

To: P. Lin, P. Broberg and Mr. Joe Fortney

From: Gary Atchison

Date: 2/22/10

Re: Forming Die Test Press
Design Project Report

Report Outline

- Report Summary
- Problems and Corrections
- Status of the Machine
- Timeline for Completion
- Supporting Information
 - System Block Diagram
 - Project Gantt Chart
 - Hydraulic Power Unit Calculations
 - Motion Controller Information Calculations

Report Summary

Gentlemen, what you will find in the following report are updated screen shots of my project Gantt chart, the system calculations for the hydraulic power unit required for the machine and the MMC Standalone control setup file calculations. Also is a brief description of any issues that have come up along the way and their corrections, what is the status of the machine and what is left to be done. I would like to note that this machine has had an Ethernet module installed on the MMC Standalone control that will allow us to connect remotely from Marion with the machine in Germany. This will allow us to be able to modify and download control programs if needed without making a trip to Germany.

Problems and Corrections

The original electrical design of the machine was done a year ago before the hydraulic system was designed so the intention was to use the hydraulic system design of the first test press machine. It did not have a cooling fan motor on the hydraulic unit. Instead it used 2 electrical enclosure cooling fans mounted around the hydraulic unit to help cool it. Because we wanted to improve the design of the hydraulic power unit a cooling fan was included so we had to update the electrical design to include the hydraulic power unit cooling fan.

Another problem that has arose because of the changing the hydraulic power unit design from that of the original test press design is with the new design we changed from a hydraulic servo valve which uses a current input to a proportional valve which uses a voltage input. Because of this, the electrical system has been updated which requires another 24V power supply for the proportional valve and the removal of the VC2124 which was going to be used to convert the analog +/- 10V signal to a current which the servo valve used. We are currently awaiting the

arrival of the power supply so it can be installed. At that time we will remove the VC2124 converter and complete the wiring as necessary.

There was some confusion when parts were ordered for the hydraulic system and the wrong length cylinder and linear transducer were ordered. Parts were ordered for a 10 inch cylinder instead of a 15 inch cylinder. A 15 inch cylinder and a 15 inch MTS linear transducer have been ordered and are expected to arrive any time.

Status of the Machine

Presently the machine has been built allowing the installation of the hydraulic power unit and the electrical enclosure. Hoses are being routed to length so that they can be crimped. The safety pin cylinder has been installed and guards are in the process of being installed. Most of the electrical installation has been done but does not include the installation of the outputs solenoids for air control. The MS Project Gantt chart has been updated to reflect the recent progress on the machine and a document containing the calculations for the hydraulic power unit and the motion control system has been created.

What is left to be done is to complete the hydraulic hose installation and the machine wiring at which time we can begin installing the programs for the operation of the machine. Once these are complete we can begin testing and debug of the various systems. Once testing and debug are complete we can fully run the machine to make sure that all requirements have been met.

Time Line for Completion

Present: 2/19/10

Finish electrical and hydraulic installation: 3/1/10

Finish the installation of interlocks and guards: 3/1/10

Testing and Debug complete by: 3/15/10

Ship the Machine: 3/15/10 to 4/15/10 depending on machine schedule

Supporting Information

What you will find in the following information is the information for the system design, including hydraulic and motion control calculations. These will be included in the final report at the end of the semester. You will also find a block diagram that shows the basic system components and how they are connected to create a complete system. The only updated Gantt chart that will be shown are those with recent activity and those to yet be completed. I will begin on the next page with the System Block Diagram and I will provide subheadings for clarity.

System Block Diagram:

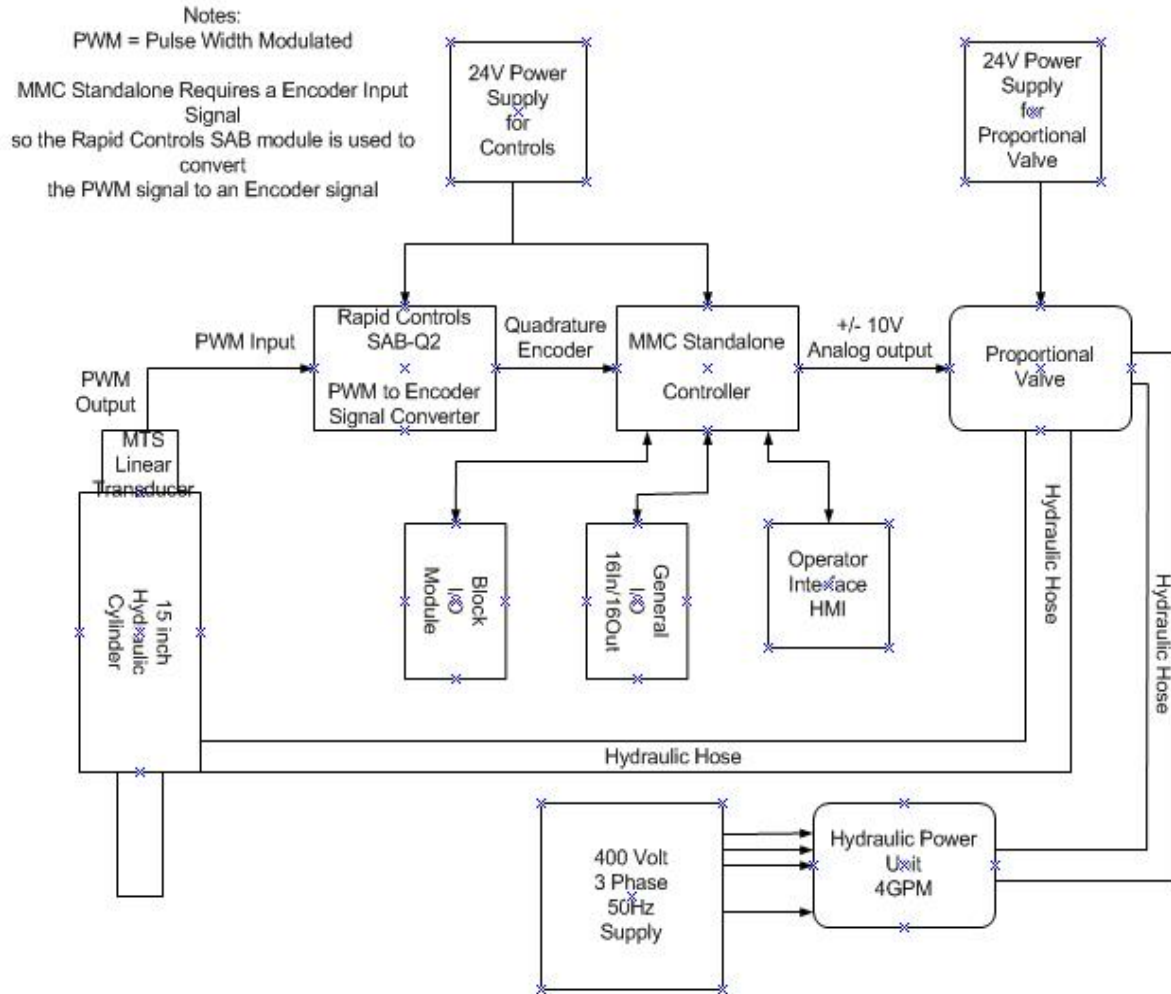


Figure 1 System Block Diagram showing interconnectivity of all components

Gantt Charts:

	Task Name	Duration	Start	Finish	Resource Names
1	Analysis	30 days	Mon 2/9/09	Thu 3/19/09	
2	Analyze Existing Program	1 day	Mon 2/9/09	Mon 2/9/09	Gary Atchison,Roger Beck
3	Review Controls and I/O Operation in Existing Sequential Code	1 day	Mon 2/9/09	Mon 2/9/09	Gary Atchison
4	Analyze Existing Controls	1 day	Mon 2/9/09	Mon 2/9/09	Gary Atchison[18%],Roger Beck
5	Review Existing Controls Usage and Wiring Schematics to determine what is needed	1 day	Mon 2/9/09	Mon 2/9/09	Roger Beck,Gary Atchison
6	Compare Delta Computer System with G&L Controls MMC to determine brand of Controls	1 day	Mon 2/9/09	Mon 2/9/09	Roger Beck,Gary Atchison
7	Order New Control System	30 days	Mon 2/9/09	Thu 3/19/09	Gary Atchison[17%],Roger Beck
8	Place order for control system components and electrical parts	30 days	Mon 2/9/09	Thu 3/19/09	Gary Atchison,Roger Beck
9	Developing the New Control System	38 days	Wed 2/11/09	Wed 4/1/09	Roger Beck,Gary Atchison
10	Create New Electrical Drawings	5 days	Tue 2/24/09	Mon 3/2/09	Roger Beck
11	Create New Ladder Program	21 days	Wed 2/11/09	Tue 3/10/09	Gary Atchison
12	Mock Up Control System to test Communication	1 day	Wed 4/1/09	Wed 4/1/09	Gary Atchison
13	Progress Report 1	1 day	Thu 9/10/09	Thu 9/10/09	Gary Atchison
14	Progress Report 2	1 day	Thu 10/1/09	Thu 10/1/09	Gary Atchison
15	Progress Report 3	1 day	Thu 10/22/09	Thu 10/22/09	Gary Atchison
16	Progress Report 4 Initial Proposal and 10 minute presentation	1 day	Thu 11/19/09	Thu 11/19/09	Gary Atchison
17	Final ECET 490 Report and Presentation	1 day	Thu 12/10/09	Thu 12/10/09	Gary Atchison
18	Develop and Order Hydraulic System	62 days	Thu 10/22/09	Tue 1/12/10	Joe Fortney,AJ Lindvall
19	Create New Hyd Sytem Design	18 days	Thu 10/22/09	Fri 11/13/09	AJ Lindval,Joe Fortney
20	Order Hyd System	45 days	Fri 11/13/09	Tue 1/12/10	AJ Lindvall
21	Building the Press and Installing Components	25.38 days	Mon 1/11/10	Thu 2/11/10	Assembly Department,Electrical Department
22	Paint the machine structure	1 day	Mon 1/25/10	Mon 1/25/10	Assembly Department
23	Build the Press	14.75 days	Mon 1/25/10	Thu 2/11/10	Assembly Department
24	Assemble the Forming Head	1 day	Mon 1/25/10	Mon 1/25/10	Assembly Department
25	Install Brass Forming Head to Guide Pin Bushings	1 day	Fri 2/5/10	Fri 2/5/10	Assembly Department
26	Install Guards and Interlocking Mechanisms	2 days	Mon 2/8/10	Tue 2/9/10	Assembly Department
27	Install air solenoids and Safety Axis Lock Cylinders	2 days	Tue 2/9/10	Wed 2/10/10	Assembly Department
28	Install Hydraulic Cylinder and Linear Transducer	1 day	Tue 2/9/10	Tue 2/9/10	Assembly Department
29	Install Hydraulic Hoses, Check Valves any remaining components	2 days	Wed 2/10/10	Thu 2/11/10	Assembly Department
30	Install Electrical Components	10.56 days	Mon 1/11/10	Fri 1/22/10	Electrical Department
31	Install Electrical Components such as Switches and Relays	2 days	Mon 1/11/10	Tue 1/12/10	Electrical Department
	Task Name	Duration	Start	Finish	Resource Names
32	Added Cooling Fan Output to Ladder code and Drawings	1 day	Fri 1/22/10	Fri 1/22/10	Gary Atchison,Roger Beck
33	Install Controls Components such as MMC, Ethernet Module, SAB, I/O Blocks	1 day	Wed 1/13/10	Wed 1/13/10	Electrical Department
34	Install Heat Controls	1 day	Thu 1/14/10	Thu 1/14/10	Electrical Department
35	Install Operator interface	1 day	Thu 1/14/10	Thu 1/14/10	Electrical Department
36	Run and attach all wiring	3 days	Thu 1/14/10	Mon 1/18/10	Electrical Department
37	Progress Report Due January 25, 2010	1 day	Mon 1/25/10	Mon 1/25/10	Gary Atchison
38	Updated Progress Report Due by 5:00pm 1-25-10	1 day	Mon 1/25/10	Mon 1/25/10	Gary Atchison
39	Updated Flow Diagrams for clarity, created paint documents and inserted into the proposal	1 day	Mon 1/25/10	Mon 1/25/10	Gary Atchison
40	Added Summary, updated Table of Contents, added departments to Resources	1 day	Mon 1/25/10	Mon 1/25/10	Gary Atchison
41	Updated the MS Project Gantt Chart	1 day	Mon 1/25/10	Mon 1/25/10	Gary Atchison
42	Finalized Report Due February 1, 2010	1 day	Mon 2/1/10	Mon 2/1/10	Gary Atchison
43	Progress Report #1 Phase II Due by 5:00pm 2-1-10	1 day	Mon 2/1/10	Mon 2/1/10	Gary Atchison
44	Update, Breakdown further the MS Project Gantt Chart Information	1 day	Mon 2/1/10	Mon 2/1/10	Gary Atchison
45	Add summary for any new changes and or modifications, review requirements	1 day	Mon 2/1/10	Mon 2/1/10	Gary Atchison
46	Design Report (2nd Report) Due by 5:00pm 2-22-10	1 day	Mon 2/9/09	Mon 2/9/09	Gary Atchison
47	Installing Hydraulics and Starting Up the Machine	308.06 days	Mon 2/9/09	Fri 3/19/10	Assembly Department
48	Install Hydraulic System to the Machine	3 days	Mon 2/15/10	Wed 2/17/10	Assembly Department
49	Setup New Control System	308.06 days	Mon 2/9/09	Fri 3/19/10	Gary Atchison
50	Download Operator Interface Program	1 day	Mon 3/1/10	Mon 3/1/10	Gary Atchison
51	Download the machine program (Ladder)	1 day	Mon 3/1/10	Mon 3/1/10	Gary Atchison
52	Establish Communication with MMC remotely using PicPro for Internet Downloading	1 day	Mon 3/1/10	Mon 3/1/10	Gary Atchison
53	Figure out Axis Setup Data for Motion Control (Accel, Dece, Velocity and Head Open Positions)	3 days	Mon 3/8/10	Wed 3/10/10	Consultant,Gary Atchison
54	Test Operator Interface Communication (Is it communicating with the ladder)	1 day	Tue 3/2/10	Tue 3/2/10	Gary Atchison
55	Test heat Control and setup parameters for the heat	1 day	Wed 3/3/10	Wed 3/3/10	Gary Atchison
56	Test I/O Operation	1 day	Mon 2/9/09	Mon 2/9/09	
57	Solenoid Operation (Top Die Air, Bottom Die Air)	1 day	Mon 2/9/09	Mon 2/9/09	
58	Pilot Light Operation (Power On, Run Mode, Manual Mode, Lock Pins Retracted, Lock Pins Extended)	1 day	Mon 2/9/09	Mon 2/9/09	
59	Test Safety Systems (Guards)	2.06 days	Thu 3/11/10	Fri 3/12/10	Gary Atchison
60	Test Guard Operation	1 day	Thu 3/11/10	Thu 3/11/10	Gary Atchison
61	Test Palm Button Operation	1 day	Thu 3/11/10	Thu 3/11/10	Gary Atchison
62	Test Operation of the Auto/Manual Mode Switch	1 day	Thu 3/11/10	Thu 3/11/10	Gary Atchison

	Task Name	Duration	Start	Finish	Resource Names
63	Can we only start the hydraulics in Manual Mode using the Simultaneous Press of the Palm Buttons?	1 day	Thu 3/11/10	Thu 3/11/10	Gary Atchison
64	Can the accumulator only be charged when the guards are closed?	1 day	Fri 3/12/10	Fri 3/12/10	Gary Atchison
65	Does the accumulator only charge in Auto Mode?	1 day	Fri 3/12/10	Fri 3/12/10	Gary Atchison
66	Do the safety Pins engage when the sliding guard door is opened?	1 day	Fri 3/12/10	Fri 3/12/10	Gary Atchison
67	Test the 8 Operations of the machine as described in the flow diagrams	3.13 days	Mon 3/15/10	Wed 3/17/10	Gary Atchison
68	Locking Pins Operation	1 day	Mon 3/15/10	Mon 3/15/10	Gary Atchison
69	Going to Start Position	1 day	Mon 3/15/10	Mon 3/15/10	Gary Atchison
70	Hydraulic Startup	1 day	Mon 3/15/10	Mon 3/15/10	Gary Atchison
71	Homing the Machine	1 day	Tue 3/16/10	Tue 3/16/10	Gary Atchison
72	Going to Start Position based on the Program Selected (1-4) from the HMI	1 day	Tue 3/16/10	Tue 3/16/10	Gary Atchison
73	Cycle Start (Machine Start)	1 day	Tue 3/16/10	Tue 3/16/10	Gary Atchison
74	Manual movement of the head (Jogging)	1 day	Wed 3/17/10	Wed 3/17/10	Gary Atchison
75	Heat Control	1 day	Wed 3/17/10	Wed 3/17/10	Gary Atchison
76	Test Motion Control and perform debug of motion control until proper control is established	2 days	Thu 3/18/10	Fri 3/19/10	Gary Atchison
77	Test functionality of the overall systems for proper operation (All systems working together)	1 day	Fri 3/19/10	Fri 3/19/10	Gary Atchison
78	Do we meet the requirements for Safety, EC, Electrical and System	1 day	Fri 3/19/10	Fri 3/19/10	Gary Atchison
79	System Construction and Unit Testing Report (3rd Report)	1 day	Mon 3/22/10	Mon 3/22/10	Gary Atchison
80	First Testing Report Due 5:00pm 4-5-10 (4th Report)	1 day	Mon 4/5/10	Mon 4/5/10	Gary Atchison
81	Second Testing Report Due 5:00pm 4-12-10 (5th Report)	1 day	Mon 4/12/10	Mon 4/12/10	Gary Atchison
82	Progress Report and Design Review	14.63 days	Tue 4/13/10	Fri 4/30/10	
83	Final Report Writing	4 days	Tue 4/13/10	Fri 4/16/10	Gary Atchison
84	Final Project and Presentation	5 days	Mon 4/26/10	Fri 4/30/10	Gary Atchison

Figure 2 Gantt Chart updated to show recent and future activity

Hydraulic Power Unit Calculations:

The following given parameters will be used to make hydraulic calculations to simulate a production speed of 40 SPM:

Time to Retract = 350ms

Time to Extend = 350ms

Closed Dwell = 500ms

Note:

Because this machine does not run in a continuous mode, open dwell is not considered in the calculation for head speed. Time to retract plus time to extend plus closed dwell as noted yield a 50 SPM machine rate. If we added an open dwell of 300ms then it would be equal to a 40SPM machine.

Head Open Position 11.375 inches – Die Shut Height 7.25 inches = 4.125 inch head stroke

Forming Pressure required = 20,000 pounds forming force

Head weight with components (HW) = 1250 pounds head + 110 pounds components = 1360 pounds

Friction Force (FF) = .24*HW*cos(0°) = .24*1360*1 = 326.4 pounds

The pages following are the calculations to be used in the development of the Forming Die Test Press based on the above given conditions:

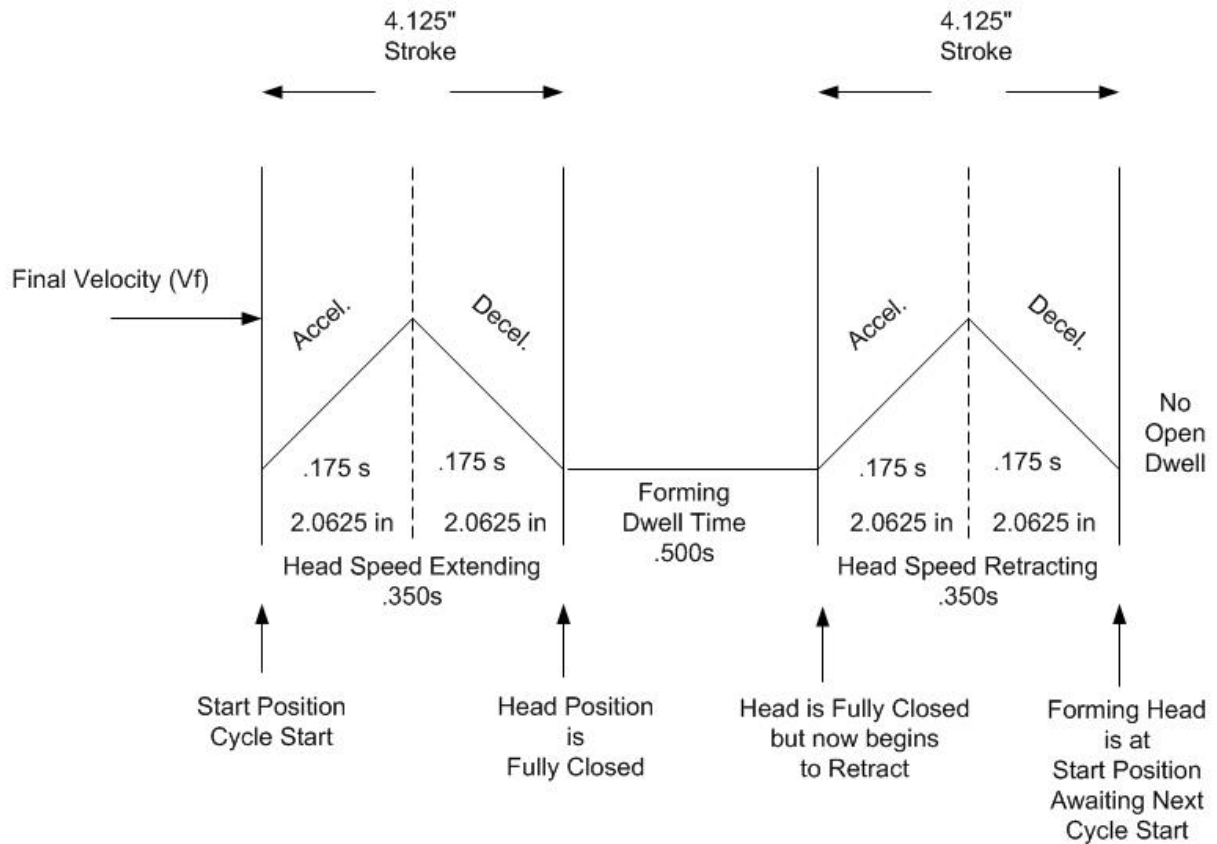
$AverageVelocity(Va) = 4.125inches / .350ms = 11.78inches / sec\ on\ d$

$FinalVelocity(Vf) = 2 * S \div t = (2 * 2.0625inches) \div .175sec = 23.6inches / sec\ on\ d$

Using the distance and time under acceleration

Where S = Distance moved in inches = 2.0625 inches

t = Time of acceleration = .175 seconds



Maximum Oil Flows:

Cylinder Bore = 3.25 inches

Cylinder Rod = 2 inch diameter

$CRA = CylinderRodArea = \pi * r^2 = 3.14 * 1.0^2 = 3.14inches^2$

$CPAE = CylinderPistonAreaExtending = \pi * r^2 = 3.14 * 1.625inches^2 = 8.3inches^2$

$CPAR = CylinderPistonAreaRetracting = CPAE - CRA = 8.3inches^2 - 3.14inches^2 = 5.16inches^2$

Oil Flow to Extend (OFE):

$OFE = CPAE * Vf = (8.3in^2 * 23.6in / sec) = (195.9in^3 / sec) * (60sec / min) =$

$(11754in^3 / min) / (231in^3 / gal) = 50.9gal / min$

Oil Flow to Retract (OFR):

$OFR = CPAR * Vf = (5.16inches^2 * 23.6in / sec) = (121.8inches^3 / sec) * (60sec / min) =$

$(7308inches^3 / min) / (231inches^3 / gal) = 31.6gal / min$

Hydraulic Oil Pressure Required to generate 20,000 pounds of forming force (HOPR):

$$HOPR = \text{For min gForce Required} / CPAE = 20000 / 8.3 \text{ inches}^2 = 2410 \text{ pounds} / \text{inches}^2$$

Weight of the Head and Components (HW) + Friction Force (FF)

$$HW + FF = 1360 \text{ pounds} + 326.4 \text{ pounds} = 1686.4 \text{ pounds}$$

Find the amount of hydraulic pressure required to accelerate the head upward (PAHU):

To accelerate the 1686.4 pounds of the head at a production speed: "Use the formula"

a = acceleration rate

S = distance moved in inches

t = time of acceleration in seconds

$$a = (2 * S) / t^2$$

$$a = (2 * 2.0625 \text{ inches}) / .175 \text{ sec}^2 = 134.7 \text{ inches} / \text{sec}^2$$

Convert acceleration to feet/sec:

$$a / 12 \text{ inches} = (134.7 \text{ inches} / \text{sec}^2) / 12 = 11.23 \text{ feet} / \text{sec}^2$$

As well as knowing acceleration we also need to know (R) which is the Resultant Force On the Body. To find (R) use the following formula:

R = Resultant Force on the Body

w = HW + FF

g = Gravitational Force (32.16 feet/sec²) or (9.81 meters/sec²)

a = acceleration rate in feet/sec²

$$R = (w / g) * a = 1686.4 \text{ pounds} / (32.16 \text{ ft} / \text{sec}^2) = 52.4 \text{ footpound} / \text{sec}^2$$

$$(52.4 \text{ footpound} / \text{sec}^2) * (11.23 \text{ ft} / \text{sec}^2) = 587.9 \text{ pounds}$$

$$W = R + w = 587.9 \text{ pounds} + w = 587.9 + 1686.4 \text{ pounds} = 2274.3 \text{ pounds}$$

To finish finding hydraulic pressure need to accelerate the head upward:

Use the flowing formula for Pressure to Accelerate Head Upward (PAHU):

$$PAHU = W / CPAR = (2274.3 \text{ pounds}) / (5.16 \text{ inches}^2) = 441 \text{ pounds} / \text{in}^2$$

Note:

Accumulator Pressure must be greater than or equal to the Forming Pressure (HOPR), which is 2410 pounds/inch² because pressure is required from the accumulator for movement of the forming head.

To find the amount of pressure required for the accumulator pre-charge we must know and do the following:

1) The largest volume of oil taken from the accumulator will be at the maximum amount of head stroke (HS) which is:

Four head open positions will be needed:

20.375 inches

17.375 inches

14.375 inches

11.375 inches

Two different shut heights (closed die height) will be used for the dies:

12 inch

7.25 inch

12 inch shut height will be used with the 20.375 inch and 17.375 inch Machine Head Open Position

7.25 inch shut height will be used with the 14.375 inch and 11.375 inch Machine Head Open Position

The greatest head travel is realized when using the 20.375 inch Head Open Position with the 12 inch shut height die, so;

$$HS(\text{HeadStroke}) = 20.375\text{inch} - 12\text{inch} = 8.375\text{inches}$$

2) The oil volume required from the accumulator to move the head 8.375 inches is found by the following:

Extending:

$$HS * CPAE = 8.375\text{inch} * 8.3\text{in}^2 = 69.5\text{in}^3$$

This 69.5inches^3 is compressed to 2410 pounds/inch²

We need to know that .5% oil volume compression/1000 psi is:

$$2410\text{psi} / 1000\text{psi} / .005 = 2.41 * .005 = 1.205\% \text{ or } \mathbf{.01205}$$

Now we can finish finding oil volume from the accumulator (OFA) to move the head 8.375 inches

$$OFA = (HS * CPAE) * .01205 = .84\text{in}^3 + (HS * CPAE) = 70.34\text{in}^3$$

$$OFA = 69.5 * .0125 = .84 + 69.5 = 70.34\text{in}^3$$

Now we can find the amount of pressure required for the accumulator pre-charge

Use the equation:

$$P_1 * V_1 = P_2 * V_2$$

Where:

$$P_1 = HOPR = 2410 \text{ pounds / inches}^2$$

$$P_2 = \text{Accumulator Pre-charge Pressure}$$

$$V_1 = \text{Rated Gas Volume} = 1124 \text{ in}^3$$

$$V_2 = V_1 - OFA = 1124 \text{ in}^3 - 70.34 \text{ in}^3 = 1053.7 \text{ in}^3$$

$$P_2 = (P_1 * V_1) / V_2 = (2410 * 1124) / 1053.7 = 2708840 / 1053.7 = 2570.8 \text{ psi Accumulator Pressure}$$

PVR = Pump Volume Required at a 4.125" stroke

$$P = \text{Pump} = 4 \text{ gallons/minute}$$

$$\text{Stroke} = 4.125 \text{ inches}$$

$$A = \text{Cylinder Volume Extending}$$

$$B = \text{Cylinder Volume Retracting}$$

$$A = CPAE * \text{Stroke} = 8.3 \text{ inches}^2 * 4.125 \text{ inches} = 34.24 \text{ inches}^3$$

$$B = CPAR * \text{Stroke} = 5.16 \text{ inches}^2 * 4.125 \text{ inches} = 21.29 \text{ inches}^3$$

$$PVR = A + B = 34.24 + 21.29 = 55.53 \text{ inches}^3$$

$$PVR \text{ Converted to gallons} = .24 \text{ gallons}$$

TTR = Time Required to Refill the Accumulator at a 4.125" stroke

$$TTR = .24 \text{ gallons required at } .066 \text{ gallons/second (4gallonsl/minute)} = 3.64 \text{ sec}$$

M = Motor Size Required

$$P = \text{Pump} = 4 \text{ gallons/minute}$$

$$P_2 = 2571 \text{ pounds/inches}^2$$

$$K_1 = 1714$$

$$K_2 = .85$$

$$M = \frac{P_2 * P}{K_1 * K_2} = \frac{2571 * 4}{1714 * .85} = 7.06 \text{ HorsePower}$$

We will use the common size 10HorsePower motor

The volume of oil required to manually move the forming head at 1 inch/sec is as follows:

To manually extend the head:

$$1\text{gallon} = 231\text{inches}^3$$

$$CPAE * 1\text{inch} = 8.3\text{inches}^3$$

$$8.3\text{inches}^3 / 231\text{inches}^3 = .036\text{gallons} / \text{sec ond}$$

$$(.036\text{gallons} / \text{sec ond}) * (60\text{sec onds} / 1) = 2.16\text{gallons} / \text{min ute}$$

Using a 4-gallons/minute pump, the velocity that can be achieved manually extending the head 1inch/second:

$$4\text{gallons} / \text{min ute} / 2.16\text{gallons} / \text{min ute} = 1.85\text{inches} / \text{sec ond}$$

To manually retract the head:

$$1\text{gallon} = 231\text{inches}^3$$

$$CPAR * 1\text{inch} = 5.16\text{inches}^3$$

$$5.16\text{inches}^3 / 231\text{inches}^3 = .023\text{gallons} / \text{sec ond}$$

$$(.023\text{gallons} / \text{sec ond}) * (60\text{sec onds} / 1) = 1.34\text{gallons} / \text{min ute}$$

Using a 4 gallons/minute pump, the velocity that can be achieved manually retracting the head 1inch/second:

$$4\text{gpm} / 1.34\text{gpm} = 2.98\text{inches} / \text{sec ond}$$

Motion Controller Information Calculations:

The setup information for the motion controller to make its calculations requires the following input data.

Resolution to be used for calculations = .00025 inch

Axis Data:

Output Type = D/A

Input Type = Encoder

Output Slot Channel = 1.1

Input Slot Channel = 1.1

Encoder Driver = Differential

Encoder Type = Quadrature

Scaling Data Requires:

Input Scaling:

Feedback Units = 4 (4*resolution to = .001" of an inch = 4*.00025 = .001 inch)

Ladder Units = 1 (1LU = .001 inch so values in the ladder to = 1 inch are * 1000)

So 4 inches in the ladder = 4000

Ladder Units/Axis Units = 1 (These are the units of measurement for the system and must be integers, at 1 no further scaling is needed)

Output Scaling:

Commanded Voltage = 10000 mv (This is equal to 10V which is the analog signal the Controller outputs)

Motor RPM at Voltage = 23.6 inches/second or 1416 inches/minute (This is our calculated Vf)

Counts/Motor Rev = 4000 pulses/inch (Based on the resolution, 4000*.00025 = 1 inch)

Iterator Data:

$$\text{Velocity Limit} = V_f * (\text{Counts} / \text{Mtr Rev}) * (\text{AU} / \text{LU}) * (\text{LU} / \text{FU})$$
$$1416 * 4000 * 1 * (1/4) = 1,416,000 \text{ AU} / \text{minute}$$

$$\text{Acceleration Ramp} = \frac{\text{VelocityLimit}}{t} =$$
$$1416000 / .175 = 8,091,428 \text{ AU} / \text{minute} / \text{second}$$

$$\text{Deceleration Ramp} = \frac{\text{VelocityLimit}}{t} =$$
$$1416000 / .175 = 8,091,428 \text{ AU} / \text{minute} / \text{second}$$

$$\text{Controlled Stop Ramp} = \frac{\text{VelocityLimit}}{t} * 10^1 =$$
$$1416000 / .175 = 80,914,280 \text{ AU} / \text{minute} / \text{second}$$

$$\text{Move Accel/Decel Max Accel} = \frac{(3/2) * \text{VelocityLimit}}{3 \text{ seconds}} =$$
$$(3/2) * 1416000 / 3 = 708000 \text{ AU} / \text{min} / \text{sec}$$

$$\text{Move Accel/Decel Constant Jerk} = 3 * \text{Max Accel} / 3 = 708000 \text{ AU} / \text{min} / \text{sec} / \text{sec}$$

Based on previous projects the following are givens:

Slow and Fast Velocity Filters = 0ms

Slow/Fast Velocity Threshold = 0 AU/minute

Rollover Position = 0 AU

Software Upper Limit = +100000

Software Lower Limit = -100000

Ignore Limits = Yes

Resume able Estop Allowed? = No

Position Data:

Input Polarity = Negative

Output Polarity = Negative

Analog Output Offset = 0mv

Feed Forward % = 0%

Proportional Gain (Kp) = 2000 (AU/min)/(AUFE)

Integral Gain (Ki) = 0 (AU/min)/(AUFE*min)

Derivative Gain (Kd) = 0 (AU/min)/(AUFE/min)

+ Integral Error Limit = +100

- Integral Error Limit = -100

Following Error Limit = $(Counts / Motor Rev) / 8 * (AU / LU) * (LU / FU)$

$$4000 * 8 * .250 = 125 AU$$

This will be fine tuned on start up

Update rate for the axis = 1.0 ms

In Position Band = $10LU*(AU/LU) = 10 AU$ This will be fine tuned on start up

Note:

The servo file setup data is used to determine the movement of the proportional valve during operation. We do not enter values for voltage for moving the valve during different modes of operation. The motion controller uses the values entered above plus for certain moves we provide a position and a rate to the motion controller and it adjust the valve accordingly through its analog output to the valve.