ETM ENGINEERING & TECHNOLOGY MANAGEMENT

Title: JM Corporation

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Abstract: JM Corporation is a growing manufacturer of plastic injection molded products. One of its manufacturing lines for consumer packaging is comprised of ten-year old machines which appear to have exceeded their economic life. Reject rates are high and maintenance costs have risen dramatically. Using the financial constraints of the company and economic analysis, Rejects Limited, and Engineering consulting firm, has considered several options for bringing the production line back up to economic efficiency. The options include using the 'do nothing' as a base and comparing different scenarios of new and/or rebuild replacement of machines. The options were considered on a Present Worth and Annual Equivalent basis. The scenario consisting of replacing all old machines with all new, was chosen as the best option and a sensitivity analysis revealed that Capital investment has the greatest impact when deviated significantly from the expected values used in the cash flow analysis

JM Corporation

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EMP-P9823

JM CORPORATION

REPLACEMENT ANALYSIS

OF

INJECTION MOLDING EQUIPMENT

EGMT 535 SPRING 1998

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JM CORPORATION

REPLACEMENT ANALYSIS
INJECTION MOLDING EQUIPMENT

Concepts Illustrated: Present Worth Analysis, Replacement Analysis and Sensitivity Analysis

Abstract - JM Corporation is a growing manufacturer of plastic injection molded products. One of its manufacturing lines for consumer packaging is comprised of ten-year old machines which appear to have exceeded their economic life. Reject rates are high and maintenance costs have risen dramatically. Using the financial constraints of the company and economic analysis , Rejects Limited, an Engineering consulting firm, has considered several options for bringing the production line back up to economic efficiency. The options include using the 'do nothing' as a base and comparing different scenarios of new and/or rebuild replacement of machines. The options were considered on a Present Worth and Annual Equivalent basis. The scenario consisting of replacing all old machines with all new, was chosen as the best option and a sensitivity analysis revealed that Capital investment has the greatest impact when deviated significantly from the expected values used in the cash flow analysis.

BACKGROUND

JM Corporation is a plastics injection molding company which produces a wide variety of consumer products. One product line that is currently showing a 20% product returns as well as a 30% late delivery rate, is the manufacturing line for consumer packaging. The eight molding machines that comprise this product line were purchased ten years ago.

They had a recommended economic life of eight years. These machines have an optimal yield of 98 % when properly operated or maintained. A four person maintenance team was originally able to meet maintenance requirements for all eight machines.

JM has undergone significant growth over a ten year period and expects a minimum 1.5% annual growth rate (adjusted for inflation) [1] over the next business cycle. The current machines, even though exceeding their economic life by two years, are currently being operated at 24 hours a day, seven days a week which is twice their recommended cycle. This type of production is not without a high cost. Reject rates are up to 12% and utilizes a twelve person maintenance team to keep the machines operating. The direct costs of an increase in rejects has been estimated by JM to be approximately $135,000 per percentage point. Net loss for rejects is currently running at 1.62 million dollars a year in waste and re-manufacturing costs.

RESEARCH AND ITS IMPACT

Bown [2] indicates that the main fixed cost for an injection molding company is the capital cost of the equipment. JM recognizes this and has chosen to push the useful life of its machine to a maximum and into what is possibly a money losing situation. Rejects Limited, an engineering consulting firm, has been retained to conduct an analysis to determine how JM can improve this particular production line.

JM has budgeted $1 million, from cash, to achieve a minimum of 30% reject reduction rate in the first year. An additional $1 million will be made available through equity financing in order to achieve 98% yield within three years. Increased yields will have a dramatic positive impact on product returns and late deliveries.

Research by Rejects Limited, found a variety of 'value priced' injection molding machines that would meet the needs of JM. Computer aided manufacturing (CIM) systems are being utilized in mid-size manufacturing companies to provide competitive advantage through high yield and excellent quality [3]. In addition, automation (robotics) is being used in conjunction with injection molding machines to achieve higher level of efficiencies [4]. JM does not currently incorporate CIM technology nor does it have sophisticated automation. However in researching new machinery it was found that most equipment from suppliers such as Husky or Engel have these types of capabilities which can be incorporated [5] at later times should the company wish to pursue such options. Rejects limited considered these capabilities a plus and based its machine pricing on this type of equipment.

The options considered by Rejects Limited, included the *status quo*, rebuilding old machines and purchasing new. From the standpoint of reducing rejects by at least 30% in the first year, the "do nothing' option was used as a baseline. The one million a year in the first two years was an additional constraint that limited the options as well. In terms of equipment, the new machines are priced at $500,000 each and have a capacity more than twice that of the old machines (1 new replaces 2 old). Rebuilt machines cost $100,000 each with no additional capacity (replace 1 for 1). Service lives are eight years and four years respectively.

DESCRIPTION OF ALTERNATIVES

We have identified five different alternatives to be considered for this evaluation. Each of the alternatives other than the 'do nothing' involves the purchase of new equipment. Since all the alternatives involve an equipment cost of two million dollars, the question we ask ourselves is what alternative will give us the minimum cost? These alternatives will be analyzed using a Cash Flow Approach and they will be assessed using the Present Worth (PW) and Annual Equivalent (AE) values. Any investment totaling more than $1,000,000 in a year will be financed through a cooperate loan at a rate of 10% annually. However, any investments of $1,000,000 or less in a year will be financed through the company's own funds. Revenues are not expected to increase by a significant amount, this project will merely be a cost-improvement project, therefore decision will be made in favor of the alternative with the least cost to the company.

Tables 1 through 5, describe the options used by Rejects Limited in their analysis:

ITEM	YEAR	COST $
8 Old machines	10 years old	325,000 each
Reject Rate 12%	Per Year	1,620,000
Maintenance Labor	Per Year	376,000
Parts/tools	Per Year	240,000
Service Life	8 Years	

Table 1: 'Do Nothing'

ITEM	YEAR	COST $
4 **New** machines	Bought in year 0	500,000 each
Reject Rate 2%	Per Year	270,000
Maintenance Labor	Per Year	72,000
Parts/tools	Per Year	20,000
Service Life	8 Years	

Table 2: All new machines in year 0

ITEM	YEAR	COST $
8 **Rebuilds** machines	Bought in Year 0	100,000 each
Reject Rate 8%	Per Year	1,080,000
Maintenance Labor	Per Year	264,000
Parts/tools	Per Year	80,000
Service Life	4 Years	

Table 3: All rebuild machines bought in year 0

ITEM	YEAR	COST $
2 **New** machines	Bought in year **0**	500,000 each
Reject Rate 7%	**Year 1**	945,000
4 **Rebuilds**	Bought in Year **1**	100,000 each
Reject Rate 5%	**From Year 2**	675,000
Maintenance Labor	Per Year	132,000
Parts/tools	For Year 1	130,000
Parts/tools	From Year 2	50,000
Service Life NEW	8 Years	
Service Life REBUILD	4 Years	

Table 4: Combination of 2 new and 4 old machines

ITEM	YEAR	COST $
2 **New** machines	Bought in year **0**	500,000 each
Reject Rate 7%	**Year 1**	945,000
2 **New** machines	Bought in Year **2**	500,000 each
Reject Rate 2%	**From Year 2**	270,000
Maintenance Labor	For Year 1	132,000
Maintenance Labor	**From Year 2**	72,000
Parts/tools	For Year 1	130,000
Parts/tools	**From Year 2**	20,000
Service Life New	8 Years	

Table 5: Four new machines bought in different years

Note: All the above options are using a tax rate of 34%, 7 years MACRS and an 8 year analysis period. The companies Minimum attractive rate of return (MARR) is 12%

CASH FLOWS

OPTION 1: 'DO NOTHING'

To understand what running the old machines in their current situation is costing JM Corp. a "do nothing" option was studied. This should explain why the company is considering alternatives today for its manufacturing line.

8 machines were bought 10 years ago at a cost of $325,000 each. The machines were classified as 7-year MACRS properties and they have fully depreciated by now. They have no market value today, and are not expected to have any market value in 8 years.

Over the years, the reject rate of these machines increased to 12%, costing $1,620,000 every year, and as they fulfilled their projected service life, the maintenance costs increased to an annual $376,000 and the cost of necessary parts and tools to keep the machines running are now $240,000 per year. A decrease in rejects, maintenance or tooling costs is not expected and the best estimate is that they will remain the same over the next 8 years at the capacity the machines are run currently. Clearly, this option does not involve any investment activities, financing, or depreciation.

Using the information in table 1, an annual equivalent cost of $1,475,760 is calculated, see table 6.

OPTION 2: NEW ONLY IN YEAR 0

This alternative involves replacing all the existing machines today with new technology. The new reject rate is estimated to be 2% depending on the manufacturer of the equipment, totaling a loss of $270,000 every year over the service life of the machines.

The cost of a new machine is $500,000, and every new machine has the capacity to replace two old machines which will necessitate buying 4 new machines. Total cost of the machines will exceed $1,000,000 in a year,(totaling $2,000,000) so the company will have to use a million dollars from borrowed funds at 10% annual rate to finance part of this project. This will introduce tax savings every year over the interest of the debt, and will be beneficial for JM Corp. because the company has the opportunity to borrow at a rate lower than its MARR. The new machines are classified as 7-year MACRS properties for tax purposes and they have a service life of 8 years at the end of which they are not expected to have any salvage value. Annual maintenance labor and parts/tools costs will decrease to a significant $72,000 and $20,000, respectively.

Using the information in table 2, the Present Worth of this project is calculated to be $2,537,933and the Annual cost of the project is calculated to be $510,893, see table 7.

OPTION 3: REBUILDS ONLY IN YEAR 0

A third alternative is to replace all the existing machines with rebuilds, that will reduce the rejects by 4% to $1,080,000 annually. Rebuilds will also help reduce maintenance labor cost to $264,000, and parts/tools to $80,000 annually. The rebuilds will cost $100,000 each, totaling $800,000 for the 8 machines and extend the service life of the machine by 4 years. At the end of the first 4 years, a second rebuild of all machines is predicted at the same costs.

A depreciation schedule of 7-year MACRS will be applied to the rebuilt machines. The rebuilt machines will not be fully depreciated by the end of their useful lives, and as there will be no salvage value of the rebuilt machinery, there will be a gains tax shield of $101,959 at the end of their useful lives (periods 4 and 8)

Analysis using the given information in table 3, yields a cost of $5,654,577 for the project at present worth and an annual equivalent cost of $1,138,282, see table 8.

OPTION 4: COMBINATION OF 2 NEW AND 4 OLD

A different approach is to consider performing a cost-improvement project over a period of time instead of replacing all the machines at once. It is assumed that 2 new machines replacing 4 current machines will be bought in the year 0, at $500,000 a machine, reducing the rejects rate by 5%. The losses because of the reject rate of 7% will be $945,000 the first year of the project. The remaining 4 old machines will be replaced by rebuilts at the end of the first year, reducing the rejects to 5%, and the reject costs to $675,000 from year 2 onwards.

Parts/tools cost will be $130,000 the first year, and will go down to $50,000 after the rebuilds are bought. The combined maintenance labor will be $132,000 every year throughout the project.

Service life of new machines is 8 years. Service life of rebuilt machines is 4 years, requiring a second rebuild of the 4 old machines in year 5 at a total investment cost of $400,000. All machines are considered as 7-year MACRS properties for tax purposes. As the rebuilt machines are not fully depreciated by the end of their service lives, they allow for tax shields in years 5 and 8. Total investments in one year never exceed $1,000,000 in this alternative, therefore, debt financing cannot be allowed.

Using the information in table 4, the cost of the project in present worth is calculated to be $3,345,932 over the life of the project and the annual equivalent cost is calculated to be $673,546, see table 9.

OPTION 5: TWO NEW MACHINES BOUGHT IN YEAR 0 AND 2

Instead of replacing all machines with new ones in a year, it is projected that JM Corp. replaces 4 machines every year for two years to allow for maximizing the capacity of the new machines without decreasing the production volume by a significant amount in a single year which could strike a blow to the company. It is assumed that the new machines will reach their desired capacity by the end of the first year they are installed. The reject rate will go down to 7% in the first year, totaling $945,000 in costs; and the replacement of the remaining machines will cut rejects down to 2%, resulting in an annual cost of $270,000 .

It is expected that the cost of the new machines will be $500,000 next year, the same as this year's price. The first year, 4 old machines will be kept to run, which will require a maintenance labor cost of $132,000 and tool/parts at $130,000. After the replacement is complete, maintenance and parts/tools costs will be down to $72,000, and $20,000 respectively.

The machines are considered as 7-year MACRS properties. The second set of two machines bought will not have depreciated fully by the end of the project. This will introduce a gains tax shield of $30,345 in the 8th year of the project.

Using the given information table 5, the present worth of this project was calculated to be $3,138,770 and the annual equivalent cost was calculated to be $631,843, see table 10. The result from the above options is that the purchase of two new machines in year 0 would involve the greatest PW and an immediate decrease in rejects.

SENSITIVITY ANALYSIS

A sensitivity analysis was performed on option 2, the alternative of replacing all current machines with new ones in year 0. The factors analyzed are Tax Rate, Capital Investment required to perform the project, Salvage Value of the machines at the end of the project life, Reject Costs, Changes in Maintenance Labor and Tooling/Parts Costs, and the Loan Rate. A maximum deviation of 50% from the expected values was allowed. Effect of such variations on the net cash flows were calculated, table 11 and the PW was plotted against the deviation from the expected values, see graph 1.

The analysis shows that the Tax Rate and Capital Investment required are the major factors affecting the results. Change in the Rejects Rate could become an important factor, should any unexpected changes occur to offset the project from its projected goals. Deviating the Rejects by ± 50% varies their cost by ± 1% which is ± $(135,000) annually. However, even in the worst case of lowering the capital investment by 50% from the expected value, this option remains as the most preferable option, with a PW of less than $ (3,300,000) which is better than any of the other alternatives. Even though tax rates are a major influence in the sensitivity analysis, chances of that changing are unlikely. Changes in Labor, Parts and Salvage Values result in no significant impact on the project. An increase in maintenance labor and tools costs could be fairly well tolerated providing these maintain the projected rejects rate. Any increase in the salvage values would be welcome.

CONCLUDING REMARKS

In summary, the economic analyses presented above show that the all new machines in year 0 alternative is preferable to all the other alternatives. When viewed from the PW , AE and the goal of decreasing reject rates by at least 30% and least cost to JM Corp., Option 2 appears as the best alternative enabling a reject rate of 2% , and having a PW value of $(2,537,933) compared to $(7,331,044) for the current situation at the company's MARR of 12%. The Annual equivalent for option 2 is $(510,893) as compared to $(1,475,760) for the current situation. Please note that the Rejects rate will stay at 2% over the course of their service life if a proper Preventive Maintenance system is implemented, the thing that changes over time is the capacity. Sensitivity analysis indicates that the present worth is very sensitive to Capital Investment and Tax Rate. However, a change in rejects rate by ±50% does not have a significant impact on the PW, which leads us to conclude that investment in new equipment is highly necessary for JM Corp.

REFERENCES

[1] Plastics World, page 32, January 1997.

[2] Bown, J, Injection Molding of Plastic Components, McGraw Hill Book Company (UK) Limited, page 183, 1979.

[3] Smock, D, Micro Switch Flipson, New Molding Strategy in Plastics World, pages 12-13, July 1996

[4] Mallon IV, J.M., Automation Value for Molders in Molding Systems, pages 28-31, 1997

[5] Smock, D, New Machines Automation Concepts are Ready to Show, Plastics World, Pages 10, June 1996

TABLES AND GRAPHS

	A	B	C	D	E	F	G	H	I	J	K
1		CASH FLOW STATEMENT 1		TABLE 6							
2											
3		Entered values in blue	INPUT			OUTPUT					
4		Check purple formulas	Tax rate %=	34.00		PW(i)= $	(7,331,044)				
5		Answers in red	MARR %=	12.00		AE(i)=	(1,475,760)				
6			Loan int %=	10.00	<--Not applicable in this sheet						
7											
8			0	1	2	3	4	5	6	7	8
9											
10		INCOME STMNT									
11	+	Revenues									
12	-	Expenses:									
13		COGS: Reject cost		(1,620,000)	(1,620,000)	(1,620,000)	(1,620,000)	(1,620,000)	(1,620,000)	(1,620,000)	(1,620,000)
14		O&M: Labor		(376,000)	(376,000)	(376,000)	(376,000)	(376,000)	(376,000)	(376,000)	(376,000)
15		Maintenance parts		(240,000)	(240,000)	(240,000)	(240,000)	(240,000)	(240,000)	(240,000)	(240,000)
16		Others									
17		Depreciation		0	0	0	0	0	0	0	0
18		Debt interest pmts		0	0	0	0	0	0	0	0
19		Taxable Income	$ -	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)	$ (2,236,000)
20		Income taxes (34%)	0	760,240	760,240	760,240	760,240	760,240	760,240	760,240	760,240
21		Net Income	$ -	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)
22											
23		CASH FLOW STMNT									
24		Operating activities:									
25	+	Net Income	0	(1,475,760)	(1,475,760)	(1,475,760)	(1,475,760)	(1,475,760)	(1,475,760)	(1,475,760)	(1,475,760)
26	+	Depreciation		0	0	0	0	0	0	0	0
27		Investment activitites:									
28	-	Capital Investment	0								
29	+	Salvage value									0
30	-	Gains Tax (last n only)									0
31		Financing activities:									
32	+	Borrowed Funds	0								
33	-	Principal repayment		0	0	0	0	0	0	0	0
34		Net Cash Flow	$ -	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)	$ (1,475,760)
35											
36											
37											
38		Depr rates % (1/2 last n)		14.29	24.49	17.49	12.49	8.93	8.92	8.93	4.46
39		Cost basis for depr=	0								
40		Depreciation		0	0	0	0	0	0	0	0

	B	C	D	E	F	G	H	I	J	K
1	**CASH FLOW STATEMENT 2**		**TABLE 7**							
2										
3	Entered values in blue	INPUT			OUTPUT					
4	Check purple formulas	Tax rate %=	34.00		PW(i)= $	(2,537,933)				
5	Answers in red	MARR %=	12.00		AE(i)=	(510,893)				
6		Loan rate %=	10.00	8 year loan term						
7										
8		0	1	2	3	4	5	6	7	8
9										
10	**INCOME STMNT**									
11	Revenues									
12	Expenses:									
13	COGS: Reject cost		(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)
14	O&M: Labor		(72,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)
15	Maintenance parts		(20,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)
16	Others									
17	Depreciation		(285,800)	(489,800)	(349,800)	(249,800)	(178,600)	(178,400)	(178,600)	(89,200)
18	Debt interest pmts		(100,000)	(91,256)	(81,637)	(71,056)	(59,417)	(46,615)	(32,532)	(17,040)
19	Taxable Income	$ -	$ (747,800)	$ (943,056)	$ (793,437)	$ (682,856)	$ (600,017)	$ (587,015)	$ (573,132)	$ (468,240)
20	Income taxes (34%)	0	254,252	320,639	269,768	232,171	204,006	199,585	194,865	159,202
21	Net Income	$ -	$ (493,548)	$ (622,417)	$ (523,668)	$ (450,685)	$ (396,011)	$ (387,430)	$ (378,267)	$ (309,039)
22										
23	**CASH FLOW STMNT**									
24	Operating activities:									
25	Net Income	0	(493,548)	(622,417)	(523,668)	(450,685)	(396,011)	(387,430)	(378,267)	(309,039)
26	Depreciation		285,800	489,800	349,800	249,800	178,600	178,400	178,600	89,200
27	Investment activitites:									
28	Capital Investment	(2,000,000)								
29	Salvage value									0
30	Gains Tax (last n only)									0
31	Financing activities:									
32	Borrowed Funds	1,000,000								
33	Principal repayment		(87,444)	(96,188)	(105,807)	(116,388)	(128,027)	(140,829)	(154,912)	(170,404)
34	Net Cash Flow	$ (1,000,000)	$ (295,192)	$ (228,805)	$ (279,676)	$ (317,273)	$ (345,438)	$ (349,859)	$ (354,579)	$ (390,242)
35										
36										
37										
38	Depr rates % (1/2 last n)		14.29	24.49	17.49	12.49	8.93	8.92	8.93	4.46
39	Cost basis for depr=	(2,000,000)								
40	Depreciation		(285,800)	(489,800)	(349,800)	(249,800)	(178,600)	(178,400)	(178,600)	(89,200)
41										

New Only

	A	B	C	D	E	F	G	H	I	J	K
1		CASH FLOW STATEMENT 3		TABLE 8							
2											
3		Entered values in blue	INPUT			OUTPUT					
4		Check purple formulas	Tax rate %=	34.00		PW(i)= $	(5,654,577)				
5		Answers in red	MARR %=	12.00		AE(i)=	(1,138,282)				
6			Loan int %=	10.00	<--Not applicable in this sheet						
7											
8			0	1	2	3	4	5	6	7	8
9											
10		INCOME STMNT									
11	+	Revenues									
12	-	Expenses:									
13		COGS: Reject cost		(1,080,000)	(1,080,000)	(1,080,000)	(1,080,000)	(1,080,000)	(1,080,000)	(1,080,000)	(1,080,000)
14		O&M: Labor		(264,000)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)
15		Maintenance parts		(80,000)	(80,000)	(80,000)	(80,000)	(80,000)	(80,000)	(80,000)	(80,000)
16		Others									
17		Depreciation		(114,320)	(195,920)	(139,920)	(49,960)	(114,320)	(195,920)	(139,920)	(49,960)
18		Debt interest pmts		0	0	0	0	0	0	0	0
19		Taxable Income	$ -	$ (1,538,320)	$ (1,619,920)	$ (1,563,920)	$ (1,473,960)	$ (1,538,320)	$ (1,619,920)	$ (1,563,920)	$ (1,473,960)
20		Income taxes (34%)	0	523,029	550,773	531,733	501,146	523,029	550,773	531,733	501,146
21		Net Income	$ -	$ (1,015,291)	$ (1,069,147)	$ (1,032,187)	$ (972,814)	$ (1,015,291)	$ (1,069,147)	$ (1,032,187)	$ (972,814)
22											
23		CASH FLOW STMNT									
24		Operating activities:									
25	+	Net Income	0	(1,015,291)	(1,069,147)	(1,032,187)	(972,814)	(1,015,291)	(1,069,147)	(1,032,187)	(972,814)
26	+	Depreciation		114,320	195,920	139,920	49,960	114,320	195,920	139,920	49,960
27		Investment activitites:									
28	-	Capital Investment	(800,000)				(800,000)				
29	+	Salvage value					0				0
30	-	Gains Tax (last n only)					101,959				101,959
31		Financing activities:									
32	+	Borrowed Funds	0								
33	-	Principal repayment		0	0	0	0	0	0	0	0
34		Net Cash Flow	$ (800,000)	$ (900,971)	$ (873,227)	$ (892,267)	$ (1,620,894)	$ (900,971)	$ (873,227)	$ (892,267)	$ (820,894)
35											
36											
37											
38		Depr rates % (1/2 last n)		14.29	24.49	17.49	6.25	14.29	24.49	17.49	6.25
39		Cost basis for depr=	(800,000)								
40		Depreciation		(114,320)	(195,920)	(139,920)	(49,960)	(114,320)	(195,920)	(139,920)	(49,960)

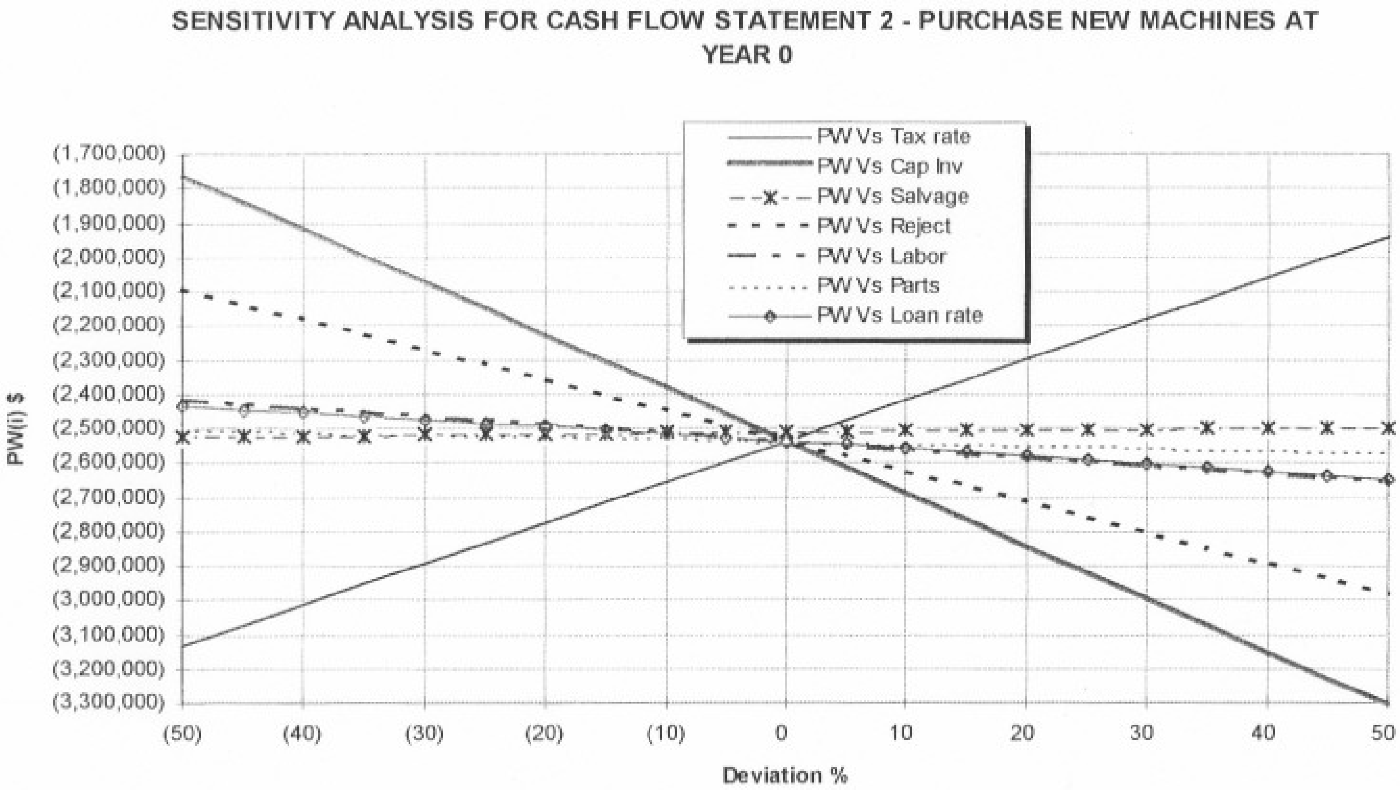
	A	B	C	D	E	F	G	H	I	J	K
1		CASH FLOW STATEMENT 4		TABLE 9							
2											
3		Entered values in blue	INPUT			OUTPUT					
4		Check purple formulas	Tax rate %=	34.00		PW(i)= $	(3,345,932)				
5		Answers in red	MARR %=	12.00		AE(i)=	(673,546)				
6			Loan int %=	10.00	<--Not applicable in this sheet						
7											
8			0	1	2	3	4	5	6	7	8
9											
10		**INCOME STMNT**									
11	+	Revenues									
12	-	Expenses:									
13		COGS: Reject cost		(945,000)	(675,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)
14		O&M: Labor		(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)	(132,000)
15		Maintenance parts		(130,000)	(50,000)	(50,000)	(50,000)	(50,000)	(50,000)	(50,000)	(50,000)
16		Others									
17		Depreciation		(142,900)	(302,060)	(272,860)	(194,860)	(114,280)	(146,360)	(187,260)	(79,580)
18		Debt interest pmts		0	0	0	0	0	0	0	0
19		Taxable Income	$ -	$ (1,349,900)	$ (1,159,060)	$ (724,860)	$ (646,860)	$ (566,280)	$ (598,360)	$ (639,260)	$ (531,580)
20		Income taxes (34%)	0	458,966	394,080	246,452	219,932	192,535	203,442	217,348	180,737
21		Net Income	$ -	$ (890,934)	$ (764,980)	$ (478,408)	$ (426,928)	$ (373,745)	$ (394,918)	$ (421,912)	$ (350,843)
22											
23		**CASH FLOW STMNT**									
24		Operating activities:									
25	+	Net Income	0	(890,934)	(764,980)	(478,408)	(426,928)	(373,745)	(394,918)	(421,912)	(350,843)
26	+	Depreciation		142,900	302,060	272,860	194,860	114,280	146,360	187,260	79,580
27		Investment activitites:									
28	-	Capital Investment	(1,000,000)	(400,000)				(400,000)			
29	+	Salvage value						0			0
30	-	Gains Tax (last n only)						50,980			71,366
31		Financing activities:									
32	+	Borrowed Funds	0								
33	-	Principal repayment		0	0	0	0	0	0	0	0
34		Net Cash Flow	$ (1,000,000)	$ (1,148,034)	$ (462,920)	$ (205,548)	$ (232,068)	$ (608,485)	$ (248,558)	$ (234,652)	$ (199,897)
35											
36											
37											
38		Depr rates % (1/2 last n)		14.29	24.49	17.49	12.49	8.93	8.92	8.93	4.46
39		Cost basis for depr=	(1,000,000)								
40		Depreciation		(142,900)	(244,900)	(174,900)	(124,900)	(89,300)	(89,200)	(89,300)	(44,600)
41					14.29	24.49	17.49	6.25	14.29	24.49	8.75
42				(400,000)							
43					(57,160)	(97,960)	(69,960)	(24,980)	(57,160)	(97,960)	(34,980)

	A	B	C	D	E	F	G	H	I	J	K
1		**CASH FLOW STATEMENT 5**		**TABLE 10**							
2											
3		Entered values in blue	INPUT			OUTPUT					
4		Check purple formulas	Tax rate %=	34.00		PW(i)= $	(3,138,770)				
5		Answers in red	MARR %=	12.00		AE(i)=	(631,843)				
6			Loan int %=	10.00	<--Not applicable in this sheet						
7											
8			0	1	2	3	4	5	6	7	8
9											
10		**INCOME STMNT**									
11	+	Revenues									
12	-	Expenses:									
13		COGS: Reject cost		(945,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)	(270,000)
14		O&M: Labor		(132,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)	(72,000)
15		Maintenance parts		(130,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)	(20,000)
16		Others									
17		Depreciation		(142,900)	(387,800)	(419,800)	(299,800)	(214,200)	(178,500)	(178,500)	(89,250)
18		Debt interest pmts		0	0	0	0	0	0	0	0
19		Taxable Income	$ -	$ (1,349,900)	$ (749,800)	$ (781,800)	$ (661,800)	$ (576,200)	$ (540,500)	$ (540,500)	$ (451,250)
20		Income taxes (34%)	0	458,966	254,932	265,812	225,012	195,908	183,770	183,770	153,425
21		Net Income	$ -	$ (890,934)	$ (494,868)	$ (515,988)	$ (436,788)	$ (380,292)	$ (356,730)	$ (356,730)	$ (297,825)
22											
23		**CASH FLOW STMNT**									
24		Operating activities:									
25	+	Net Income	0	(890,934)	(494,868)	(515,988)	(436,788)	(380,292)	(356,730)	(356,730)	(297,825)
26	+	Depreciation		142,900	387,800	419,800	299,800	214,200	178,500	178,500	89,250
27		Investment activitites:									
28	-	Capital Investment	(1,000,000)	(1,000,000)							
29	+	Salvage value									0
30	-	Gains Tax (last n only)									30,345
31		Financing activities:									
32	+	Borrowed Funds	0								
33	-	Principal repayment		0	0	0	0	0	0	0	0
34		Net Cash Flow	$ (1,000,000)	$ (1,748,034)	$ (107,068)	$ (96,188)	$ (136,988)	$ (166,092)	$ (178,230)	$ (178,230)	$ (178,230)
35											
36											
37											
38		Depr rates % (1/2 last n)		14.29	24.49	17.49	12.49	8.93	8.92	8.93	4.46
39		Cost basis for depr=	(1,000,000)								
40		Depreciation		(142,900)	(244,900)	(174,900)	(124,900)	(89,300)	(89,200)	(89,300)	(44,600)
41					14.29	24.49	17.49	12.49	8.93	8.92	4.47
42				(1,000,000)							
43					(142,900)	(244,900)	(174,900)	(124,900)	(89,300)	(89,200)	(44,650)

TABLE 11

B	C	D	E	F	G	H	I	J	K	L	M	N	O
SENSITIVITY ANALYSIS FOR CASH FLOW STATEMENT 2 - PURCHASE NEW MACHINES AT YEAR 0										TABLE 11			
Deviation %	Tax rate %	PWVs Tax rate	Cap Inv $	PWVs Cap Inv	Salvage Value $	PWVs Salvage	Reject Cost $	PWVs Reject	Labor $	PWVs Labor	Parts $	PWVs Parts	Loan rate %
	34.00	(2,537,933)	(2,000,000.00)	(2,537,933)	100,000.00	(2,537,933)	(270,000)	(2,537,933)	(72,000)	(2,537,933)	(20,000)	(2,537,933)	10.00
(50)	17.00	(3,133,686)	(1,000,000.00)	(1,769,459)	50,000.00	(2,524,605)	(135,000)	(2,095,316)	(36,000)	(2,419,902)	(10,000)	(2,505,146)	5.00
(45)	18.70	(3,074,111)	(1,100,000.00)	(1,846,306)	55,000.00	(2,523,272)	(148,500)	(2,139,578)	(39,600)	(2,431,705)	(11,000)	(2,508,425)	5.50
(40)	20.40	(3,014,536)	(1,200,000.00)	(1,923,154)	60,000.00	(2,521,939)	(162,000)	(2,183,840)	(43,200)	(2,443,508)	(12,000)	(2,511,704)	6.00
(35)	22.10	(2,954,960)	(1,300,000.00)	(2,000,001)	65,000.00	(2,520,606)	(175,500)	(2,228,101)	(46,800)	(2,455,311)	(13,000)	(2,514,982)	6.50
(30)	23.80	(2,895,385)	(1,400,000.00)	(2,076,849)	70,000.00	(2,519,274)	(189,000)	(2,272,363)	(50,400)	(2,467,114)	(14,000)	(2,518,261)	7.00
(25)	25.50	(2,835,810)	(1,500,000.00)	(2,153,696)	75,000.00	(2,517,941)	(202,500)	(2,316,625)	(54,000)	(2,478,917)	(15,000)	(2,521,540)	7.50
(20)	27.20	(2,776,234)	(1,600,000.00)	(2,230,543)	80,000.00	(2,516,608)	(216,000)	(2,360,886)	(57,600)	(2,490,720)	(16,000)	(2,524,818)	8.00
(15)	28.90	(2,716,659)	(1,700,000.00)	(2,307,391)	85,000.00	(2,515,275)	(229,500)	(2,405,148)	(61,200)	(2,502,524)	(17,000)	(2,528,097)	8.50
(10)	30.60	(2,657,084)	(1,800,000.00)	(2,384,238)	90,000.00	(2,513,942)	(243,000)	(2,449,410)	(64,800)	(2,514,327)	(18,000)	(2,531,376)	9.00
(5)	32.30	(2,597,508)	(1,900,000.00)	(2,461,086)	95,000.00	(2,512,609)	(256,500)	(2,493,671)	(68,400)	(2,526,130)	(19,000)	(2,534,654)	9.50
0	34.00	(2,537,933)	(2,000,000.00)	(2,537,933)	100,000.00	(2,511,277)	(270,000)	(2,537,933)	(72,000)	(2,537,933)	(20,000)	(2,537,933)	10.00
5	35.70	(2,478,358)	(2,100,000.00)	(2,614,780)	105,000.00	(2,509,944)	(283,500)	(2,582,195)	(75,600)	(2,549,736)	(21,000)	(2,541,212)	10.50
10	37.40	(2,418,782)	(2,200,000.00)	(2,691,628)	110,000.00	(2,508,611)	(297,000)	(2,626,456)	(79,200)	(2,561,539)	(22,000)	(2,544,490)	11.00
15	39.10	(2,359,207)	(2,300,000.00)	(2,768,475)	115,000.00	(2,507,278)	(310,500)	(2,670,718)	(82,800)	(2,573,342)	(23,000)	(2,547,769)	11.50
20	40.80	(2,299,632)	(2,400,000.00)	(2,845,322)	120,000.00	(2,505,945)	(324,000)	(2,714,980)	(86,400)	(2,585,145)	(24,000)	(2,551,047)	12.00
25	42.50	(2,240,056)	(2,500,000.00)	(2,922,170)	125,000.00	(2,504,613)	(337,500)	(2,759,241)	(90,000)	(2,596,948)	(25,000)	(2,554,326)	12.50
30	44.20	(2,180,481)	(2,600,000.00)	(2,999,017)	130,000.00	(2,503,280)	(351,000)	(2,803,503)	(93,600)	(2,608,752)	(26,000)	(2,557,605)	13.00
35	45.90	(2,120,906)	(2,700,000.00)	(3,075,865)	135,000.00	(2,501,947)	(364,500)	(2,847,765)	(97,200)	(2,620,555)	(27,000)	(2,560,883)	13.50
40	47.60	(2,061,330)	(2,800,000.00)	(3,152,712)	140,000.00	(2,500,614)	(378,000)	(2,892,026)	(100,800)	(2,632,358)	(28,000)	(2,564,162)	14.00
45	49.30	(2,001,755)	(2,900,000.00)	(3,229,559)	145,000.00	(2,499,281)	(391,500)	(2,936,288)	(104,400)	(2,644,161)	(29,000)	(2,567,441)	14.50
50	51.00	(1,942,179)	(3,000,000.00)	(3,306,407)	150,000.00	(2,497,948)	(405,000)	(2,980,550)	(108,000)	(2,655,964)	(30,000)	(2,570,719)	15.00

Salvage value is offset by $100,000


SENSITIVITY ANALYSIS FOR CASH FLOW STATEMENT 2 - PURCHASE NEW MACHINES AT YEAR 0
PW Vs Tax rate
PW Vs Cap Inv
PW Vs Salvage
PW Vs Reject
PW Vs Labor
PW Vs Parts
PW Vs Loan rate
PW(i) $
(1,700,000)
(1,800,000)
(1,900,000)
(2,000,000)
(2,100,000)
(2,200,000)
(2,300,000)
(2,400,000)
(2,500,000)
(2,600,000)
(2,700,000)
(2,800,000)
(2,900,000)
(3,000,000)
(3,100,000)
(3,200,000)
(3,300,000)
(50)
(40)
(30)
(20)
(10)
0
10
20
30
40
50
Deviation %

GRAPH 1

of 1997. Last year's strong monthly numbers in both housing starts and appliance shipments cannot be matched this year given the prevailing economic conditions. The trend of negative growth in the monthly data will persist until the end of this year.

One emerging trend in the appliance market is the increasing demand for machines that make more efficient use of space and electricity. Such machines have been the norm in Europe for years, and European manufacturers are making inroads into the American market.

Household furniture

The market for home furnishings will suffer all of the demand constraints that will afflict the appliance and other consumer markets in 1997. In the case of furniture however, these constraints will be exacerbated by the diminishing importance of furniture in household budgets. After a respectable rise of 4% in 1996, shipments of domestically produced household furniture will recede by 6% in 1997.

The impending recession in the demand for new houses and the slower growth in remodeling expenditures will be the primary pressures on furniture shipments in 1997. In order to flourish, this industry requires low interest rates and rising disposable incomes. Financing rates will be stable, but the income data are well past their peak. With a mountain of credit card debt already accrued, consumers have little room left for discretionary, big-ticket purchases like furniture. This is relatively short-term, cyclical situation which should improve, however, there are longer-term factors that are inhibiting this market as well.

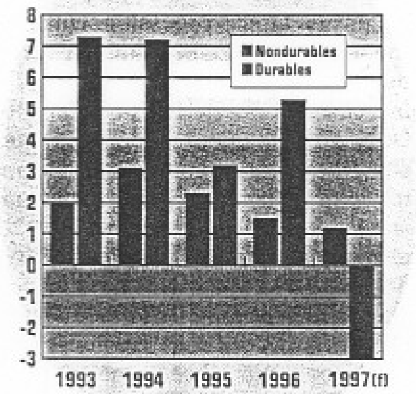
Prior to the 1970s, Americans allocated a substantial portion of their household budget for the purchase of furniture. Formal dining and living rooms were high on consumers' wish lists. In the late-70s, the amount of money Americans spent on home electronics equaled the amount spent on furniture. Since that time, expenditures on electronics have averaged annual growth rates in the double-digits, while incomes have expanded only moderately. The result has been a cutback in the portion of the household budget that is spent on furniture.

Despite its diminution in importance, this is still a large industry and certain sectors will perform better than others. Ready-to-assemble furnishings will continue to dominate in terms of growth. RTA furniture is improving its image as well as its design and function. Because it is usually less expensive than traditional furnishings, RTA also offers many consumers better value for their ever-shrinking furniture budgets.

CONSUMER NONDURABLES

In 1997, growth in consumer spending for non-durable goods (defined as goods with an expected lifetime of less than three years) will be lackluster, but steady. About one-third of the total U.S. consumer expenditures is for non-durable items. Because this category includes most foods, personal and healthcare items, and cleaning supplies, it is a good indicator of the demand for plastics packaging materials.

Consumer spending nondurables vs. durables (annual % change, 1992 $)



Source: U.S. Commerce Dept.
Forecast: Plastics World

Demand for packaging materials will be pressured in 1997, as growth in spending for nondurable goods slows. Because these markets are relatively stable, they will fare better than the more volatile sectors of the economy.

Over the next twelve months, our forecast calls for an inflation-adjusted increase of 1.5% in personal consumption expenditures for non-durable goods. This is the same percentage increase that occurred in 1996. The difference between this year and last is that in 1997 this spending category will be the strongest in terms of annual growth instead of the weakest.

Similar to the situation in the big-ticket categories such as appliances and furniture, spending for non-durables will be inhibited by consumers' reticence to accrue more debt. Because they are relatively cheap, purchases of these goods are usually not financed by outside sources. Therefore low interest rates will be of little help. However, as Americans allocate a larger share of their budgets to debt reduction, all types of expenditures—including spending on cheaper items—will be restrained.

Demand for pharmaceuticals will continue to be a strong. Though still relatively small in terms of the amount of dollars spent, growth rates in the alternative therapies sector (i.e. herbal or homeopathic remedies) will exceed the gains in the traditional medicines. Spending for food will remain stable, but consumers will cut back on the amount of upscale and discretionary items they purchase. Demand for clothing and cosmetics will plateau. The trend towards greater amounts of recycled and recyclable packaging will remain a factor in these markets.

The entertainment industry is one other plastic-intensive market in the non-durables category that bears mentioning, and here the news is mixed. Though unit sales of CDs, video-, and audiocassettes will remain at high levels, the market growth will recede a bit. These markets are now mature, therefore their growth curves will more closely correlate with the overall spending cycle. Since there are no new technologies to drive demand, sale of entertainment-related items will be flat-to-down in 1997. **PW**

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INJECTION MOULDING OF PLASTIC COMPONENTS

A GUIDE TO EFFICIENCY, FAULT DIAGNOSIS AND CURE

John Bown

a small percentage loss caused by incorrect costing, poor estimating, or inefficient working on the shop floor, can rapidly lead to a position of financial insolvency. Any savings effected in materials costs, shorter operating cycles, reduction in power requirements, or lower labour costs, are likely to have a large impact on the profitability of the process.

Fixed and variable costs

The main fixed cost of the injection moulding process is, of course, the capital cost of the equipment, but other fixed costs—rent of property, rates, etc.—must not be lost sight of. In the world of the entrepreneur—and many companies in the field of injection moulding were started by such people—machine capital cost has not seemed so important in the past. Starting operations with one or two small secondhand machines, the minimum of ancillary equipment, and often poor or even inadequate premises, it has been possible by meeting a local need, perhaps in a specialized field, to make a very reasonable profit. This may have been achieved by hard work and vigilance on the part of the owner of the company, but it has enabled many small companies to grow and invest in newer and better equipment in the knowledge that any new capital expenditure has been met out of profit. It is probably fair to say that, of some 1500 companies in the United Kingdom engaged in injection moulding, perhaps half of them have operated, and many still do operate, in this way.

The owner-manager of such a company does not need to consider the servicing of his capital at, say, 15 per cent per annum. He only considers the loss of interest, less tax, on his capital which may, ultimately, be no more than 5 or 6 per cent. In such a situation, quoted prices tend to be lower than the general market prices. The owner-manager can afford to be selective in his business, avoiding projects that present difficulties, and not needing to bother unduly if machines are idle, as long as any paid operative can be fully and gainfully employed. Often, such a company will have little, if any, rent to pay and the small premises will not attract large rates.

The full impact of high capital costs is felt when machines are acquired on borrowed finance, when full labour costs for all operatives have to be paid out of cash flow, and when premises are large, adequate, and of good standard. If, in such circumstances, the management cannot afford to be selective in their choice of work and have to tackle the difficult, time-consuming jobs, as well as the less critical ones, cost savings of whatever type and magnitude are important.

There are various ways of financing the purchase of injection moulding equipment, but, at a time when borrowing is expensive, an allowance of about 15 per cent per annum for servicing the capital involved would appear to be prudent. In times of financial stringency, such as have been experienced in the United Kingdom since 1970—and to some extent ever since the end of the Second World War—a company is fortunate indeed which has sufficient new

INJECTION MOLDING

Micro Switch flips on new molding strategy

New machines, highly integrated CIM and automated cells support 25%/year growth in sensing and control components.

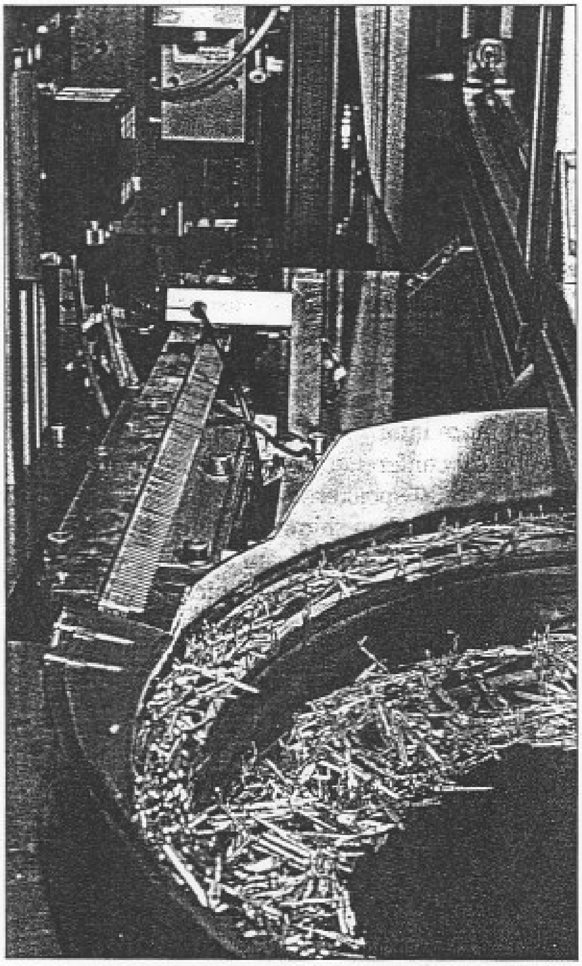
Looking for a blueprint to dramatically upgrade a mid-sized injection molding facility? Take a look at developments in Honeywell's Micro Switch Division in Freeport, Ill.

Four years ago, Micro Switch identified significant growth opportunities in electronic sensing equipment, particularly for cars, with customers who were raising the bar on quality. Meanwhile, Micro Switch was supplying virtually all of its own plastic requirements, much of it insert molded, from a molding shop established in 1964. There were eight different machine brands in the facility.

"The machines had been bought in different eras," commented Todd L. Breneman, location manager for electronic fabrication for Micro Switch. As the plant added capacity, machines from different manufacturers were added in small groups. Result: a spare parts maze, difficult training and overall inflexibility for the 40-plus presses in the facility.

One of the first steps was creation of a Plastics Commodity Center in which key plastics personnel were located together and organized in a single unit. Professionals in the group include purchasing, tool designers, part design engineers, and quality engineers. Micro Switch designs all of its own tools and also manufactures most of them on site as well.

The next step was a "machine replenishment" program in which older injection molding machines were phased out and replaced by presses with sophisticated process control and high repeatability. Micro Switch also required 24-hour service and parts availability as well as compatibility with computer-integrated manufacturing (CIM).



Inserts are loaded into a bowl feeder in a new automation cell developed by Battenfeld for Micro Switch.

Many molders are finding the last issue to be a real sticking point with many machine OEMs. Many equipment builders still jealously guard the proprietary software protocol that allows the onboard process controller to communicate with other software. Complicating the issue is that, until recently, the CIM vendors in the plastics industry only offered proprietary hardware and software to interface with the machine and a host system.

That frustration led one molder, SPM in Anaheim, Calif. to develop its own Windows-based control system that operates on portable computers, which were not dedicated to single machines. Very few molders are large enough to develop their own systems. Nor will it be necessary any longer.

Machinery manufacturers and CIM vendors are both changing their strategies. One machine manufacturer reportedly is dropping its proprietary networking option, for example. Others are adding more generic industry-standard controls to base-line machines.

And in the case of Micro Switch, one machine builder—Battenfeld—agreed to share its proprietary machine protocol to allow a seamless interface with Mattec, which was chosen to provide the CIM software. And in another development, Mattec, Loveland, Ohio, is using a new level of software based on a Unix platform, allowing plantwide integration.

Breneman said in a press conference last month that Micro Switch will use Battenfeld of America, West Warwick, R.I. as its primary machine vendor. Micro Switch has purchased 13 Battenfeld thermoplastic presses to date, including two shuttle presses and three with rotary tables. The range of press sizes in the plant, for all machines, is 28 to 300 tons.

Quick mold changes

Other features of the Micro Switch plan include new quick-change desiccant drying equipment and increased use of hot runner molds. Several portable Novatec dryers are used to predry material in preparation for the next cycle. As a result, mold change time has been reduced dramatically, said Brian D. McBride, principal engineer for plastics at Micro Switch. Mobile dryers are moved to the press (with an alert from the Mattec system in the near future) and material is changed in 10-15 minutes. Total mold change time depends on other factors. Micro Switch owns more than 1,000 molds to support a company catalog that has more than 3,000 part numbers.

Fast drying at Micro Switch took another unique twist. McBride worked with Universal Dynamics, Woodbridge, Va. to develop a flexible mini-hopper system for supplying single-cavity molds to make very small parts.

"We don't need to dry 30 pounds of material (typically the smallest drying hopper) to supply a mold (with hot sprue bushing) that only need five pounds for eight hours," said McBride. Ten hoppers on the specially built stand receive dry, heated air from a central dryer with a capacity of 100 lb/hour. The small hoppers are so efficient at exposing resin to dried air that savings in drying time can be achieved. UnaDyn custom designed the system for Micro Switch.

In your plant, how do you determine how often to change molds? At Micro Switch, the process is a science. "We run an elaborate model to try to balance the cost of a switchover versus the cost of increased inventory," commented Breneman.

In another aspect of Micro Switch's new plastics strategy, a special development program was established to study new technology. It was headed up by Scott E. Michelhaugh, a senior plastics engineer.

The first machine purchased for the center was a fully automated, three-station/two station rotary table system from Battenfeld. The 77-ton clamp is vertical, while the injection unit is horizontal due to height restrictions. The machine makes an automotive part from engineering resins.

The molding cycle begins with metered output of metal inserts from a bowl feeder to a linear feeder. Parts are exactly aligned for precision placement with a pick-and-place robot on a staging plate. A loading robot on a "tandem" system loads the inserts in the mold. The mold is then rotated prior to overmolding.

This takes places simultaneously while molded parts are rotated out and unloaded by a second robot, mechanically attached to the first on a linear bar. Parts are degated robotically at the end of the tandem apparatus. Parts are removed from the runner on a mechanical chute. Runners go down the middle into a granulator, while parts exit through outside chutes. The rotary machine has moved from development to production.

The CIM system in the plant is also state of the art. Each new Battenfeld press has an interface to a Mattec unit, allowing operators to retrieve set-up data, instruction and real-time quality information on the process. The Mattec data is displayed on a full-color screen, while input/output functions are still handled by a dedicated machine-mounted box. Each machine is controlled by the Battenfeld Unilog 4000 multiprocessor, which includes profiling capabilities for critical process parameters. State-of the-art OEM machine controllers, such as the Unilog, typically store statistical process control data for 25 cycles. With the Mattec interface, process data can be stored and analyzed for large runs.

"We could, of course, store more data but it would require a giant control or slow down other functions in the control," commented Wolfgang Meyer, president of Battenfeld of America.

Software intregration

The Mattec system also ties in data on mold maintenance. Breneman told reporters that machine maintenance will also be an important function of the Mattec system at Micro Switch. Preventative maintenance will be tied to number of cycles per machine and mold. That data will be tracked by a central host computer. The Mattec system is also being tied into other Micro Switch management software programs to allow easy data porting to and from a variety of departments, Breneman said.

The problem now is the onslaught of data available for analysis. "How do you take that enormous amount of data out of a CIM system to make decisions?" Breneman asks, obviously glad to have that problem versus the lack of data.

Micro Switch said its has achieved considerable savings with its molding upgrade. Machines are utilized more effectively, quality is up, costs are more competitive. Micro Switch was a finalist in the Malcolm Baldridge competition and received the Gold PentaStar award from Chrysler.

The plant is also quietly pushing the envelope on injection molding. For example, housing wall sections "well blow" 0.030-inch are being molded from engineering thermoplastics.

Cost and quality issues pushed Micro Switch to develop its new molding strategy three years ago. Breneman said the same two factors will keep the pressure on. In addition, speed to market is a growing issue as Micro Switch plans the next phase in its continuous improvement program.—*Doug Smock*

For more information

Supplier	Circle No.
Battenfeld	143
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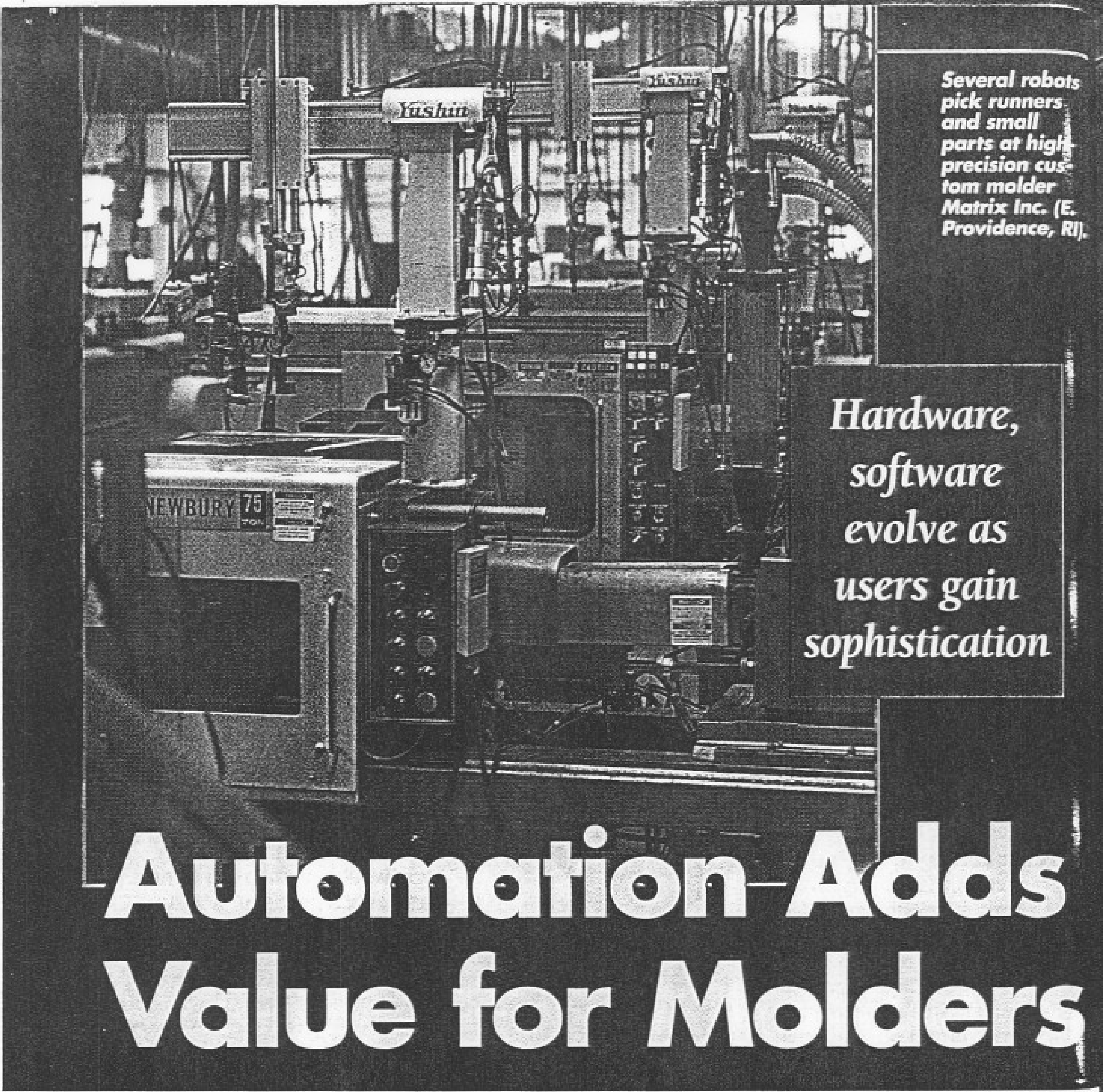


Several robots pick runners and small parts at high-precision custom molder Matrix Inc. (E. Providence, RI).

Automation Adds Value for Molders

Hardware, software evolve as users gain sophistication

John M. Mallon IV

President,
Yushin
America Inc.

The basic goals of automation in injection molding operations are to boost productivity and generate cost savings. Molding robots accomplish these goals by speeding production, reducing the labor required for value-added operations, minimizing scrap, and improving part quality. Automation and integration of secondary operations with molding produces more benefits, including reduced work-in-process and floor space requirements.

Many injection molders, however, have yet to take advantage of automation. This is not surprising, because robotics was until recently an adolescent technology. Only in the past ten years or so have robot hardware and software been able to deliver benefits consistently and economically.

Two automation-related issues now face injection molders. The first concerns companies that have yet to automate any substantial part of their post-mold processes. Many jobs simply cannot be performed profitably without automation, and these companies now find themselves in a catch-up position. They must work hard to regain competitiveness.

The second issue concerns the future of all injection molders: Where do we go from here? Now that automation has become a basic competitive tool, the technology will continue to advance. Molders will seek progressively higher levels of automation to continually improve productivity and bolster their competitive positions. What directions are those advances likely to take, how will molders benefit, and what strategies should molders adopt to stay on top of the productivity curve?

The trends that brought the industry to its present state will continue to influence technology and robot penetration into new molding-related applications. So, answering these questions requires an analysis of how molding automation developed.

Just a Phase

Robot use by molders can be viewed in three phases. The entry level, where purchase costs are low, involves pneumatic robots used in simple, dedicated pick-and-place applications. In fact, robots have become an essential tool for sprue picking and part take-out, and anyone not using them at this level is at a competitive disadvantage.

A Rhode Island-based molder provides an example of this type of application, using pneumatic traverse robots to pull closures for cosmetics packaging from multi-cavity molds and place them on conveyors.

While the application is straightforward, it provides multiple benefits. Compared to automatic parts ejection, the robotic approach provides additional cooling time and prevents parts from being marred or scratched. The system also verifies part removal, avoiding mold damage that could occur if an ejector failed to fully eject a part from a cavity.

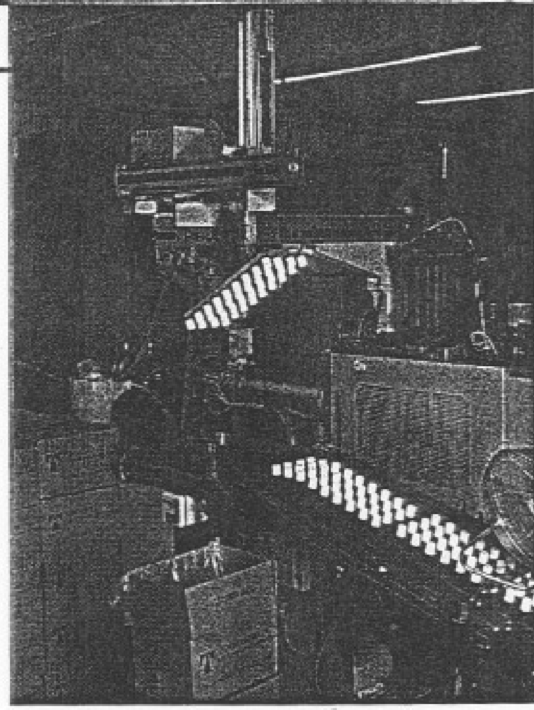
During phase 2, servo robots perform simple post-mold operations, like degating, to add value to parts. In this phase, robots have the flexibility to be used across many molds. These types of applications are growing rapidly, so that molders who currently enjoy a competitive advantage from using servo robots will soon see that fade. The servo robot is becoming an essential tool.

A Michigan molder implemented a phase 2 application primarily to reduce manufacturing costs. The company had been running single-cavity molds on multiple presses for the production of milk sampling vials used by the dairy industry. In order to seal out contamination, the vials are molded with a press-fit cap on a living hinge, and each mold tool contained a mechanism to close the cap as soon as the mold opened.

When the customer demanded lower part costs, the molder designed a new 16-cavity tool to run on a single press. The more complex tool design meant a cap-closing mechanism was no longer feasible, so a servo-traverse robot was installed to do the work. The robot uses custom end-of-arm tooling with suction cups to assist in removal of the deep-draw parts as they are ejected. After exiting the mold-open area, the robot moves to a cap-closing station where pneumatic fingers and plates snap the caps shut. The tooling then "flips" to a horizontal position and releases the vials into boxes. Press cycle time is 14 sec.

The application allows cap sealing on a single machine far more economically than was previously possible. And, the robot can be readily reprogrammed to add value to other parts when vials are not in production.

The third phase of robot implementation has been achieved by relatively few molders. "Automation cells" use servo robots non-stop during the molding cycle to add value to parts and perform the maximum amount of work possible. Robotic operations include decorating, assembly, quality testing, and boxing. In cells, robots work cooperatively with other, programmable machines downstream. This places a premium on robot reliability, programmability, and precision.



In this phase 1 automation application, a pneumatic robot demolds parts and places them gently on a conveyor. This approach yields higher quality parts and fewer rejects than automatic ejection.

How Robotics Evolved

When molding robots began appearing in the early 1970s, there were predictions they would soon be everywhere. Penetration took longer than many predicted because robots had to become faster, more reliable, more flexible, and easier to use before they could consistently deliver cost savings and productivity enhancement.

The earliest molding robots used pneumatic drives and required several seconds to remove parts from molds. Pneumatic drives began improving in the late 1970s, as compound drive configurations and better valves, cylinders, and shock absorbers gave rise to robots offering about 20% faster performance. AC servomotor drives offered immediate speed benefits when they were introduced in the late 1980s, and have been improved to easily handle press cycles under 15 sec and take-outs under 1 sec. New configurations, including side-entry robots, removed parts with two-thirds-less motion.

Early robots were built mainly of steel weldments. The weight of these structures imposed heavy shock loads on mechanisms, causing such rapid wear of moving parts that robots typically required rebuilds every five years, plus frequent downtime for preventive maintenance. As designs improved, steel was replaced with aluminum extrusions and lightweight castings. A few manufacturers recently began using composites in structural members.

Excessive bearing lubrication requirements remain a weak point in many robots even today. Since the mid-1990s, some have featured sealed bearings, which require only quarterly maintenance. The replacement of rack-and-pinion and ballscrew positioning mechanisms with toothed-belt systems is another maintenance-reduction measure implemented by some suppliers.

Based on hard-wired logic, early robot controls were programmable only via limited selector switches and timer adjustments. These units lacked the flexibility to shift easily from job to job. They were replaced by microprocessor-based systems and programmable logic controllers, which allowed robots to readily perform different sequences, but were hardly user-friendly. The current trend is toward PC-based controls offering much simpler operator interface and easier data storage/transfer.

Simultaneously, programming based on engineering languages such as Pascal and C is giving way to graphics-based systems, which allow shop-floor personnel to do programming with minimal training. A related advance is off-line programming, which allows molding to proceed uninterrupted while users write new programs in an office environment.

As more molders implement phase 2 robot technology, however, progressive competitors will shift their attention to this level.

An Alabama molder implemented a phase 3 application for the production of cassette jewel boxes. Two injection machines, each with its own servo-driven, high-speed side-entry robot, face each other across the cell. Both presses run six-cavity molds, one for bases, the other for covers. The robots wait just outside the mold areas, minimizing travel during the mold-open period and allowing take-out times under 1 sec.

The robots hand off all 12 parts to an automation system between the machines. This system reorients the parts, snaps the bases and covers together, then closes the covers and delivers the completed assemblies downstream for packing into trays. Total cycle time is 9 sec, for production of 2,400 cases per hour.

Automation Advances

Major robot technology developments aim to improve reliability and speed, and to make robots more adaptable and easier to program. Although today's robots possess adequate speed for most molding applications, further increases will certainly occur as servo systems become more sophisticated. Robot hardware also will become more modular, and thus easier to adapt to changing requirements.

But difficult programming and awkward operator interfaces are still the biggest impediments to higher levels of robot application, and that is where manufacturers will focus the bulk of their efforts. Just as graphical operating systems made personal computers more accessible, a similar approach will make robots friendlier to shop-floor personnel. More robot manufacturers will adopt highly graphical approaches to programming and control. Users will be able to configure the operator interface as a cell controller and message center.

Controllers will incorporate enhanced diagnostics and, ultimately, artificial intelligence, so that robots will be able to recommend process improvements and troubleshooting fixes to the user. Robots will also communicate through external networks (including the Internet) with the robot manufacturer, who will be able to assist the molder in monitoring, troubleshooting, programming, and even automated ordering of replacement parts.

Another major area of development made possible by easier programming will be systems integration. More and more value-added operations will be automated, including those that occur in remote areas of the plant. There will be more intensive electronic communications to manage automation cells. Robots and injection molding machines will

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be tied into plant-wide control and data networks to meet quality and scheduling objectives. Robots will change their own end-of-arm tooling and make other adjustments automatically after receiving mold information over the network, eliminating the remaining vestiges of manual intervention during mold changes.

Plant-wide networks will also support the proliferation of automated material handling between plant areas, including automated guided vehicles. Molders will realize substantial benefits from reduced indirect labor and work-in-process. Ultimately, this trend may culminate in widespread adoption of "lights-out" production facilities.

User Evolution

Even as robots become easier to use, users are getting more sophisticated. Competitiveness will be determined largely by a molder's ability to deploy automation resources in the most productive and cost-efficient manner.

Want More Information?

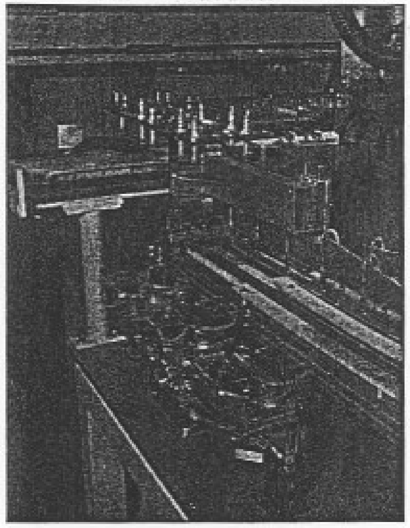
The Robotics International of SME (RI/SME) is a resource for manufacturing professionals involved with robotics technology. Members receive the *Robotics Today* quarterly newsletter, have access to a technical referrals database that can help them solve robotics-related problems, and receive information on robotics issues and technology via ongoing technical reports.

For more information on RI/SME activities and benefits, contact the RI/SME Association Manager at (313) 271-1500, ext. 518, or visit Robotics International's page on the Global Manufacturing Network at www.globalmfg.com.

For more information on molding robots, Circle 200.

Molders will respond to these pressures by developing higher levels of in-house programming, tooling, applications, and project management expertise. This will allow them to readily manage frequent changes in requirements for automated production equipment, with the result that robot efficiency will rise from today's average of 60% to 90% or more. Higher levels of automation integration will no longer seem so daunting, and cell-type automation will become commonplace, adding substantial value to parts right beside the press.

Concurrent engineering is becoming common in mold making, and this trend will naturally extend to automation. Molders will find that their ability to respond quickly to customer demands will rely on partnering with automation vendors, who will provide substantial expertise that molders cannot afford to maintain in-house or do not have the time to acquire.■



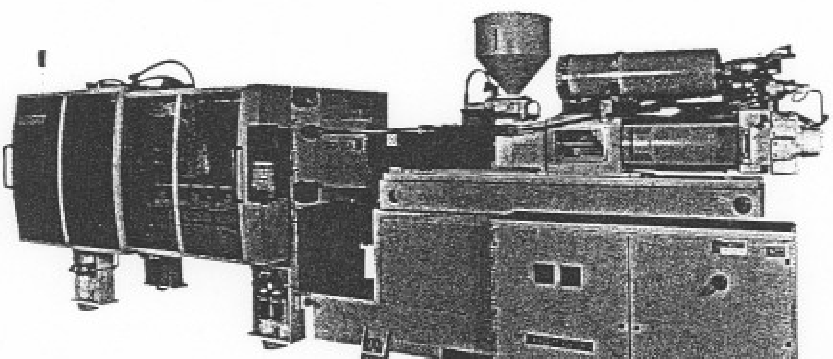
Two presses, two side-entry robots, and additional automation are integrated in a single production cell in this phase 3 application for assembling cassette jewel boxes at a rate of 2,400 per hour.

SHOW PREVIEW

New machines, automation concepts are ready to show

Innovations from leading machine builders at Plastics Fair focus on productivity and automation.

Husky Injection Molding Systems, Bolton, Ontario will begin delivery in two months of a new machine series, designated Moduline G. Ranging in size from 250 to 825 tons of clamp force, the new line is "value priced" and features several interesting functions. These include simultaneous operation of clamp and injection function and proportionally controlled hydraulic ejector. The machines will debut this month at the Plastics Fair in Rosemont, Ill.



There are several engineering innovations in Husky's Moduline G models.

Husky said one of the most significant advances is the spool valve used to control mold stroke through a regenerative circuit that directs oil from the rod side of the mold stroke cylinder to the bore side during mold close to conserve energy.

The hydraulic reservoir on the G series is divided into two sides, one for return and one for filtering. A dedicated fixed-displacement-pump circulates oil from the tank return side through a 6 micron glass fiber filter and heat exchanger to the filtered side. The off-line filtration system filters 100% of the oil returned by the system, compared to 15% in conventional bypass systems, according to Husky.

GE Fanuc North America designed and supplied the complete electronic control system, including software.

Moduline machines allow users to mix and match screws, hydromechanical clamp and control modules to meet specific requirements in applications ranging from automotive and closures to medical and consumer products.

Engel, Guelph, Ontario will introduce the 320-bit RISC microprocessor CC100 control designed expressly for injection molding applications. The CC100 features a coordinated multitasking operating system that includes so-called fuzzy logic for "self-learning" of temperature control.

Boy Machines, Exton, Pa. is introducing a computer-integrated manufacturing (CIM) system that will allow control of up to 32 of its machines.

The interface (via an RS485 port) can load or store set-up records, transmit data, and archive on-line data such as actual and setpoint values, error messages and critical machine parameters. The operator can centrally monitor and manage an entire molding operation from a single computer.

Production can be monitored by actual parts produced, balance of parts to be produced, remaining production time required, material usage, or other user-defined variables.

New Arburg press

Another major specialist in small molding machines, Arburg, Newington, Conn., will introduce a "fixed-vertical" version of the Allrounder 221 M, featuring a movable upper platen. The first model was shipped to the Dualex Division of Depco International in Toronto. Two 28-ton models will be used to mold an elastomeric window gasket around window panels on GM vehicles.

The downward-acting moving platen clamps the insert into position while the encapsulating material is injected through the parting line. Shot capacity can range from 0.52 to 2.05 oz. The machine features fully programmable hydraulic core pull, hydraulic ejection on the stationary platen and air-blast ejection on the moving platen.

—Doug Smock

For more information

Supplier	Circle No.
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Literature Review

Definition

Injection molding is a manufacturing process where plastic is forced into a mold cavity under pressure. A mold cavity is essentially a negative of the part being produced. The cavity is filled with plastic, and the plastic changes phase to a solid, resulting in a positive. Typically injection pressures range from 5000 to 20,000 psi. Because of the high pressures involved, the mold must be clamped shut during injection and cooling. Clamping forces are measured in tons.

An important future goal for injection molding is to make more structural parts than have been made in the past. The current, empirical approach to design of IM parts is "make it and break it." Major efforts by General Motors and General Electric are being expended to put science and engineering in IM design rather than relying on trial and error. The end goal is to be able to define the desired performance and select materials and arrive at a part design that will perform. In arriving at an appropriate design, it is important to remember that the injection molding parts may not always look like their metal counterparts.

Precision

The injection molding process is capable of producing large numbers of parts to very high levels of precision. Holding tolerances of less than .001" (.0025 mm) is easily accomplished with the right combination of material, part design, and mold design. Even tighter tolerances can be held with additional effort.

Tooling

Injection molding has relatively high tooling costs, ($5,000-$100,000) as the molds must be built to high levels of precision and must be robust enough to withstand the high pressures of the process. Molds are usually constructed of hardened tool steel, but may be constructed of aluminum or other soft materials when tooling life is not an issue. Typically, a hardened steel mold will withstand 500,000 to 2,000,000 molding cycles, without appreciable wear, depending upon the material and processing conditions. Aluminum and other soft molds will only withstand 1,000 to 10,000 molding cycles. Soft tooling may have a longer life on purely structural parts where injection pressures are low and materials flow easily.

Capacities

Injection molding is a high capacity process. Cycle times range from a few seconds to several minutes depending upon the configuration of the part being molded. Single cavity molds offer the lowest tooling costs and highest precision at the penalty of higher unit costs. Multi--cavity molds can be utilized to increase capacity and lower unit costs with an increasing loss of precision as cavities are added.

In terms of production, meads of plastic are fed into a hopper, melted, and injected under pressure into a mold. The hot viscous plastic (or melt) flows throughout the mold in seconds, racing through channels and merging again, until every nook and cranny is uniformly filled. Instantaneously, another short surge of hot plastic packs the already cooling mold to compensate for shrinkage and the flow shuts off. Cooling takes place in a few more seconds and the injection molding process is completed.

Molded from a fiber-reinforced polymer developed for the aerospace industry, shock-absorbing car bumpers reduce expensive repair costs and save lives. Innovative applications of materials such as this have led to the growth of injection molding from an industrial art to an applied science. Today, this manufacturing process accounts for approximately one-third of all polymer processing.

Economics

Injection molding is a process with large numbers of variables. It is well suited to applications requiring 10 or 20 pieces to billions of pieces. Sometimes there is no other way to produce parts from certain materials except via injection molding. Also, the machines used for molding require special plant services not required by other manufacturing equipment. When alternate manufacturing methods, and materials are an option, injection molding usually becomes economically viable at around 1000 pieces.

However, the greatest pressure on molders to improve productivity and cut prices will come in electronics. The push for lowering the price barrier on PCs to well below $1000 and a wave of low-cost imports from Asia will force U.S.molders to reduce prices for such products as keyboards, terminal housings, and related equipment by an average 3 to 4 percent this year alone. But regardless of pricing pressures, overall volume will still be up significantly in 1998, due to a booming market in electronics applications of all types.

Problem

Problems with injection molded parts can be attributed to the design of the part, the selection of the plastic material, or how the plastic was processed. When a plastic part that has run successfully for years begins to give problems with dimensional stability or with structural failure, the cause is probably not part design or material selection but is most likely caused by a change in the molding conditions. Therefore, there are some software used for monitoring performance of injection molding machines. These softwares perform as follows;

(a) View production as it is being made and applied to the work orders.

(b) View how long a machine has been running or whether it has gone down during the run.

(c) User defined down time codes can be used to identify an interval of press inactivity.

(d) Notifies users ahead of time for next mold and/or and material change.

(e) Unlimited user defined rejects codes

(f) Automatic recalculation of the number of parts left to produce after bad parts entered.

(g) Rejection reports and Pareto Chart displays how many parts have been rejected and why.

(h) Graph the last 50 cycles on a press for the most current production data.

(i) Interface with the IQ Scheduling module lets you know exactly where you are in your production process at any time.

(j) Shift change information converted into a Finished Production report that can be edited as needed.