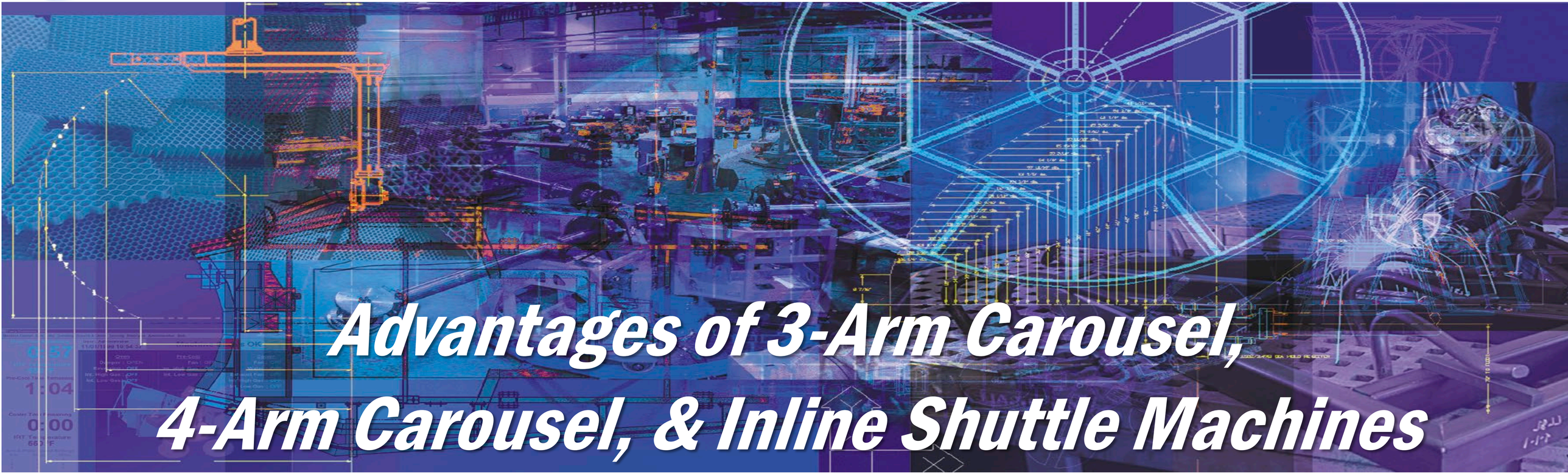
FERRY INDUSTRIES, INC.®



Advantages of 3-Arm Carousel, 4-Arm Carousel, & Inline Shuttle Machines

ASSOCIATION OF ROTATIONAL MOLDERS

Rotoplas 2024, Rosemont, IL – Sept. 24-26, 2024

ROTOSPEED® ROTATIONAL MOLDING MACHINES

FERRY INDUSTRIES, INC.®

Rotomolding Machine Sales, Engineering, Manufacturing & Support

Stow, OH USA

42+ years, 65+ Team members & 1,500+ machines delivered to over 60+ countries

Which machine type/style is best?

4 arms

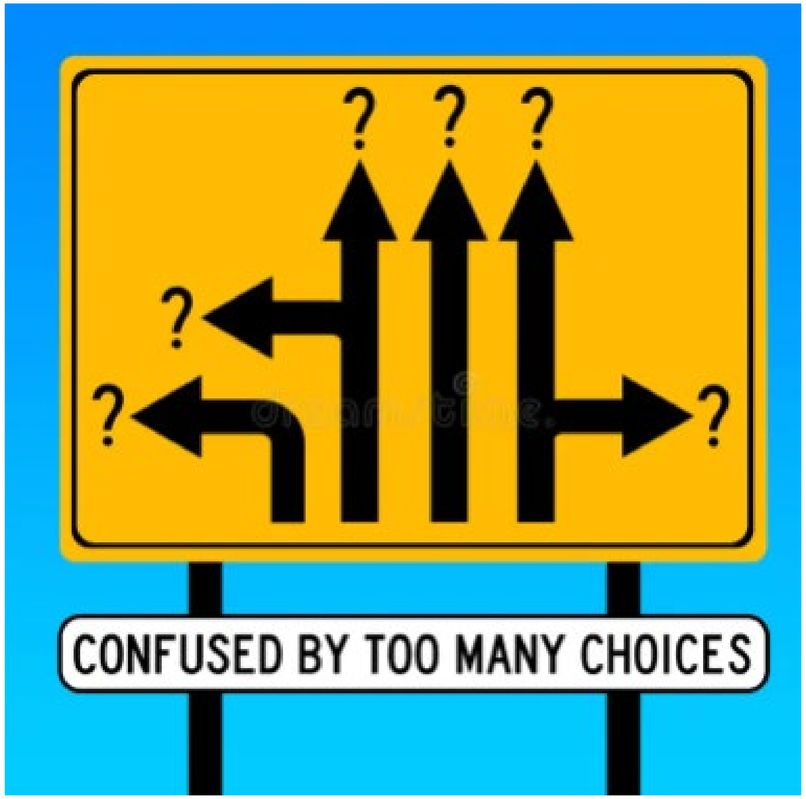
In-line Shuttle

Mold limit swing

1 station

5 stations

Shuttle-in-the-round



Carousel

1 arm

Weight capacity

Straight arm

3 stations

3 arms

2 stations

2 arms

Offset arm

4 stations

5 arms

Fixed-Arm Turret

Independent arm

Rocking oven

Clamshell

Considerations & Goals

Parts annual volume

Station Utilization

Machine cost

Cell equipment cost

Finished part handling

Maintenance needs

Product mix

Floor space needs

Efficiency

Offset arm

Productivity

Energy costs

Machine Flexibility

Platforms

Direct labor needs

Modularity/Expandable

Annual operational costs

Powder dosing/handling

Gas consumption

Crane type & qty

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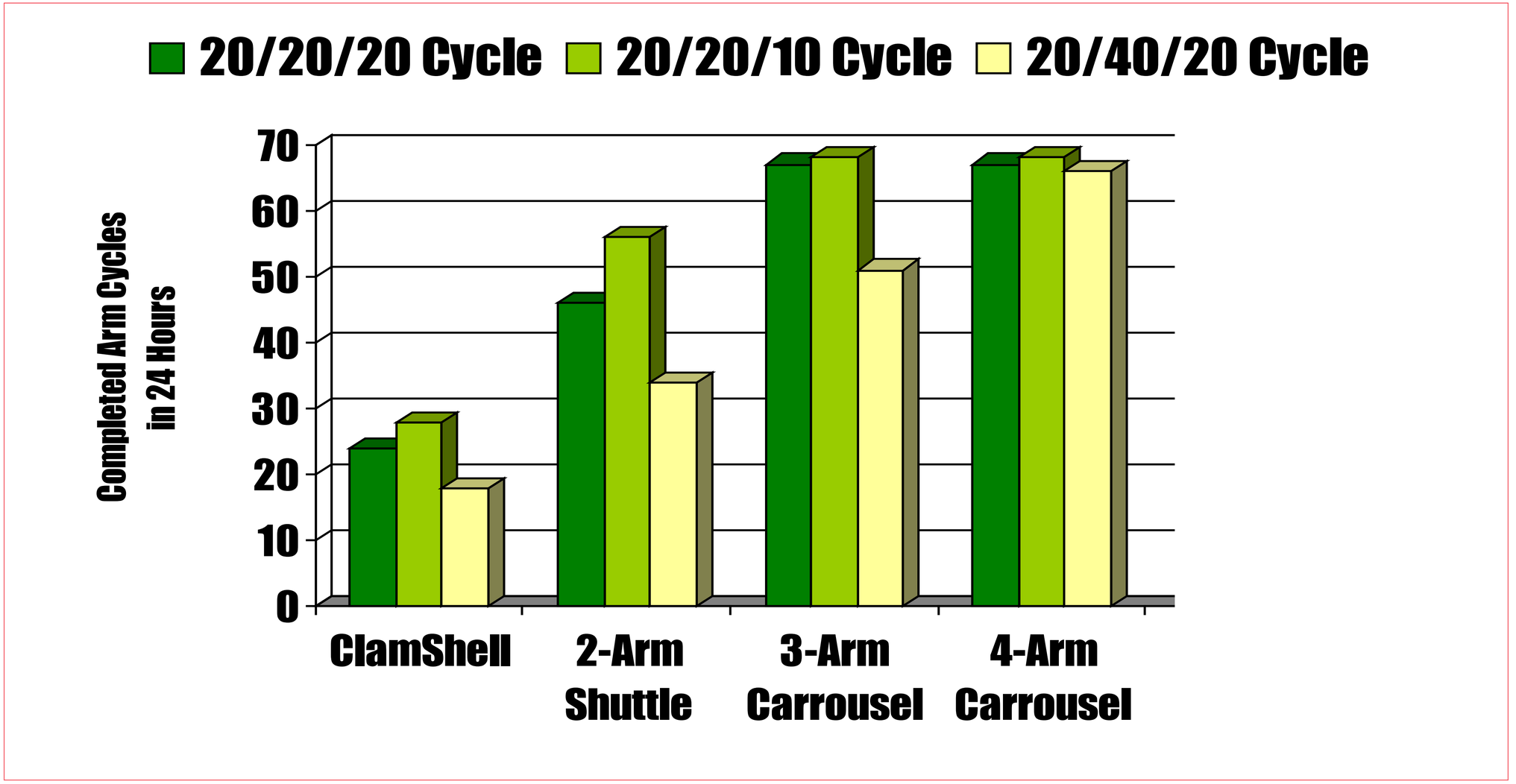
Additional considerations

- Floor space – existing space or new construction
  - Machine floor space and vertical space has a cost to the business – machine style chosen may be impacted by these factors
- Crane coverage needs and quantity of cranes needed for machine styles changes
- Product mix – materials, wall thickness, product size, quantities – just because the part fits on the machine may substantially reduce machine output, reduce oven/cooler utilization and increase takt time
- Correct sizing of machine and style selection could help reduce energy consumption – less waste – bigger is not always better
- Work with your machinery supplier to weigh options and select the right machine for the application

Which machine type/style is best?

Completed oven cycles in 24 hours



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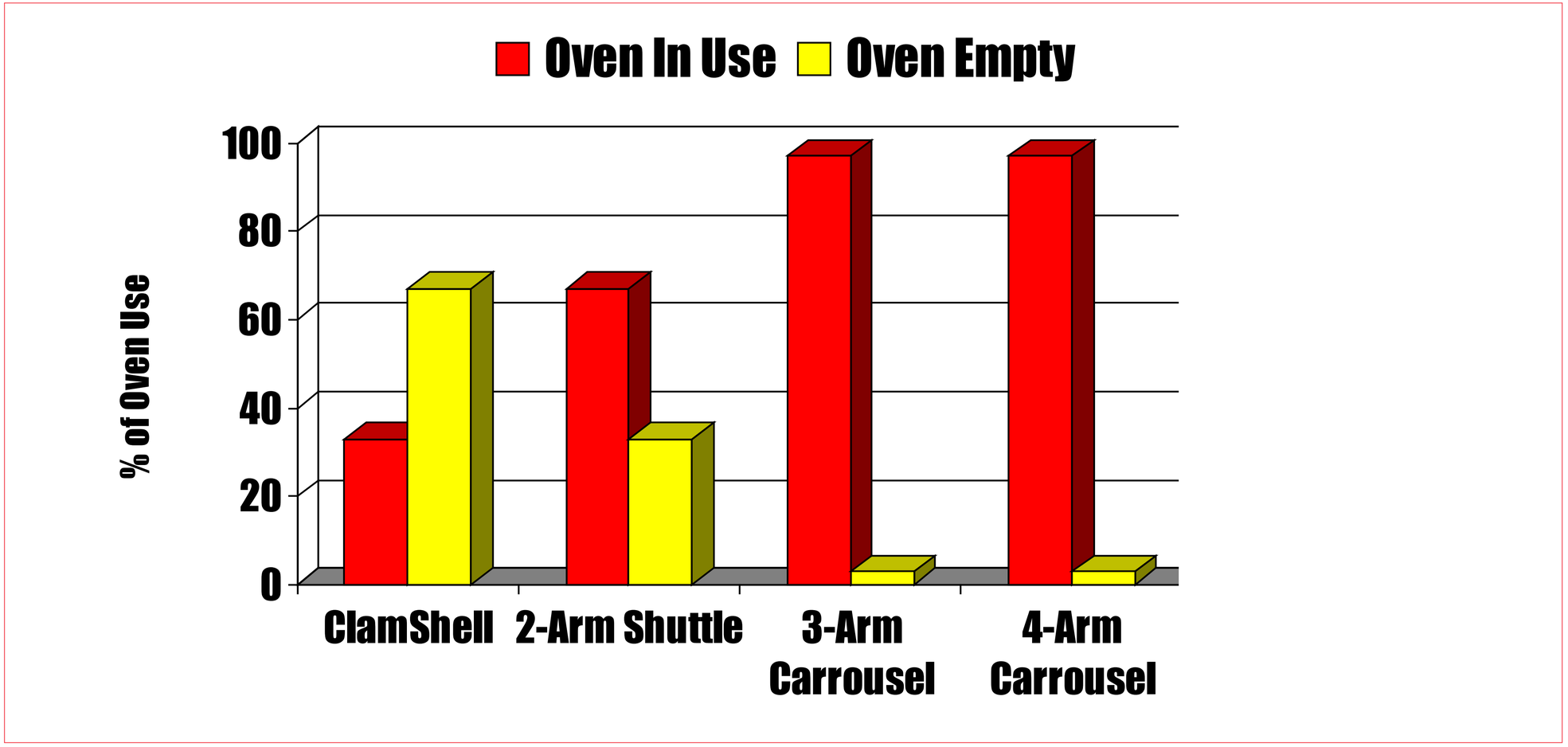
Which machine type/style is best?

% Oven Utilization – 20 min oven, cool, service



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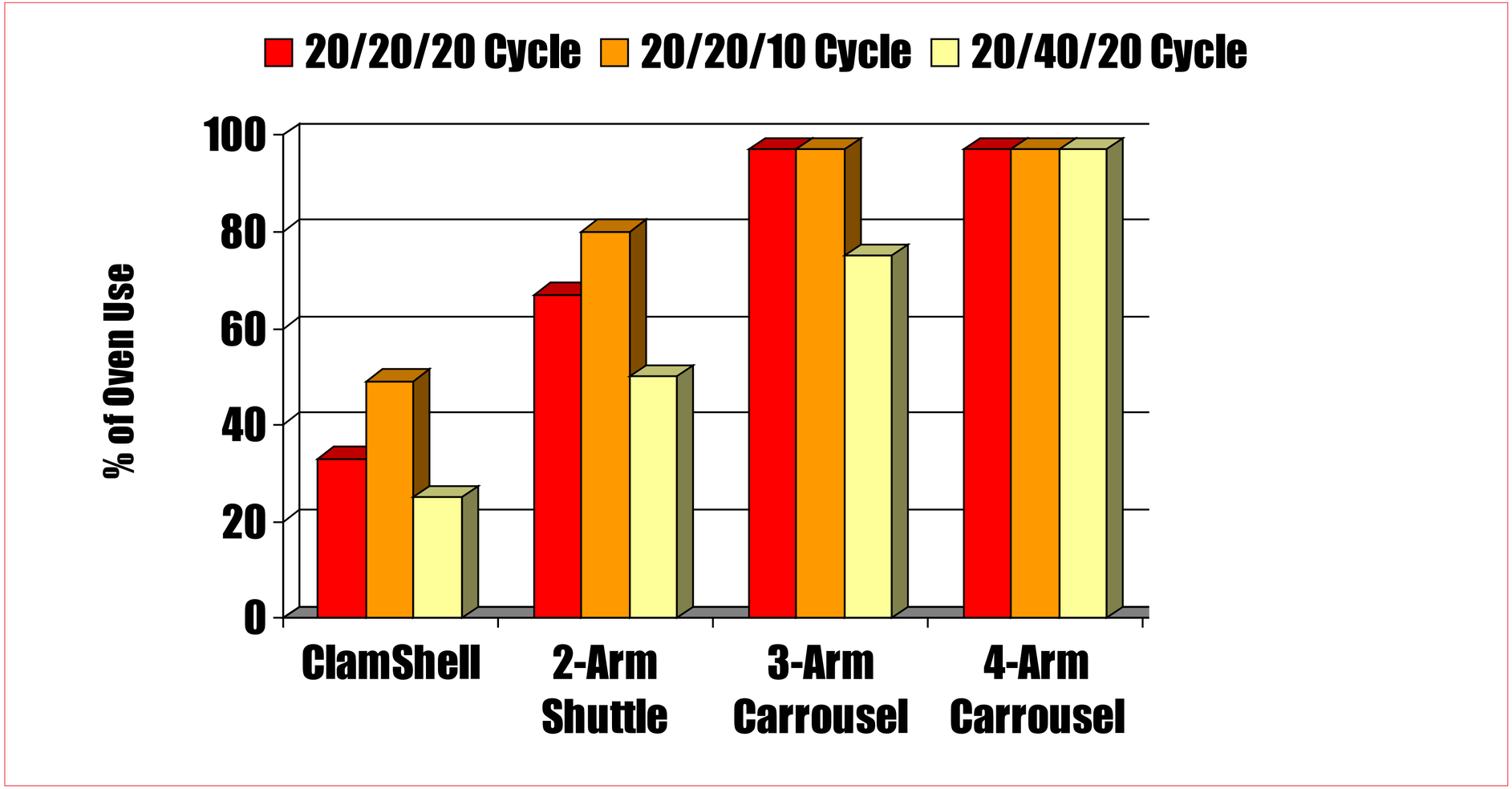
Which machine type/style is best?

% Oven Utilization



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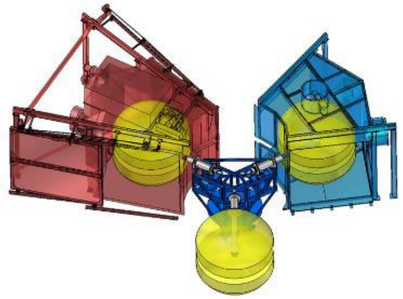
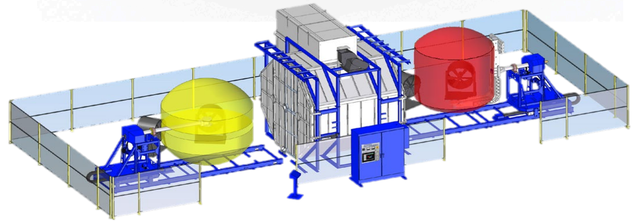
Which machine type/style is best?

Focus on most popular machine types





- Fixed-Arm Turret Carousel
- Independent-Arm Carousel
- In-line Shuttle

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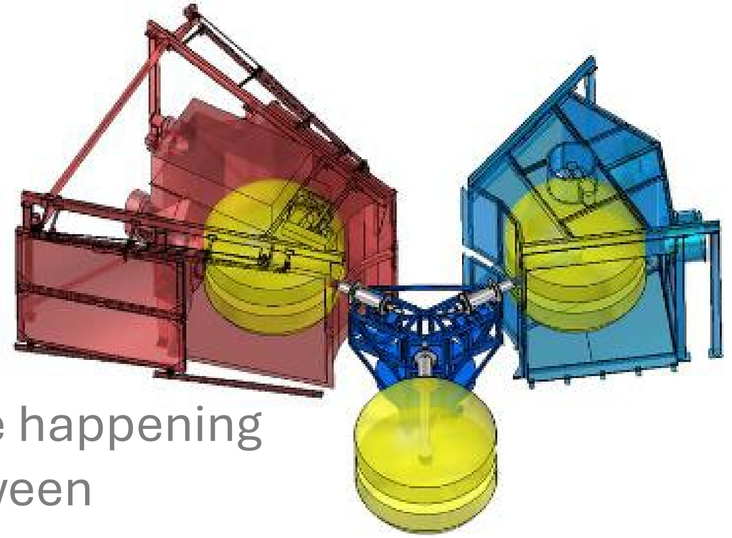
Fixed-Arm Turret



Advantages

- “Lean” production machine - heating, cooling and demolding are happening simultaneously; machine is fully utilized (except movement between stations) – high volume output

- Requires equal/balanced heating, cooling and service cycle times
  - Longest phase dictates index readiness

- Simultaneous station index – each turret index moves all arms to next station

- Reasonably compact floor space, simple controls and mechanics

- 4-arm Turret has flexibility for 2 ovens, or 2 coolers or 2 service stations

- One team of operators to service - Operator induced cycle delays are more identifiable – machine paces the operator

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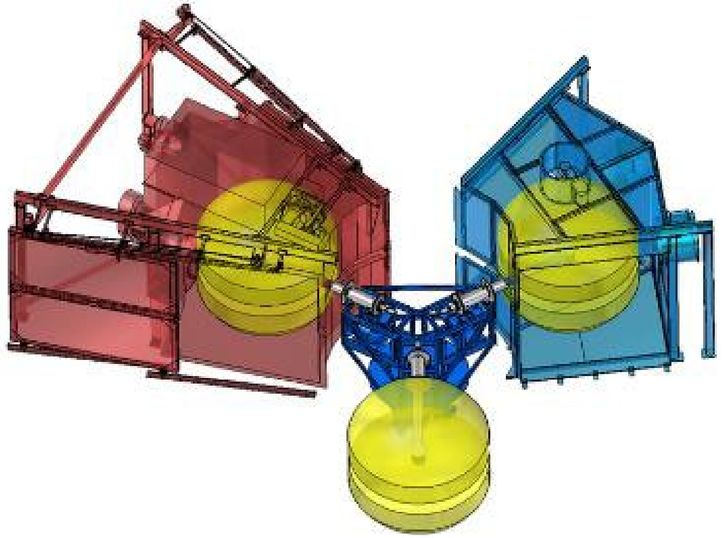
Fixed-Arm Turret



Limitations

- Machine productivity delays occur with highly dissimilar product size, wall thicknesses or service times arm-to-arm
- Limited weight carrying capacity and swing diameter
- Station cycle times need to be identical to maximize productivity
- Reversing arms out of oven for multi-shot molding hinders total machine productivity
- Not a modular or expandable design

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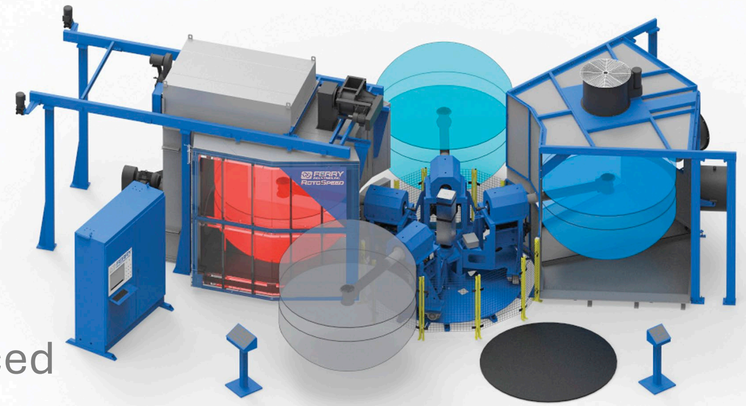
Independent-Arm Carousel



Advantages

- 3-arm Independent-Arm has the most flexibility - more flexible with imbalanced cycles from arm-to-arm
- When the cycles are balanced, the 4-arm carousel is more productive than two 2-arm shuttles especially with two cooling stations for the carousel
- Perfect for high-volume production, large parts and high-weight capacities – one machine can be used for a variety of molding – possible sacrificing some productivity/output
- Can use multi-layer molding functions on one arm without significant impact to productivity of other arms of machine.
- Modular design – expand from 1 arm to 4 arms, multiple oven or cooling chambers – machine configuration can change as production needs change
- Operators stay in one location, machine comes to them - Only requires one set of operators, to support in most molding operations.

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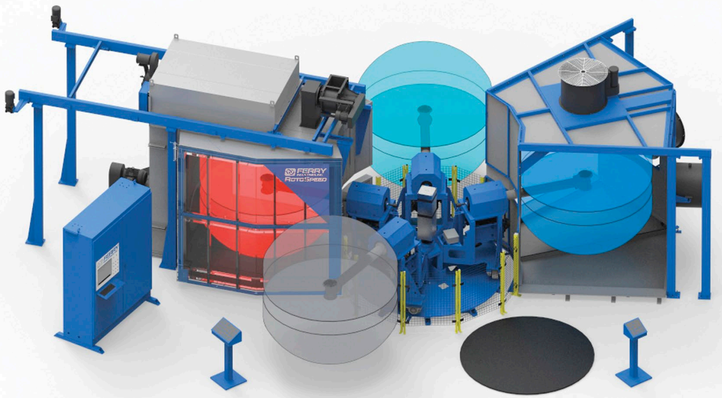
Independent-Arm Carousel



Limitations

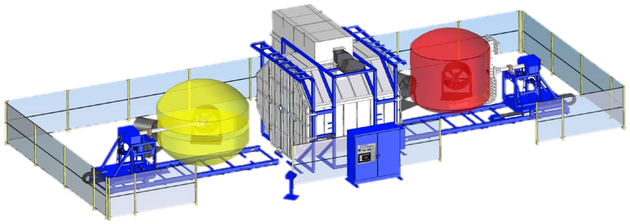
- 4 arms on a 5-station layout reduces the flexibility of the machine if there is a lot of cycle imbalance – i.e.: thick parts, foaming, lots of inserts, graphics, etc.

- Operator induced cycle delays are less identifiable – operator can pace the machine

- Larger foot-print than Turret Carousel – facility constraints can limit machine placement and machine sizes

- Arms cannot pass one another – so extreme cycle time differences arm-to-arm can reduce machine output – creating bottlenecks

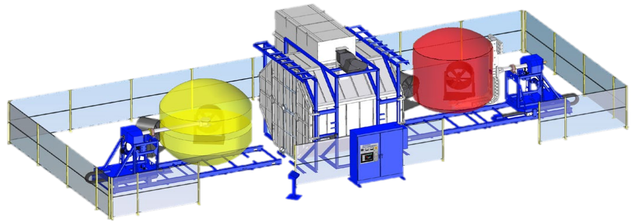
In-line Shuttle



Advantages

- Good machine design for large size, lower quantity parts. Good way to prototype new products
- Can allow for one arm to ‘bypass’ the other if mixing long and short cycles
- Two shuttles will be more productive than a 4-arm carousel when there is a lot of cycle imbalance – i.e.: thick parts, foaming, lots of inserts, graphics, etc.
- Shuttle is expandable from 1 to 2 arms and carts (3 arms for others)
- A solution for limited floor space or needing more production
- An efficient way to remove high cycle time products from a carousel production machine to help balance all machine productivity
- Staggering start times of two shuttles can help with manpower usage

In-line Shuttle



Limitations

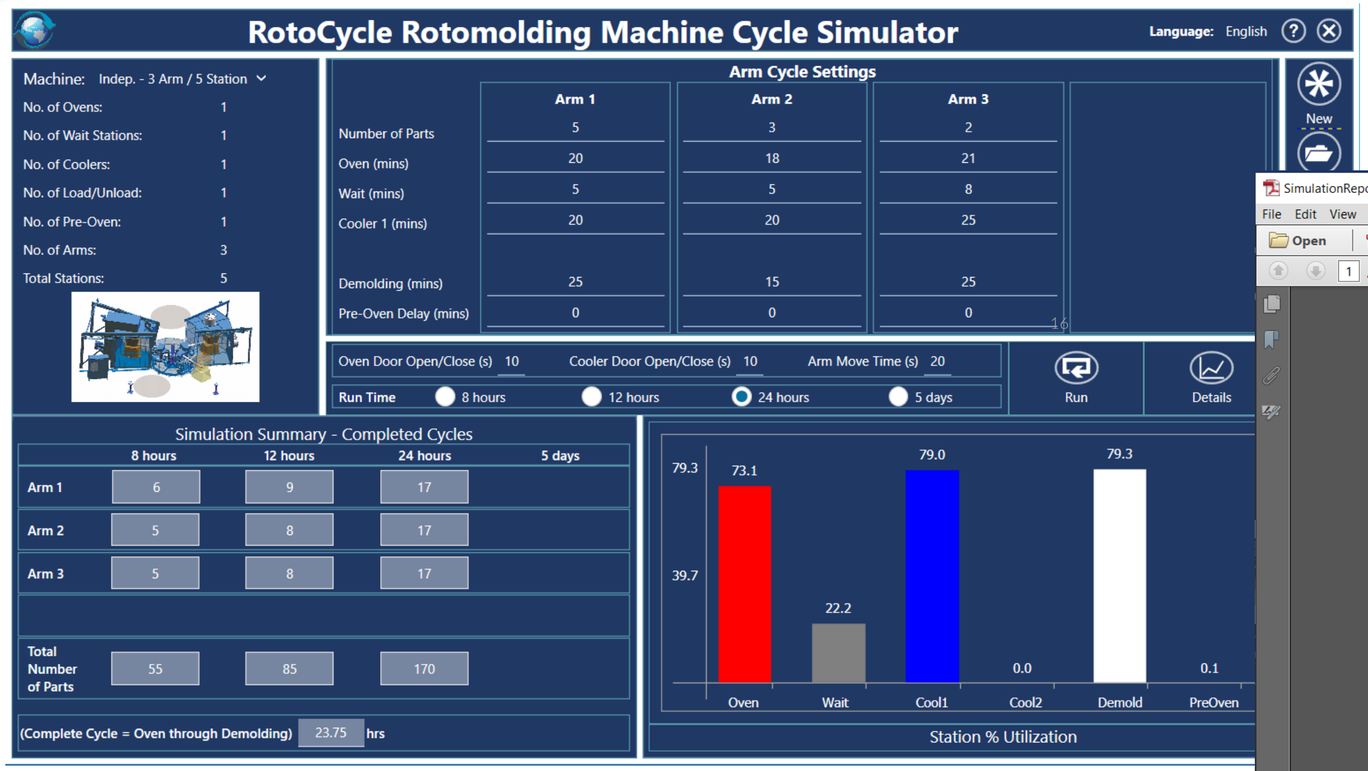
- Oven utilization of one machine is low compared to carousel machines – oven is idle approx. 33% pf the time compared to carousel machines with same cycle parameters
- Requires 2 teams to service a 2-arm shuttle, or 1 team and an arm is not serviced timely
- On a 2-arm shuttle, the 2 service stations need to be equipped each with cranes, tools, platforms, etc.
- Operators must move rather than the machine coming to them – not an “assembly-line” operation
- Operator takt time is not controlled by machine – operator can pace machine productivity/output

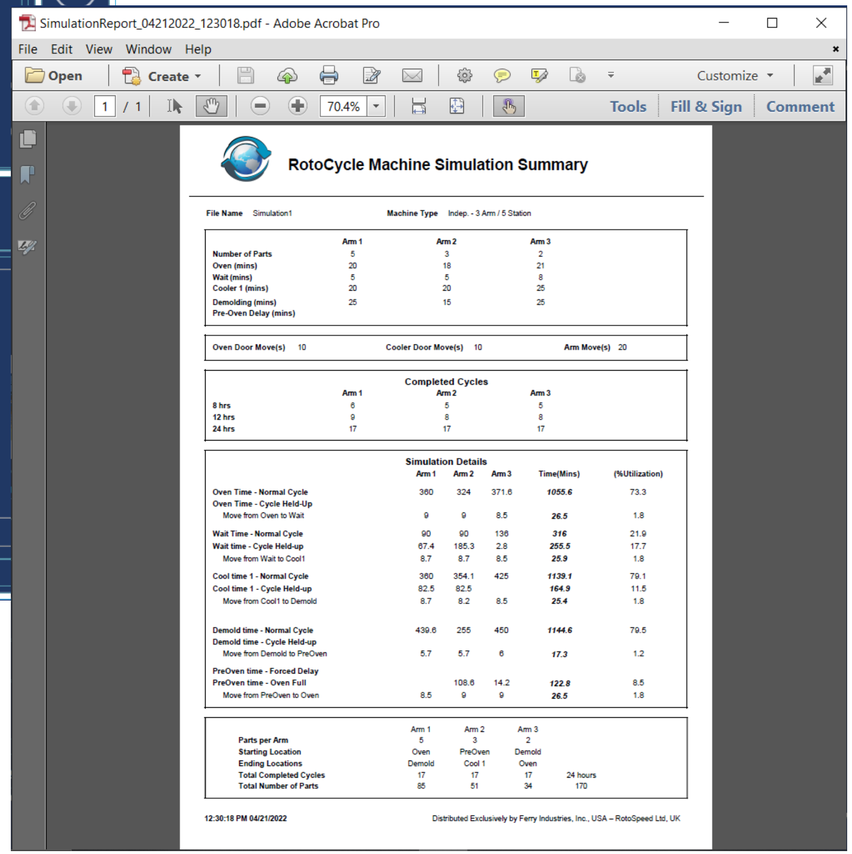
Production Simulation – 9 machines styles

See & try live demo – Booth 205

RotoCycle™
Rotational Molding Machine
Cycle Simulator Software

https://www.ferryindustries.com/RotoSpeed/RotoCycle





Calculations done by RotoCycle – a 3rd party software simulation by Paul Nugent, Ph. D.
RotoCycle is exclusively available through Ferry Industries, Inc.

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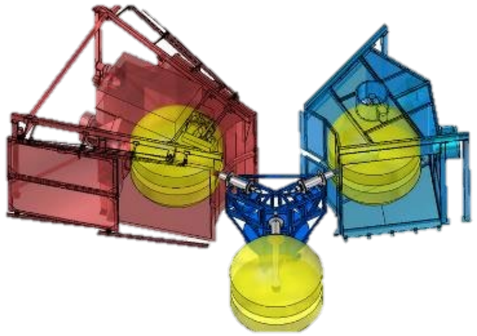
Balanced Cycles – Turret Machine



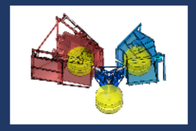
- Most efficient style of machine for output when cycles are balanced
- Minimal delay in stations - requires superb management of demolding station takt time

RotoCycle Rotomolding Machine Cycle Simulator

Language: English

Machine: Turret - 3 Arm

No. of Ovens:	1
No. of Wait Stations:	0
No. of Coolers:	1
No. of Load/Unload:	1
No. of Pre-Oven:	0
No. of Arms:	3
Total Stations:	3



Arm Cycle Settings

	Arm 1	Arm 2	Arm 3
Number of Parts	4	6	4
Oven (mins)	14	14	14
Cooler 1 (mins)	14	14	14
Demolding (mins)	14	14	14

New | Open | Save

Oven Door Open/Close (s) 10 | Cooler Door Open/Close (s) 10 | Arm Move Time (s) 20

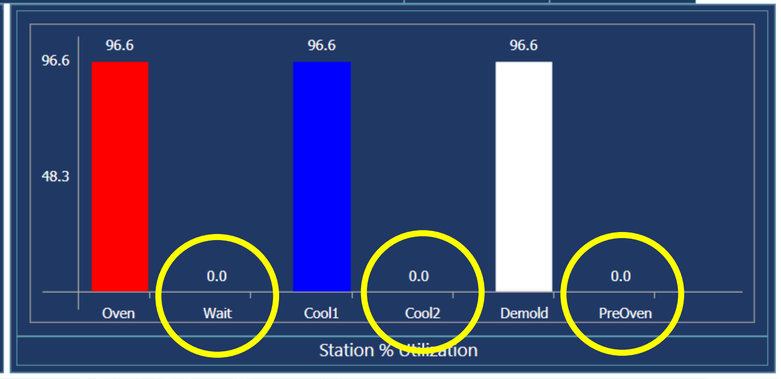
Run Time: 8 hours | 12 hours | 24 hours | 5 days

Run | Details

Simulation Summary - Completed Cycles

	8 hours	12 hours	24 hours	5 days
Arm 1	11	16	33	165
Arm 2	10	16	32	165
Arm 3	10	15	32	164
Total Number of Parts	144	220	452	2306

(Complete Cycle = Oven through Demolding) 119.87 hrs



Machine Simulator - Details of Simulation1

Description	Arm 1	Arm 2	Arm 3	Arm 4	Time (mins)	% Utlization
Oven Time - Normal Cycle	2,324.0	2,318.0	2,310.0	0.0	6,952.0	96.6
Oven Time - Cycle Held-Up	2.8	2.8	0.0	0.0	5.5	0.1
Move from Oven to Cool1	80.2	79.8	82.5	0.0	242.5	3.4
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Cool time 1 - Normal Cycle	2,318.0	2,310.0	2,324.0	0.0	6,952.0	96.6
Cool time 1 - Cycle Held-up	2.8	2.8	0.0	0.0	5.5	0.1
Move from Cool1 to Demold	79.8	79.8	83.0	0.0	242.5	3.4
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Demold time - Normal Cycle	2,310.0	2,324.0	2,318.0	0.0	6,952.0	96.6
Demold time - Cycle Held-up	2.8	2.8	0.0	0.0	5.5	0.1
Move from Demold to Oven	79.8	80.2	82.5	0.0	242.5	3.4
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

	Arm 1	Arm 2	Arm 3	Arm 4	
Parts per Arm	4	6	4	0	
Starting Location	Oven	Demold	Cool 1		
Ending Location	Cool 1	Oven	Demold		
Total Completed Cycles	165	165	164		5 days
Total Number of Parts	660	990	656	0	2306

RotoCycle™ Rotational Molding Machine Cycle Simulator Software

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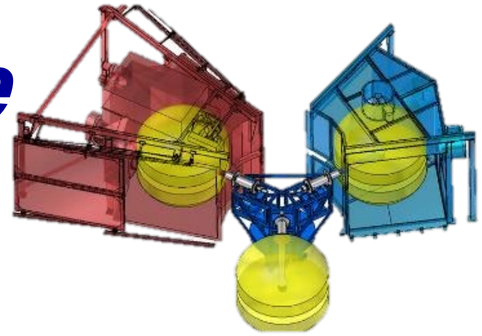
Out-of-Balance Cycles – Turret Machine



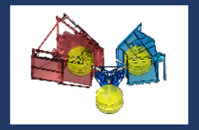
- If one arm or one station setting is out of alignment with the other stations, the imbalance is multiplied across the other arms
- Delays can affect cure if arms are left to soak in the oven and difficulty demolding if arms are left to cool too long

RotoCycle Rotomolding Machine Cycle Simulator

Language: English

Machine: Turret - 3 Arm

No. of Ovens:	1
No. of Wait Stations:	0
No. of Coolers:	1
No. of Load/Unload:	1
No. of Pre-Oven:	0
No. of Arms:	3
Total Stations:	3



Arm Cycle Settings

	Arm 1	Arm 2	Arm 3
Number of Parts	4	6	4
Oven (mins)	14	14	14
Cooler 1 (mins)	14	14	14
Demolding (mins)	20	14	14

New | Open | Save

Oven Door Open/Close (s) 10 | Cooler Door Open/Close (s) 10 | Arm Move Time (s) 20

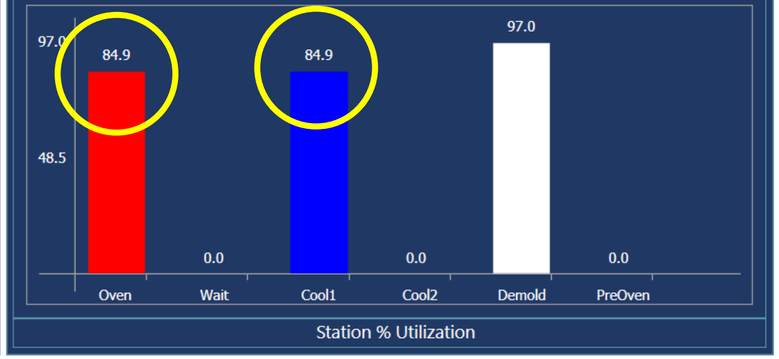
Run Time: 8 hours | 12 hours | 24 hours | 5 days (5 days selected)

Run | Details

Simulation Summary - Completed Cycles

	8 hours	12 hours	24 hours	5 days
Arm 1	9	14	29	145
Arm 2	9	14	28	145
Arm 3	9	13	28	144
Total Number of Parts	126	192	396	2026

(Complete Cycle = Oven through Demolding) 119.87 hrs



Station % Utilization

Machine Simulator - Details of Simulation1

Description	Arm 1	Arm 2	Arm 3	Arm 4	Time (mins)	% Utlization
Oven Time - Normal Cycle	2,044.0	2,038.0	2,030.0	0.0	6,112.0	84.9
Oven Time - Cycle Held-Up	0.0	2.4	872.4	0.0	874.8	12.2
Move from Oven to Cool1	73.0	70.1	70.1	0.0	213.2	3.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Cool time 1 - Normal Cycle	2,038.0	2,030.0	2,044.0	0.0	6,112.0	84.9
Cool time 1 - Cycle Held-up	0.0	872.4	2.4	0.0	874.8	12.2
Move from Cool1 to Demold	72.5	70.1	70.6	0.0	213.2	3.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Demold time - Normal Cycle	2,900.0	2,044.0	2,038.0	0.0	6,982.0	97.0
Demold time - Cycle Held-up	0.0	2.4	2.4	0.0	4.8	0.1
Move from Demold to Oven	72.5	70.6	70.1	0.0	213.2	3.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

	Arm 1	Arm 2	Arm 3	Arm 4	
Parts per Arm	4	6	4	0	
Starting Location	Oven	Demold	Cool 1		
Ending Location	Cool 1	Oven	Demold		
Total Completed Cycles	145	145	144		5 days
Total Number of Parts	580	870	576	0	2026

RotoCycle™ Rotational Molding Machine Cycle Simulator Software

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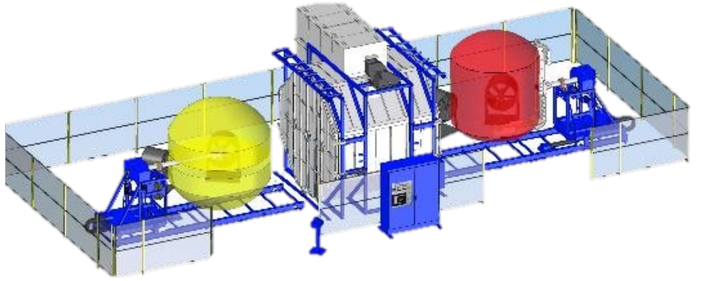
2-Arm Shuttle Machine



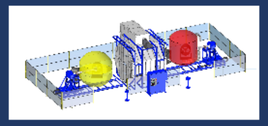
- Good machine design for large size, lower quantity parts
- Allows for one arm to ‘bypass’ the other if mixing long and short cycles

RotoCycle Rotomolding Machine Cycle Simulator

Language: English

Machine: Shuttle - 2 Arm

No. of Ovens:	1
No. of Wait Stations:	0
No. of Coolers:	2
No. of Load/Unload:	2
No. of Pre-Oven:	0
No. of Arms:	2
Total Stations:	3



Arm Cycle Settings

	Arm 1	Arm 2
Number of Parts	4	6
Oven (mins)	14	20
Cooler 1 (mins)	14	
Cooler 2 (mins)		30
Demolding (mins)	14	25

New / Open / Save

Oven Door Open/Close (s) 10 Cooler Door Open/Close (s) 0 Arm Move Time (s) 20

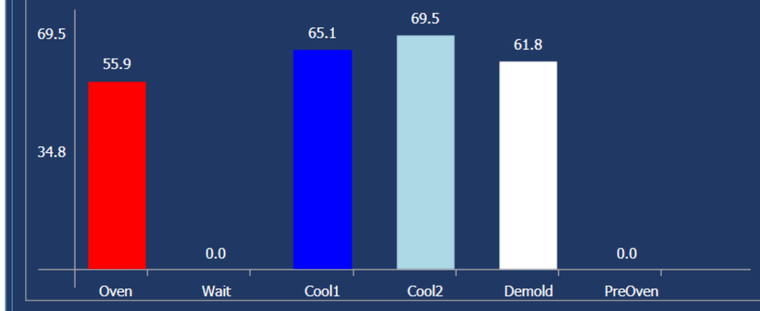
Run Time: 8 hours / 12 hours / 24 hours / 5 days

Run / Details

Simulation Summary - Completed Cycles

	8 hours	12 hours	24 hours	5 days
Arm 1	11	16	33	167
Arm 2	5	8	16	83
Total Number of Parts	74	112	228	1166

(Complete Cycle = Oven through Demolding) 119.74 hrs



Station % Utilization

Machine Simulator - Details of Simulation1

Description	Arm 1	Arm 2	Arm 3	Arm 4	Time (mins)	% Utlization
Oven Time - Normal Cycle	2,352.0	1,680.0	0.0	0.0	4,032.0	56.0
Oven Time - Cycle Held-Up	0.0	0.0	0.0	0.0	0.0	0.0
Move from Oven to Cool1	84.0	42.0	0.0	0.0	126.0	1.8
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Cool time 1 - Normal Cycle	2,339.0	0.0	0.0	0.0	2,339.0	32.5
Cool time 1 - Cycle Held-up	0.0	0.0	0.0	0.0	0.0	0.0
Move from Cool1 to Demold	0.0	0.0	0.0	0.0	0.0	0.0
Cool time 2 - Normal Cycle	0.0	2,513.0	0.0	0.0	2,513.0	34.9
Cool time 2 - Cycle held-up	0.0	0.0	0.0	0.0	0.0	0.0
Move from Cool2 to Demold	0.0	0.0	0.0	0.0	0.0	0.0
Demold time - Normal Cycle	2,338.0	2,100.0	0.0	0.0	4,438.0	61.6
Demold time - Cycle Held-up	3.5	824.4	0.0	0.0	827.9	11.5
Move from Demold to Oven	83.5	40.6	0.0	0.0	124.1	1.7
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0

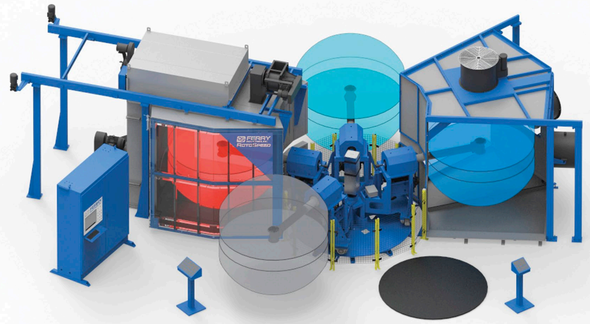
	Arm 1	Arm 2	Arm 3	Arm 4	
Parts per Arm	4	6	0	0	
Starting Location	Oven	Demold			
Ending Location	Cool 1	Cool 1			
Total Completed Cycles	167	83			5 days
Total Number of Parts	668	498	0	0	1166

RotoCycle™ Rotational Molding Machine Cycle Simulator Software

FERRY INDUSTRIES, INC.

Independent Arm Machine – Variable Cycles

- Most common/flexible machine design for mixed production models
- Longer station settings can create production delays as arms wait
- 3 arms with 5 stations provides two levels of redundancy to help reduce these delays between stations when different cycle times are used

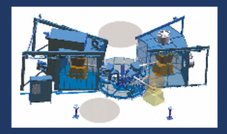


RotoCycle Rotomolding Machine Cycle Simulator

Language: English

Machine: Indep. - 3 Arm / 5 Station

No. of Ovens:	1
No. of Wait Stations:	1
No. of Coolers:	1
No. of Load/Unload:	1
No. of Pre-Oven:	1
No. of Arms:	3
Total Stations:	5



Arm Cycle Settings

	Arm 1	Arm 2	Arm 3
Number of Parts	4	6	4
Oven (mins)	14	20	16
Wait (mins)	0	0	0
Cooler 1 (mins)	14	25	18
Demolding (mins)	14	25	10
Pre-Oven Delay (mins)	0	0	0

New / Open / Save

Oven Door Open/Close (s) 10 | Cooler Door Open/Close (s) 10 | Arm Move Time (s) 20

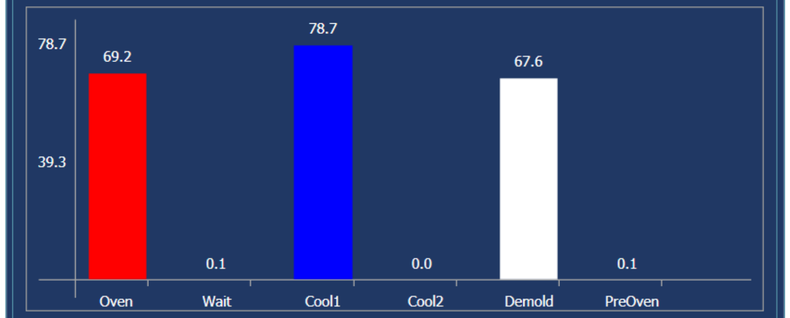
Run Time: 8 hours | 12 hours | 24 hours | 5 days

Run | Details

Simulation Summary - Completed Cycles

	8 hours	12 hours	24 hours	5 days
Arm 1	7	10	20	99
Arm 2	6	9	19	99
Arm 3	6	9	19	99
Total Number of Parts	88	130	270	1386

(Complete Cycle = Oven through Demolding) 119.77 hrs



Station % Utilization

Machine Simulator - Details of Simulation1

Description	Arm 1	Arm 2	Arm 3	Arm 4	Time (mins)	% Utlization
Oven Time - Normal Cycle	1,400.0	2,000.0	1,587.0	0.0	4,987.0	69.3
Oven Time - Cycle Held-Up	0.0	0.0	0.0	0.0	0.0	0.0
Move from Oven to Wait	50.0	50.0	49.5	0.0	149.5	2.1
Wait Time - Normal Cycle	0.0	0.0	0.0	0.0	0.0	0.0
Wait time - Cycle Held-up	1,961.9	0.0	891.0	0.0	2,852.9	39.6
Move from Wait to Cool1	48.4	50.0	47.9	0.0	146.2	2.0
Cool time 1 - Normal Cycle	1,400.0	2,478.0	1,782.0	0.0	5,660.0	78.6
Cool time 1 - Cycle Held-up	0.0	0.0	678.2	0.0	678.2	9.4
Move from Cool1 to Demold	50.0	49.5	47.9	0.0	147.4	2.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0
Demold time - Normal Cycle	1,395.0	2,475.0	1,000.0	0.0	4,870.0	67.6
Demold time - Cycle Held-up	0.0	0.0	5.0	0.0	5.0	0.1
Move from Demold to PreOven	33.0	33.0	33.3	0.0	99.3	1.4
PreOven time - Forced Delay	0.0	0.0	0.0	0.0	0.0	0.0
PreOven time - Oven Full	812.3	14.5	1,028.3	0.0	1,855.1	25.8
Move from PreOven to Oven	49.5	50.0	50.0	0.0	149.5	2.1

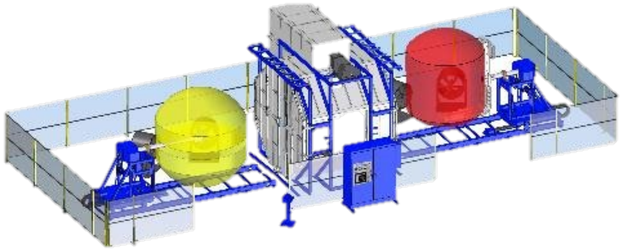
	Arm 1	Arm 2	Arm 3	Arm 4	
Parts per Arm	4	6	4	0	
Starting Location	Oven	Pre-Oven	Demold		
Ending Location	Demold	Cool 1	Oven		
Total Completed Cycles	99	99	99		5 days
Total Number of Parts	396	594	396	0	1386

RotoCycle™ Rotational Molding Machine Cycle Simulator Software

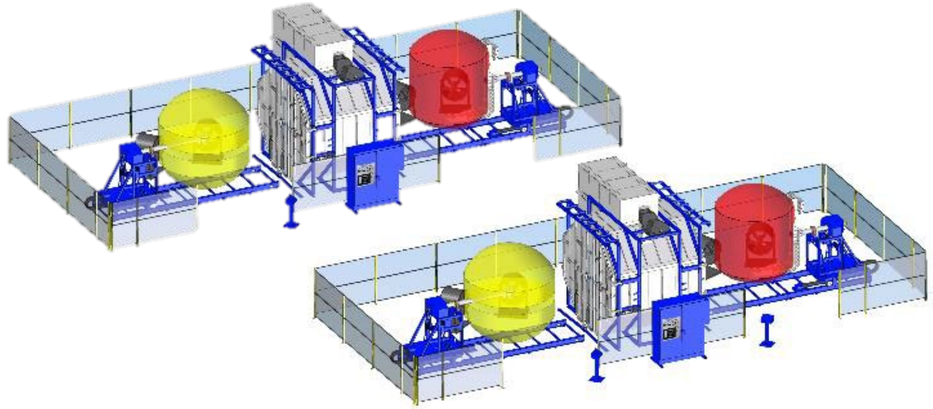
Ferry Industries, Inc.

Comparing Machine Styles - Shuttle vs. Turret

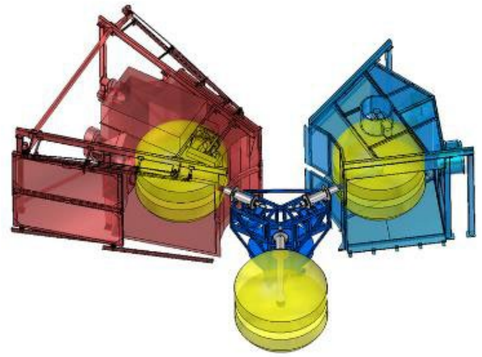
- Simulation evaluates machine styles prior to setting up an operation, allowing a comparison of output rates vs. labor requirements vs. space – many permutations are possible



14 min Heat / Cool / Demold
66 arms per 24 hours
2 operator demolding stations



14 min Heat / Cool / Demold
132 arms per 24 hours
4 operator demolding stations



14 min Heat / Cool / Demold
97 arms per 24 hours
1 operator demolding station

- Consider efficiency comparison that can be made in terms of parts/hour/operator, initial capital outlay, space required
- Flexibility of a double shuttle installation is higher than turret due to ability to run highly dissimilar cycles across arms

Comparing Machine Styles

Other comparisons:

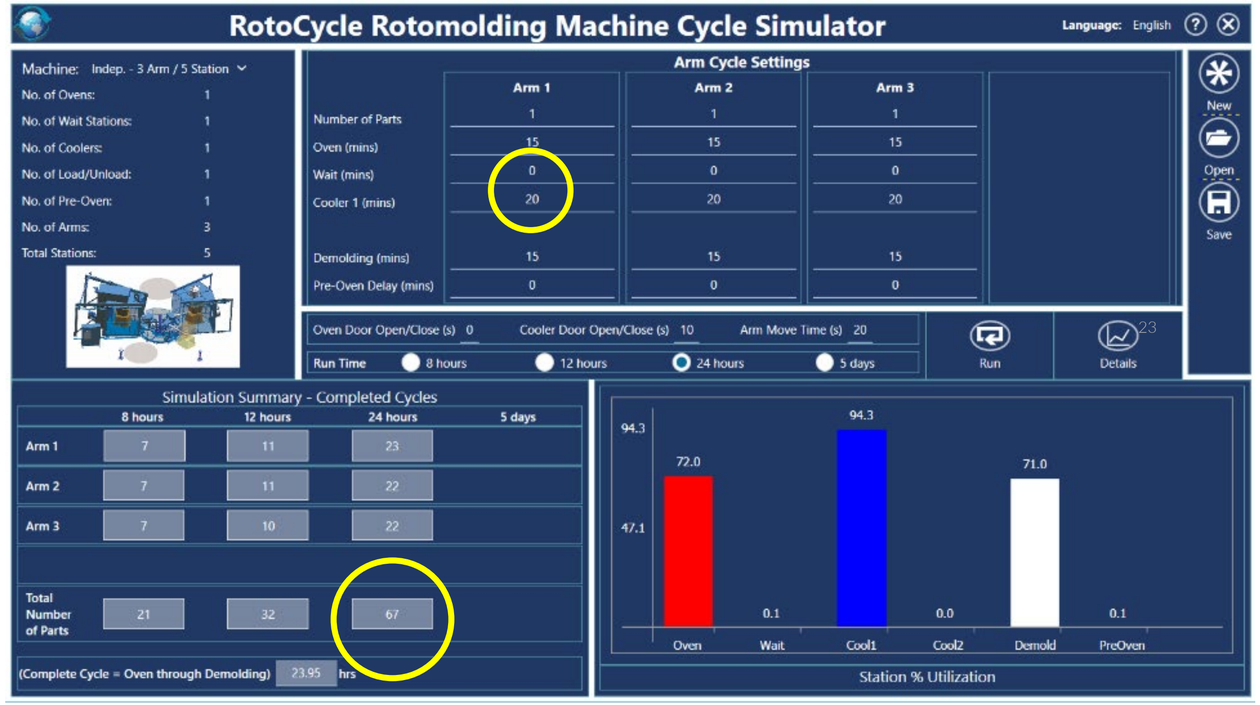
- 3-arm, 5-station independent-arm machine vs. 4-arm, 5-station independent-arm machine
  - Using 4 arms on a 5-station layout reduces the flexibility of the machine if cycles are significantly out-of-balance
  - Simulation allows an analysis of the degree of out-of-balance vs. output rates

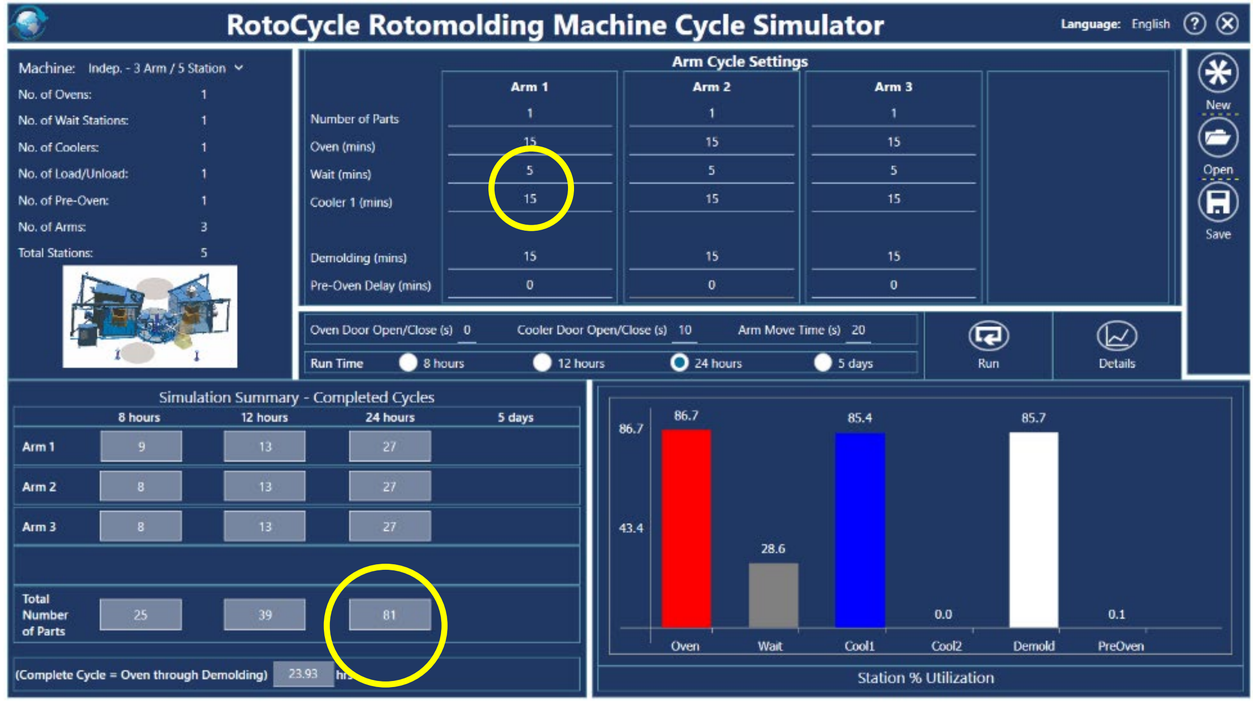
- 3-arm, 5-station independent-arm machine vs. 4-arm, 6-station independent-arm machine
  - A 4-arm, 6-station design increase the number of molds in-service but retains the two levels of redundancy
  - Throughput rates per mold may be reduced as the number of active molds is higher and the time to pass through the machine requires another station

- 4-arm Fixed-arm Turret vs. 4-arm, 5-station Independent-arm machine
  - For balanced cycles, the 4-arm turret will be more capital efficient and forces more attention on the demolding station takt time
  - For imbalanced cycles, the independent-arm machine will have slightly more flexibility but with only one degree of redundancy, machine can easily be delayed

Balancing Cycles for Optimum Output

- Simulation can assess ‘what-if’ scenarios for improving the production rhythm of the machine
- Example: Dividing cooling time between stations on a 3-arm, 5-station independent machine





- When all cooling of 20 mins is carried out in the main cooling station (left scenario), the maximum output for 24 hours is 67 arms
- When the cooling cycle is split between the wait station and the main cooling station as 5 mins and 15 mins (right scenario), the maximum output for 24 hours rise to 81 arms
- May require additional cooling fans in the wait station

Productivity Analysis

- Cycle simulation can be used to develop ideal production targets for comparison with actual

- Oven and cooling cycle times are most often fixed parameters
- Cooling times may vary according to ambient conditions
- Demolding times are the most commonly under-estimated component of the machine cycle
- Outputs based on estimates will often be low

- RotoCycle can be used to establish the ideal output and focus attention on the longest cycle elements (typically demolding)
  - Or help balance stations
  - Or identify the best mix of molds (based on their thickness and cycle times)
- Actual output rates (number of arms turned per shift, for example) vs. ideal targets can be modelled using RotoCycle by increasing the demolding times (or direct observation) to match

- Good tool for supervision in setting and monitoring targets

Summary

- The perfect machine varies based on lots of variables – molders need to weigh those most important for the business and production of the products being molded
- More arms may not always produce more parts – sensitive to cycle imbalance
- The goal is to keep the oven curing products, not idling – maximize oven utilization

- Make changes to process and product mix on machines to smooth out cycle times across all the phases of the cycle.
- Consider the other support equipment requirements that vary based on machine type and style
- Facility space costs money, machine footprint is a consideration and cost
- Cycle simulation can help production planning, takt time bottlenecks and product mix planning

Thank you for your attention and discussion. And thank you to ARM, its BOD and the Programs & Forums Committee for the opportunity to contribute.

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