Manufacturing System
A Class Project in Industry Environment

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ABSTRACT

Many of the technology students in the first two years do not understand how the coursework is applied in the practice of engineering. These courses introduce engineering students to the type of tasks they are expected to handle on the job after graduation. Courses in automated manufacturing including computer numerical control (CNC) machining, materials handling, time and motion study, etc. should be designed to provide students hands on training towards their professional goals.

The objective of this project is to manufacture a product using a complete manufacturing system. It includes manufacturing processes such as machining, materials handling, assembly, and inspection. The project also involves time and motion study, flow process charts, and operation sheets as usually required in an industrial production operation.

The sample project presented here deals with the manufacturing of a shuttle selector manifold in an industry environment. The manifold was manufactured by a group of students in a local manufacturing company. Methods engineering and work measurements functions were performed wherever possible. The manifold is designed to work on hydraulic systems using petroleum based fluid up to 3000 psi.

INTRODUCTION

Mechanical and manufacturing technology students are expected to be proficient in and be familiar with broad based manufacturing subjects. One of the most important and demanding requirements should be their familiarity with the state of the art technology including manufacturing processes such as CNC machining, materials handling, assembly, and inspection and testing. In the course of this project, students get an exposure to not only the design and machining aspects but also get into methods engineering and motion time measurements.

This project assignment include product design, CNC programming for a milling machine, and prototype manufacturing. In the course of this project students were required to prepare standard process sheets, flow process charts, standard method sheets for operation, stopwatch observation sheet, and videotaping of the manufacturing processes for motion time measurements.

THE PRODUCT

The product for this assignment is a shuttle selector manifold for high pressure hydraulic applications (fig 1). The manifold is designed to work on hydraulic systems using petroleum based fluid up to 3000 psi. Four pressure lines may be routed through the manifold and the highest pressure will be seen at the GA port or a line may be run to the load sense port of the system using a pressure compensated pump. A pressure compensated pump will only output as much pressure as the hydraulic system requires saving energy and unneeded wear on components. The manifold senses the highest pressure and returns information to the pump. Typical market for this product may be machine tools, factory automation, earth moving equipment, farm machinery, ship building, oil drilling, and automotive industries to name a few. The design of the manifold was not emphasized in this project. It is assumed that the students have previous knowledge of machine elements, computer aided design, and CNC programming. Fluid power background was very useful for this project. The drawings were made on CIM-CAD software from CIM-Line Inc. [2].

PLANT LAYOUT

Major thrust of this project was to familiarize students with the layout of the manufacturing plant which they obtained from a number of field trips to local manufacturing plants. Then through group discussions, they came up with the optimum solution for the system layout with required quality and quantity of the product in mind.
Figure 3 shows the shop floor layout indicating the material flow from raw material to the finished product including packaging and shipping. In the sample project however material flow through the plant was not exactly the same as in the layout.

As per layout, aluminum bars are transferred from the racks at station 1 to the automatic saw bar feeder at station 2, which takes it to the saw to be cut to size at station 3. The bar is then conveyed to the horizontal machining center at station 5 where all the machining operations are performed. The machined part is then transferred to the thermal deburring furnace at station 6 followed by washing and cleaning at station 8. Quality control is done at station 11 where the finished product is measured and inspected as per specifications. Then after assembly and packaging at station 12, it is stocked in the finished goods inventory at station 14 ready to be transferred to the shipping bay at station 15.

PROTOTYPE MANUFACTURE

The shuttle selector manifold was manufactured in a MAZAK VQC-20/50B double pallet horizontal mill [3]. A part of the CNC program is shown in figure 2. Once complete the parts were deburred and inspected. The manufacturing processes were videotaped for later use in motion time measurements. Standard process sheets were prepared for record keeping and future process control. Due to the limited space available, only a brief summary of the standard process sheet is shown in table 1.

Stopwatch observation sheet was used to determine the time for individual elements. The attached sample for stopwatch observation was prepared in continuous timing and a part is shown in table 2. The analyst starts the watch at the beginning of the first element and allows it to run for the duration of the study. At the end of each element, the watch reading is recorded in the proper place in the observation sheet. The

readings are listed in the R column and subtracted time under the T column. In this project four manifolds were machined and assembled.

In the project students were required to contact a number of manufacturers of machine tools, various types of conveyors, and instruments for quality control and inspection. Through this exercise students had the opportunity for communications with other professionals, investigate manufacturers catalogs, become familiar with specifications like capacity, power limitation, operation characteristics of manufacturing equipments, and the costs involved in the manufacturing system.

References

1. Amrine, H. T. , Ritchey, J. A. , Moodie, C. L. , and Kmec, J. F. , Manufacturing Organization and Management, Prentice Hall

2. CIM CAD Software, Version 3.2, Cim Line Inc., Itasca, Illinois

3. Versatech V-40, five face double column machining center, Mazak System International, Florence, Kentucky

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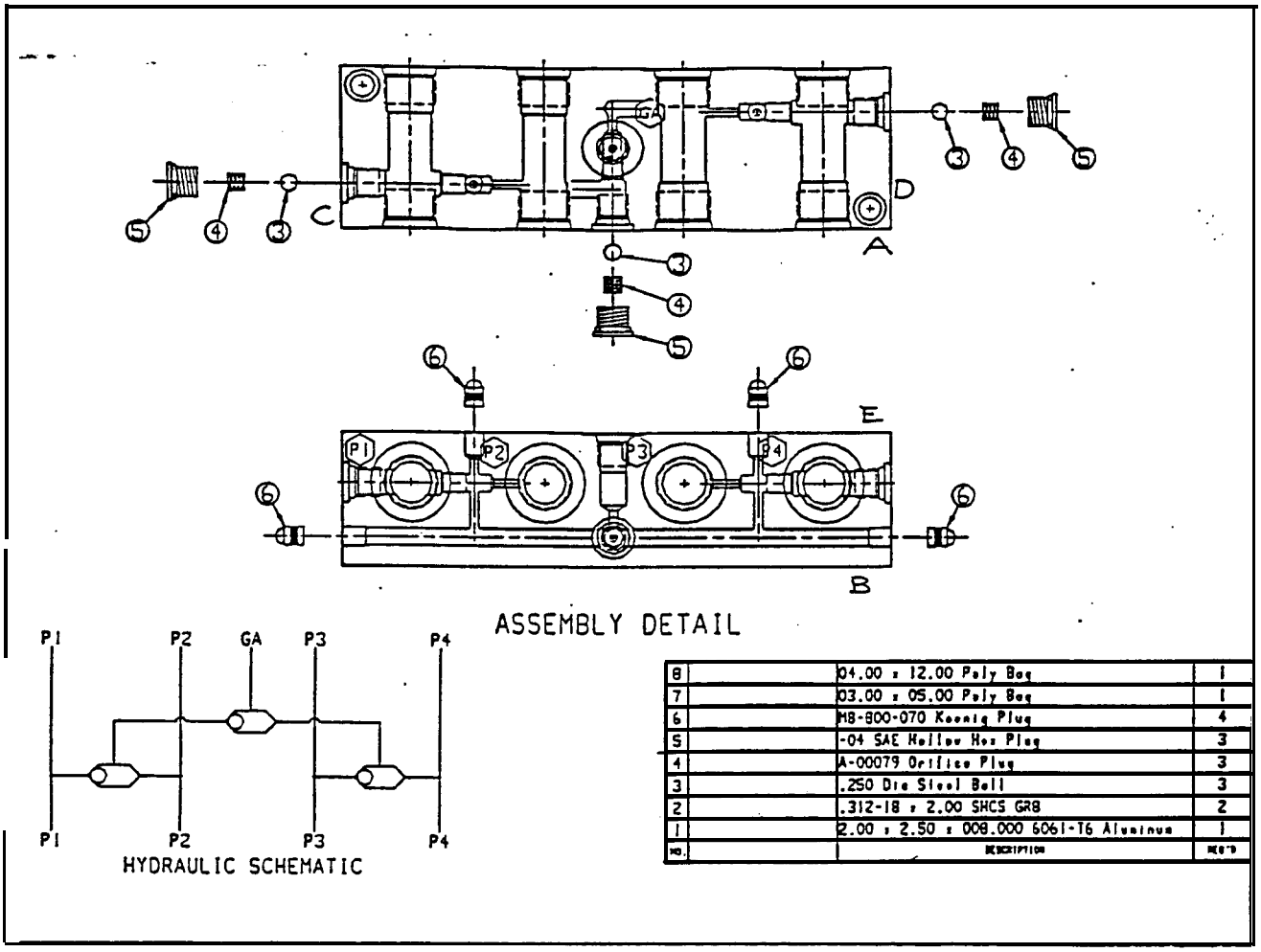

Figure 1 Shuttle Selector Manifold

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UNO MAT      INITIAL-Z  ATC MODE  MULTI MODE    MULTI FLAG   PITCH-X   PITCH-Y
  0 ALMINUM    0.1000       1      OFFSET TYPE
OFS              X           Y        THETA          Z
  1            0.0000      0.0000     0.000       0.0000
  2            9.0000      0.0000     0.000       0.0000
  3           18.0000      0.0000     0.000       0.0000
  4           27.3120      0.0000     0.000       0.0000

UNO UNIT        DIA     DEPTH  CHMF
  1 DRILLING  0.2500   4.1250 0.00
SNO  TOOL    NOM-D NO HOLE-D HOLE-DEP PRE-DIA PRE-DEP RGH DEPTH C-SP  FR     M  M
  1 CTR-DR  1.008  1  0.2500                          118        600 0.0200  8
  2 DRILL   0.25   2  0.2500  4.1250                     PCK2T0.125  185 0.0080  8
  3 DRILL   0.27   3  0.2750  0.4200                     PCK1T0.060  200 0.0080  8
FIG PTN   Z         X         Y        AN1      AN2       T1       T2     F  M  N P Q R
  1 PT    0.0000   0.4400  -1.8800                                        0  0  0

UNO UNIT        NOM-D          MAJOR-D  PITCH    TAP-DEP CHMF   CHP
  2 TAPPING UN 7S-20          0.4374 0.0500     0.5750 0.00    0
SNO  TOOL    NOM-D NO HOLE-D HOLE-DEP PRE-DIA PRE-DEP RGH DEPTH C-SP  FR     M  M
  1 CTR-DR  1.008  1  0.3914                          118        600 0.0200  8
  2 DRILL   0.26   4  0.2550  2.2800                     PCK2T0.250  185 0.0080  8
  3 DRILL   0.38   5  0.3750  1.5600                     PCK1T0.060  185 0.0080  8
  4 DRILL   0.44F  6  0.4380  0.6900                     PCK2T0.630  170 0.0050  8
  5 TAP UN 7S-20   7  0.4374  0.5750                   FIXP.0500   30 0.0500  8
FIG PTN   Z         X         Y        AN1      AN2       T1       T2     F  M  N P Q R
  1 PT    0.0000   1.2500  -1.8100                                        0  0  0
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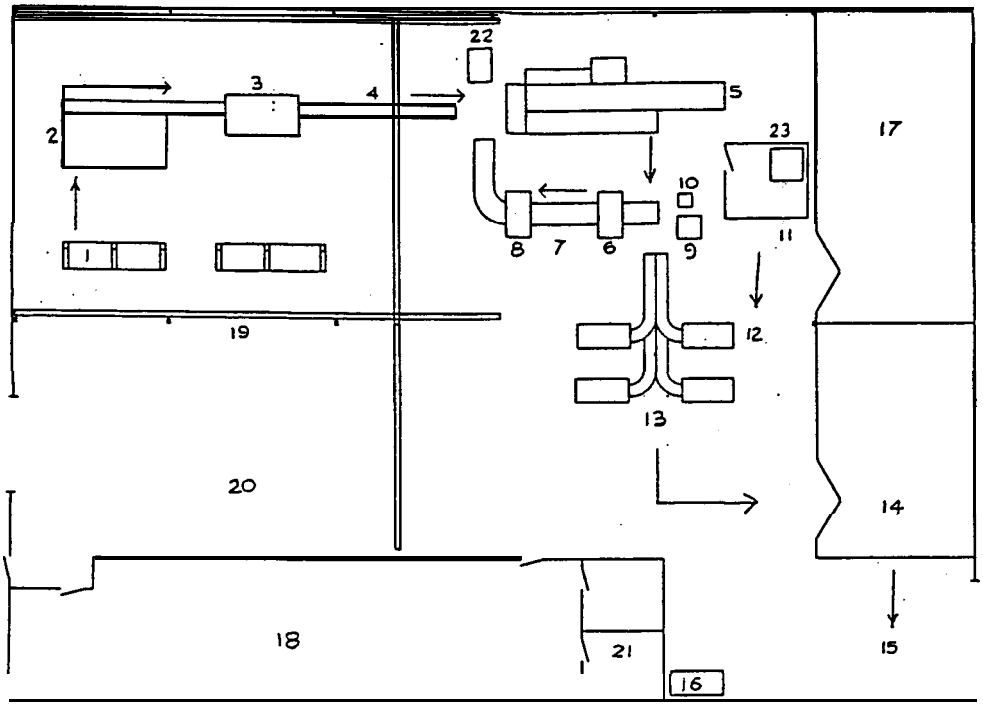
Figure 2 Mazatrol CNC Program (sample)



ITEM	Model No.	Catalog
1. Material Racks	89816508 (6) req'd	MSC pg. 1989
2. Automatic Saw Bar Feeder	Special from Bosch Automation	
3. Automatic Feed Saw	Scotchman CPO 350 NF AFR	MSC pg. 1844
4. Conveyor for sawed parts	Special from Bosch Automation	
5. Horizontal Machining center	Mazak VQC-20/50B	
6. Thermal Deburr Furnace		
7. Wash Deburr, Stamp conveyor	Special from Bosch Automation	
8. Parts wash station	Custom	
9. Roll stamping machine		
10. Roll stamper bench	Custom	
11. Quality control	--	
12. Ass'y & Packaging bench	Custom	
13. Ass'y conveyor	Special from Bosch Automation	
14. F. Inventory (shelving)	Custom	
15. Shipping Bay	--	
16. Shipping Bench	Custom	
17. Stock Room	--	
18. Offices	--	
19. Overhead cranes - trolley	89817720	MSC pg. 2030
electric hoist	89812523	MSC pg. 2029
20. Ship. & Rec'g bay	--	
21. Restrooms	--	
22. Machine operator bench	Custom	
23. Coord. Measuring machine		

Figure 3 Shopfloor Layout

Table 1 Standard Process Sheet

Material Space		Part Number		Part No		
Purchased Stock Size		Usage		Date Issued		
Pcs. Par Pur. Size		Assy No		Date Supervised		
Weight		Sub Assy No		Issued By		
Oper.	Operation Description	Dept	Machine	Set-up	Rate	Tools
10	Transport to saw	1	Overhead Crn	20 ft/min		
20	Load saw and cut to length	2, 18	Automatic		1 pc/min	saw
	16 pcs of 2x2.5x8 with .03 tol		feed saw			
30	Convey to CNC machine	19	Belt Conveyor		20ft/min	
40	Load & machine sides D,A	3, 4	Mazatrol		4 pcs/hr	
	Load pallet 1 with 8 pack, 4 on		Hozl. mill			
	each side		2 pallet			
	Machine side C					
	Drill .25x4.12 dp					.25 drill
	Drill 7 mm drx 1.56 dp					7 mm drill
	Tap .062-27 NPTFx 1.75 dp.					.38 drill
	Drill .44-20 SAE Point tool					.062NPTF
	Tap .44-20 SAE .7 dp					#4 SAE
	Machine sides D& E					#4 SAE
	(cntd. drill & tap as above)					
80	Wash & dry	5	Washer		2 ft/min	Basket
100	Thermal deburr	6	Nova 2000		4pcs/min	
	Natural gas, vacuum pump					
130	Conveyor to assembly	8	Belt conveyor		20 ft/min	
140	Inspection at quality control	11	CMM			
		9				Al.wrench
	Part removed from conveyor					Air hammer
	Assemble side A, place 7 mm					unit load
	plugs into holes, use air					pallet
	hammer to seat plugs					
	Flip part to side B					
	(Assemble continued)					
160	Transport to inventory					unit load
200	Packaging					boxes
210	Shipping					

Table 2 Stopwatch Observation Sheet

	ELEMENTS	Cycle 1		Cycle 2		Cycle 3		Cycle 4		Avg.	Rate	Time	Extra	Std
	DESCRIPTION	R	T	R	T	R	T	R	T	Elem.			Time	Time
										Time				
1	Grasp, Position work piece	0.75	0.75	1.14	1.14	1.6	1.6	1.01	1.01	1.02	100	1.02	5%	1.07
2	Reach, grasp plug	1.47	0.72	1.9	0.76	3.2	1.6	1.7	0.69	0.94	100	0.94	5%	0.91
3	Place plug into hole	4.89	3.43	6.08	4.28	11.8	8.6	8.58	6.88	5.77	100	5.77	5%	6.06
4	Install plug	7.84	4.85	12.4	6.28	17.7	7.91	13.4	5.29	6.08	100	6.09	5%	6.38
5	Lay gun down	11.3	4.43	13.7	6.33	20.5	0.88	14.7	0.91	1.12	100	1.12	5%	1.18
6	Flip part	12.2	0.92	14.4	0.73	21.1	0.66	18.4	0.72	0.76	100	0.76	5%	0.78
7	Grasp stl. ball, position	15.1	1.6	18.1	3.65	23.1	2.37	19.9	14.5	8.5	100	3.5	5%	3.68
14	Flip part	44.2	1.07	43.1	0.99	47	0.89	42	0.89	0.96	100	0.96	5%	1.01
15	Grasp, place plug	47.5	2.74	45.1	1.05	51.1	2.09	46.8	4.71	3.15	100	3.15	5%	3.31
21	Hand thd. #4 SAE plug	69.1	5.66	67.1	3.32	75.7	6.14	73.5	6.9	5.6	100	5.6	5%	5.89
22	Tighten # 4 SAE plug	75.8	6.48	74.8	3.5	83.2	7.58	78.3	4.76	6.57	100	6.57	5%	6.88

Table 3 Standard Method Sheet sample)

NO	LEFT HAND	RIGHT HAND	SPEED	FEED	STD.TIME
19	Grasp T-handle and position	Hold orifice plug in position			2.11
	into orifice plug				
20	Guide orifice plug into hole and	Guide T-handle			6.86
	tighten				
21	Lay T-handle down	Pick up #4 SAE plug and hand			5.88
		thread into position			
22	Pickup allen wrench and tighten	Hold part and allen wrench			6.89
	#4 SAE plug				