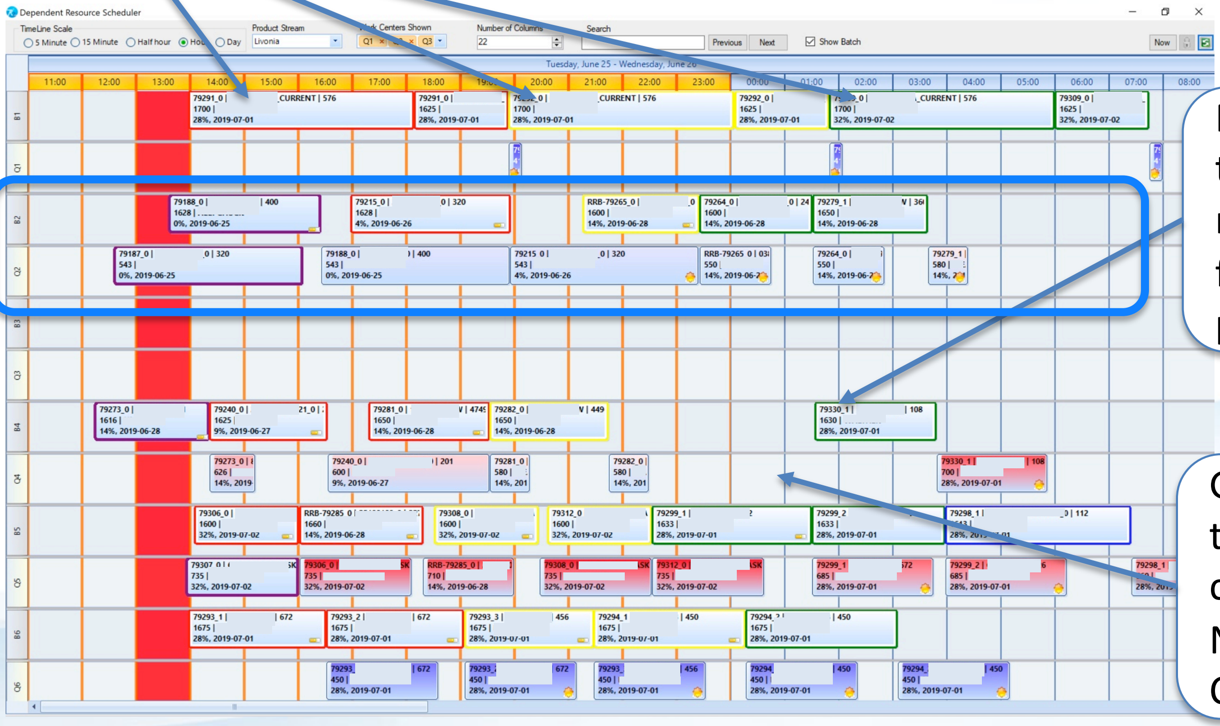
Scheduling Considerations

- Keep like Alloys together on the same Furnace / Quench
- Group orders at Quench with like temperatures
- Sequence orders to fit the blocks together
- Fill baskets as much as possible – maximize load factor
- Pre Heat as necessary except for jobs with short Furnace after jobs with long Quench
- Manage conflicts between Pre Heat and Temper demand

Dependent Resource Scheduling

Red / Yellow / Green Buffer Zones

Furnace / Quench coupled Drum

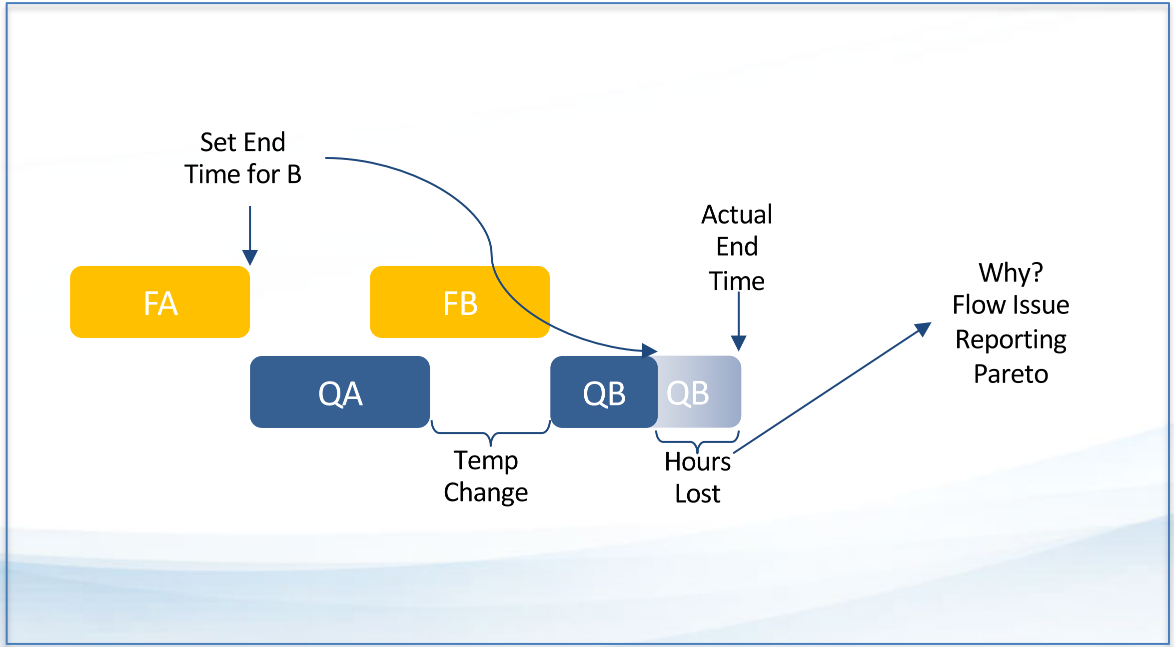


Precise Start & Stop times for each job recalculated at the finish of the previous job

Gaps inserted for temperature changes using Newton's Law of Cooling / Heating

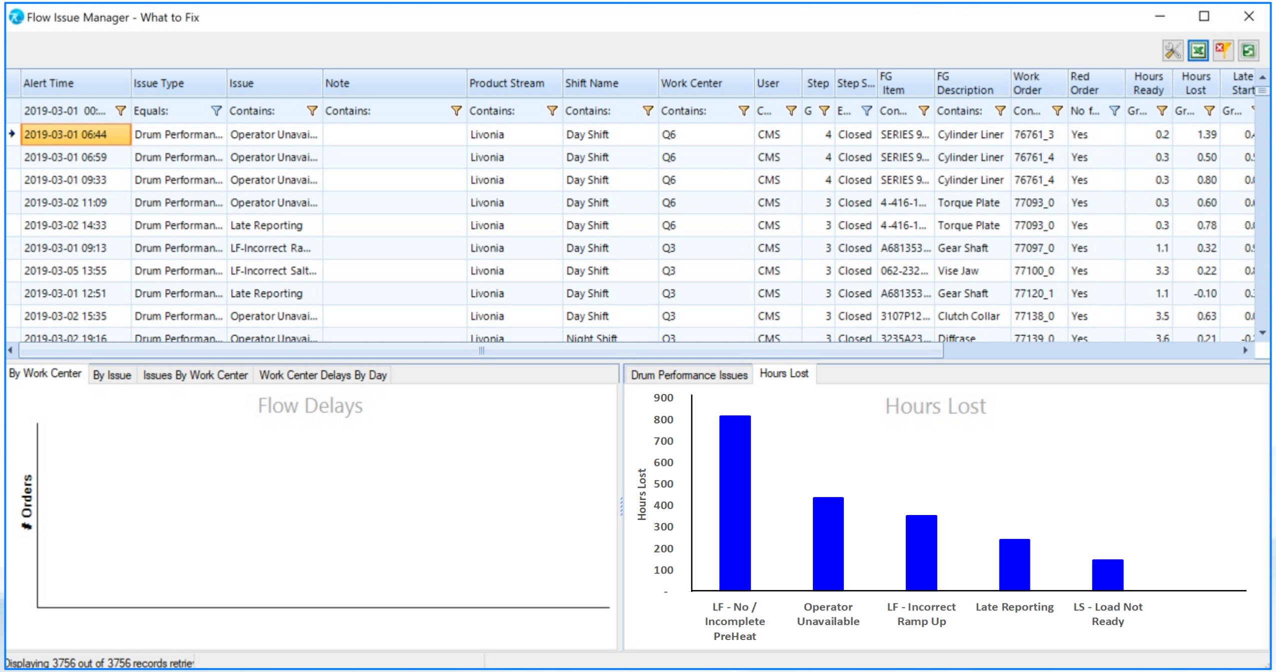
Extreme DBR (X-DBR)
requires
Extreme Buffer Management (X-BM)

Buffer Management enhanced to measure Hours Lost



Hours Lost is the difference between when an order should finish Quench and when it actually finishes Quench

Hours Lost Pareto



Alert Time	Issue Type	Issue	Note	Product Stream	Shift Name	Work Center	User	Step	Step S...	FG Item	FG Description	Work Order	Red Order	Hours Ready	Hours Lost
2019-03-01 06:44	Drum Performan...	Operator Unavai...		Livonia	Day Shift	Q6	CMS	4	Closed	SERIES 9...	Cylinder Liner	76761_3	Yes	0.2	1.39
2019-03-01 06:59	Drum Performan...	Operator Unavai...		Livonia	Day Shift	Q6	CMS	4	Closed	SERIES 9...	Cylinder Liner	76761_4	Yes	0.3	0.50
2019-03-01 09:33	Drum Performan...	Operator Unavai...		Livonia	Day Shift	Q6	CMS	4	Closed	SERIES 9...	Cylinder Liner	76761_4	Yes	0.3	0.80
2019-03-02 11:09	Drum Performan...	Operator Unavai...		Livonia	Day Shift	Q6	CMS	3	Closed	4-416-1...	Torque Plate	77093_0	Yes	0.3	0.60
2019-03-02 14:33	Drum Performan...	Late Reporting		Livonia	Day Shift	Q6	CMS	3	Closed	4-416-1...	Torque Plate	77093_0	Yes	0.3	0.78
2019-03-01 09:13	Drum Performan...	LF-Incorrect Ra...		Livonia	Day Shift	Q3	CMS	3	Closed	A681353...	Gear Shaft	77097_0	Yes	1.1	0.32
2019-03-05 13:55	Drum Performan...	LF-Incorrect Salt...		Livonia	Day Shift	Q3	CMS	3	Closed	062-232...	Vise Jaw	77100_0	Yes	3.3	0.22
2019-03-01 12:51	Drum Performan...	Late Reporting		Livonia	Day Shift	Q3	CMS	3	Closed	A681353...	Gear Shaft	77120_1	Yes	1.1	-0.10
2019-03-02 15:35	Drum Performan...	Operator Unavai...		Livonia	Day Shift	Q3	CMS	3	Closed	3107P12...	Clutch Collar	77138_0	Yes	3.5	0.63
2019-03-02 19:16	Drum Performan...	Operator Unavai...		Livonia	Night Shift	Q3	CMS	3	Closed	3235A23...	Diffrase	77139_0	Yes	3.6	0.21

The operator is prompted to record the reason for the Hours Lost for any loss greater than 15 minutes

YTD 2019, the top Flow Issues causing the most Hours Lost were

- No / Incomplete preheat
- Operator Unavailable
- Incorrect Ramp Up

The actual work order and part # is known for each issue

Since 2016

Throughput Increase 35%

OE Increase – 10%

EBITDA as % of Revenue

2016 – 29%

YTD 2019 – 38%

Two Extreme Examples

Large dependence between orders

- Heat Treating

Large number of order variables to sequence

- Aluminum Extrusion

Aluminum Extrusion

The constraint is internal – running 7x24

Order sequence matters

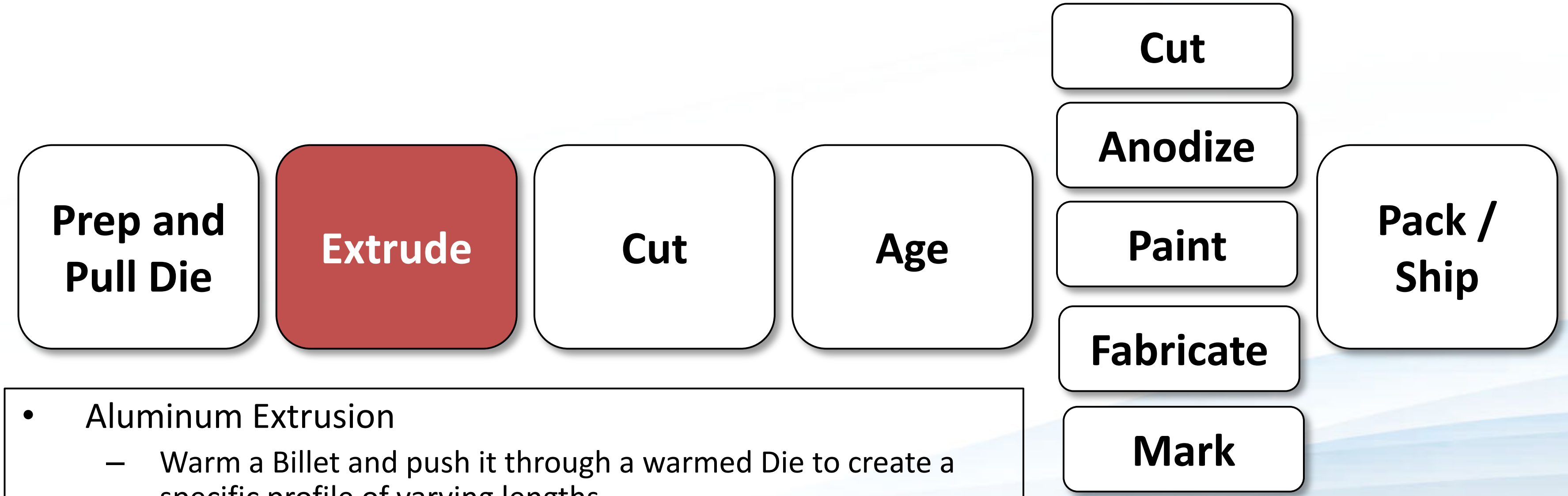
Material availability and utilization is a critical issue

Flow is a V plant

Scheduling to customer demand was already done well but very manual

Keys to exploitation are sequencing orders to maximize material utilization, machine utilization and due date performance

Aluminum Extrusion



- Aluminum Extrusion
  - Warm a Billet and push it through a warmed Die to create a specific profile of varying lengths
  - Billets - 5 alloys, 4 types, 2 diameters, 13 lengths
  - Dies - 9,400
  - Finished Goods - 14,000

Sequencing Challenges

- Maximizing Billet Recovery – billet length
- Grouping the same billet lengths
  - Billet oven holds 10 to 20 billets
- 150 to 200 work orders per day
- Die conflicts
  - Across presses
  - Several orders
  - Different Alloys
- Press length restrictions
- Full table - Multi-cavity dies
- Dies unavailable – correction

Execution Challenges

Strongly held belief - Maximizing Kg / Hour is the “only way to make money"

Dies Fail – a lot

- Of the 12,000 work orders scheduled Jan to May 2019, 1,500 were not run due to Die Failure (12.5%) representing 20% of the scheduled hours

Operators want to run…

- Orders that will run faster
- Orders with Dies that will not fail
- In other words, they don’t want to run the schedule

Variability and Dependency

Sources of Variability

- Die speed
- Die correction time
- Die warming
- Die performance
- # of Die copies available
- # of Die cavities
- Alloy type
- Billet length and availability
- Saw speed (# of cuts)
- Press performance
- Operator experience / training / absenteeism
- Customer order changes

Sources of Increased Dependency

- Buying billets to length
- Buying billets to order / forecast
- Loading billet oven with 10 to 20 billets
- Limited quantity of die copies
- Scheduling dies across presses
- Limited table size
- Make to order strategy

The TOC Approach to Flow

Focus on Reducing Variability everywhere		Focus on Reducing Dependency first, then Variability
	vs.	
Cost Focus		**Flow Focus**

Breaking Dependence

- Typically three ways – buffer with stock, time and / or capacity

Source of Dependency	Stock	Time	Capacity	Comment
Buying billets to length				Capital intensive - No short term solution
Buying billets to order / forecast	X			Billet Stock Buffers
Loading billet oven with 10 to 20 billets				Capital intensive - No short term solution
Limited quantity of die copies			X	Slowly increasing copies
Scheduling dies across presses			X	Slowly increasing copies
Limited table size				Capital intensive - No short term solution
Make to order strategy				No space - no short term solution

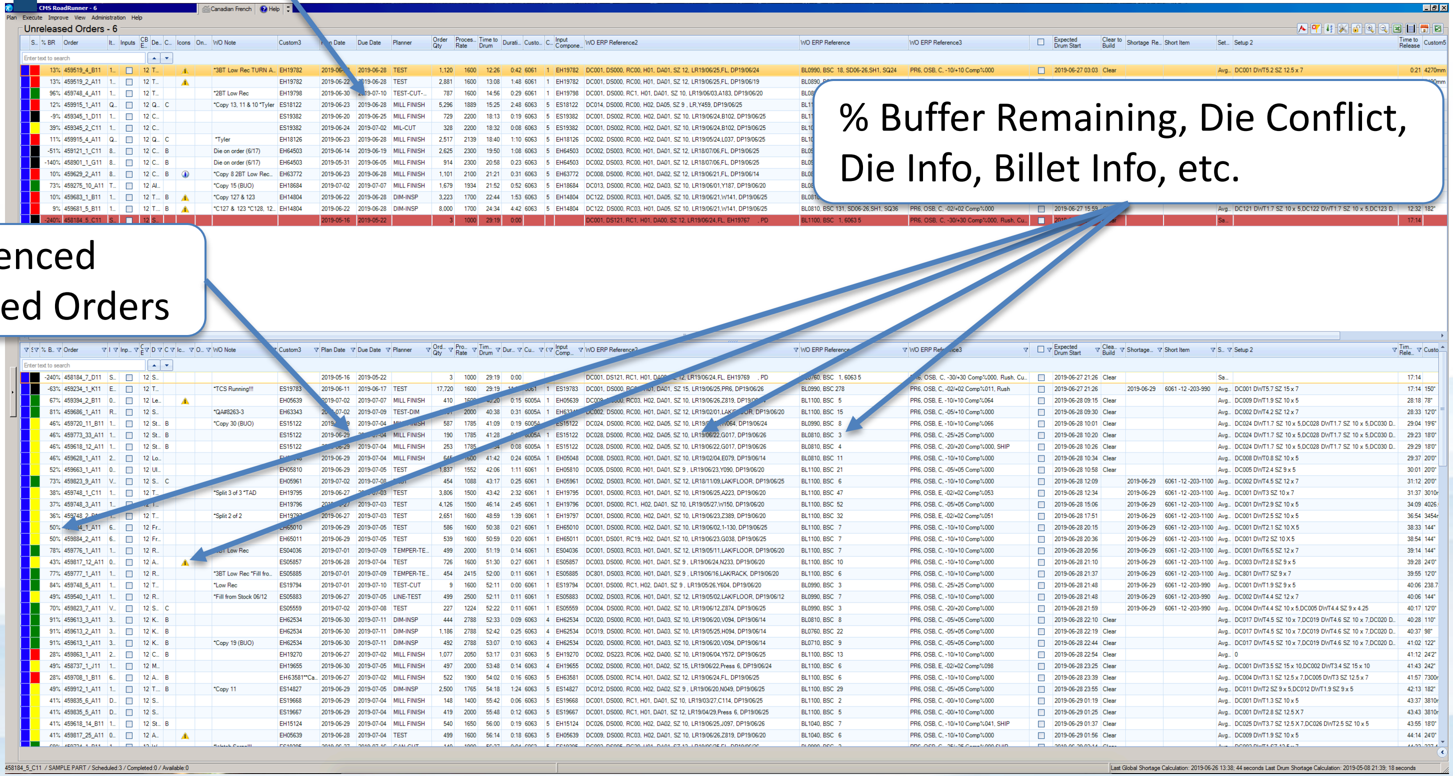
- The solution focused on ensuring VISIBILITY of the Dependence to MANAGE it vs Break it

Sequencing Visibility

Sequenced Unreleased Orders

% Buffer Remaining, Die Conflict, Die Info, Billet Info, etc.

Un-sequenced Unreleased Orders

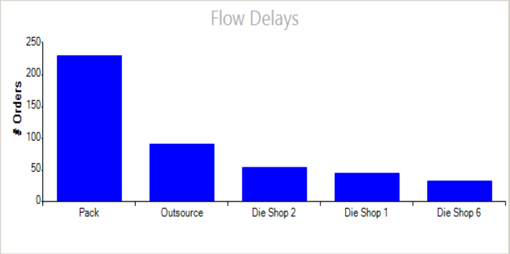


Buffer Management enhanced to measure Scheduled Difference

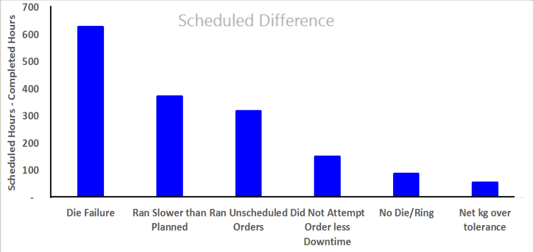
Flow Issue Manager - What to Fix

Alert Time	Work Order	Shift Na...	Issue Type	Issue	Note	Work Center	User	Step	Scheduled Hours	Completed Scheduled Hours	Step Status	FG Item	Red Order	Hours Ready	Hours Lost	Product Stream
Custom:	Contains:	Con...	Equals:	Contains:	Contains:	Contains:	C...	G	GreaterThan:	GreaterThan:	Equals:	Con...	No f...	Gr...	Gr...	Contains:
2019-05-16 07:29	458176_2_B11	1	Drum Performance	Die Failure	This order was m...	6	sado	1	8.25	2.5	Closed	19166-0...	Yes	9.7	0.00	Brampton
2019-05-09 12:57	458176_1_A11	1	Drum Performance	LC Late / Sch Re...		6	sado	1	8.2	6.04	Closed	19166-0...	No	10.2	0.00	Brampton
2019-05-12 07:56	458176_3_B11	1	Drum Performance		Only 1 copy provi...	6	press6	1	8.13	7.54	Closed	19166-0...	Yes	21.0	0.00	Brampton
2019-05-14 20:00	458176_2_A11	2	Drum Performance			6		1	7.7	3.57	Closed	19166-0...	Yes	7,202.6	0.00	Brampton
2019-05-17 17:06	458176_2_A11	1	Drum Performance			6	sado	1	7.18	4.74	Closed	19166-0...	Yes	7,202.6	0.00	Brampton
2019-05-05 20:00	458176_4_A11	2	Drum Performance			6		1	7.15	6.71	Closed	19166-0...	No	21.7	0.00	Brampton
2019-05-07 20:00	458176_4_B11	2	Drum Performance			6		1	6.94	6.75	Closed	19166-0...	No	20.2	0.00	Brampton
2019-05-24 17:48	458318_2_A11	1	Drum Performance	Die Failure		6	sado	1	5	3.85	Closed	17738-0...	No	7.5	0.00	Brampton
2019-05-30 23:27	459028_1_A11	2	Drum Performance	Die Failure		6	sado	1	5	1.04	Closed	17738-0...	No	26.5	0.00	Brampton
2019-05-21 19:36	458271_1_A11	2	Drum Performance	Die Failure	Copy 93 94 provid...	6	press6	1	4.9	0.4	Closed	R11254...	No	22.8	0.00	Brampton

By Work Center | By Issue | Issues By Work Center | Work Center Delays By Day



Drum Performance Issues | Hours Lost | Scheduled Difference



Displaying 3088 out of 3088 records retrie

A new measure of Scheduled Difference was developed to track the difference between Scheduled Hours and Completed Hours

50% of the orders needed a Flow Issue

From March to May 2019, the top Flow Issues consuming the most hours are

- Die Failure
- Ran Slower then Planned
- Ran Unscheduled orders

For the top two issues, the problem Dies are known

Our Process to Improve Flow using X-DBR

- Understand the sources of Variability – from suppliers, customers and in the plant
- Identify the current actions the company is taking to increase Dependence
- Identify the best place(s) in the flow to schedule – the control points
  - Build the capability to sequence the orders to Exploit the Drum and create the rules for Subordination
- Identify the best places in the flow to Break Dependence (with Time, Stock or Capacity) – or at least how to better manage it (with Visibility)
- Establish the mechanism to identify and record meaningful Flow Issues to prioritize the Variability reduction initiatives

From our Experience

The more Extreme the sequencing requirements, the more Extreme the Buffer Management process (Flow Issue Reporting)

Awareness / Visibility of the Dependence can go a long way to helping with Flow improvement

Presenter Bios

Duncan Patrick is Executive VP with CMS Montera (duncan.patrick@cmsmontera.com)

- Prior to CMS, Duncan was a member of the senior leadership team of an industrial distributor, consulting manager at Ernst & Young, and Landman with Husky Oil
- Duncan is a Certified Management Consultant registered in Ontario
- Duncan holds an MBA degree from the Richard Ivey School of Business, Western University and a Bachelor of Commerce degree (with distinction) from The University of Calgary
- Duncan is certified by the TOCICO in all aspects of TOC

Jack Warchalowski is the President of CMS Montera (jack.warchalowski@cmsmontera.com)

- Prior to CMS, Jack was the head of operations for the High Tech manufacturer, Ernst & Young management consultant, and a project engineer with Babcock & Wilcox
- Jack is a Certified Management Consultant and a Professional Engineer registered in Ontario
- Jack holds an MBA degree from the Wilfrid Laurier University and a Bachelor of Applied Science in Mechanical Engineering from the University of Waterloo in Waterloo, Ontario
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