

James Stallard - Interim Report

by Frederick Stallard

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Interim Report

Airway Height control using core compress feedback

PSDE6019

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Engineering

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1. Introduction and back ground

For this project a new automated airway height control system will have to be designed and constructed for the core building machine 8, (Known as (CB8) within the company). Calsonic is a company that develops parts for the automotive industry. Calsonic has plants in 16 different countries, so is a worldwide company. It is currently under the ownership for a financial company KKR. Calsonic is a company that supplies a number of vehicle manufacturers (for example Land Rover, Nissan and Audi to name a few), with OEM quality parts. These parts can vary from heat exchange parts (radiators and condensers) to exhaust systems to interior parts. This project will be located on the Llanelli site. This site is used to produce Radiators, Condensers and intercoolers.

Due to varying customer demands there are many differing types of airways being produced by Calsonic, this is due to different performance criteria asked for my customers. The airway has a huge effect on the performance of the radiator/condenser and therefore can affect the cooling system for the vehicle dramatically.

For this Project I have been asked to propose a method of measuring the height of an airway within a radiator/condenser core. To do this I will have to justify a method of solving this current issue by performing testing to prove if the method will work and prove that it will save the company money to release the funds. For this project, the measurement will have to be taken while the machine is assembling the core. From this the system, will have to take the current height and compare it to a set point, from this the airway height will have to be increased and decreased from the airway machine.

For this project there will have to be a completely new control system added to the machine CB8 that will be used to control the height of the airways coming from the airway machine. The airway machine is one part of the Core-building machine that is used to form the airway shape. This is done by using forming rolls to shape 0.08mm aluminium in to a triangular form. An airway can be seen in figure 1.1, this is one part of the core but has a major effect on whether the core will be in spec for the customer or not.



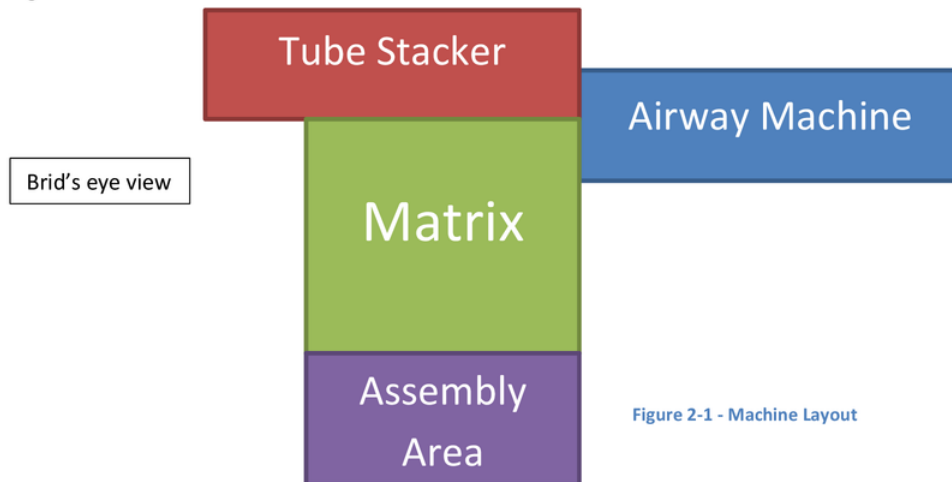
Figure 1-1 - Example of an Airway

Introduction to the existing problem seems a bit muddled in terms of airway height control.

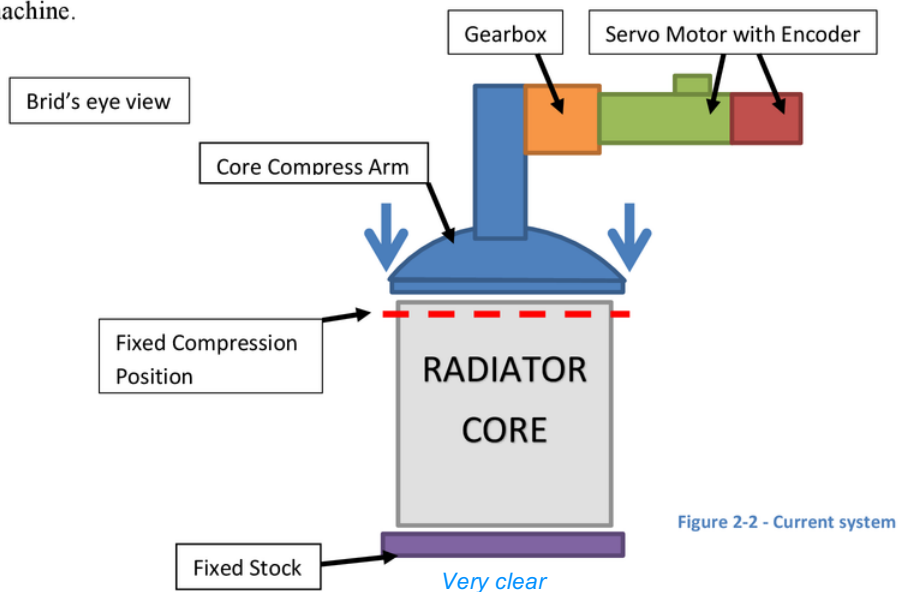
2. Current Problem

The

the core builder 8 (CB8) is made up of a number of smaller machines that work together to make the radiator/condenser as an end product a layout of the machine can be seen below in figure 2.1



The process works by the airway machine making the airway formed material. This is then fed into the matrix, where the tube stacker also adds the tubes. In the matrix the airways and tubes are arranged to create the centre part of the radiator/condenser. These are then pushed to the assembly area where the side casings and tubes plates are fitted. It is in the area where the core compress is and where the project will be, this will then feedback to the airway machine.

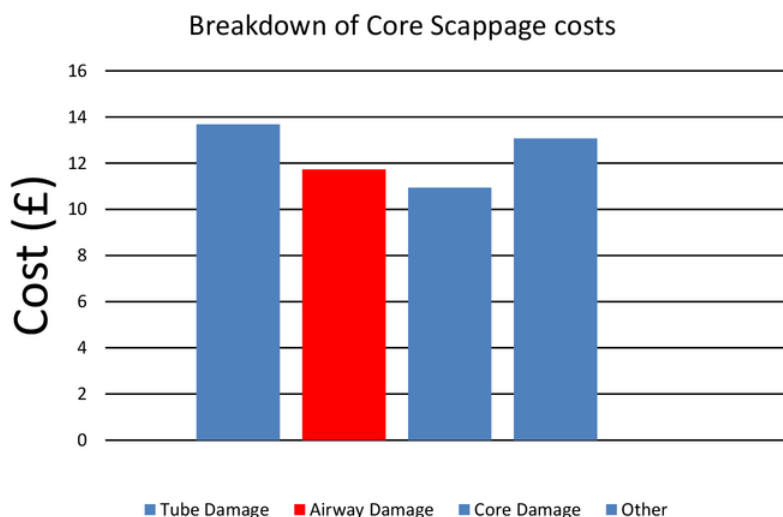


The current system does not use a feedback loop to control the airway height. The current system was by using a servo motor to drive the core compress to a fixed compress position, using feedback from an encoder. As can be seen below in the illustration (figure 2.2).

The problem with the current system is that it does not account for changing airway height, this is an issue if the airway is higher than it should be, then the core will have to be compressed more to get to the fixed compression point. This ^{in turn} will damage the airways or even crush them all together against the tubes.

Once the core has been damaged then it will have to be thrown away ^{in turn} this drives up scrappage costs and reduces the machines overall efficiency. Currently the scrappage cost due to damaging airways is around £11.73 a week for the core-builder 8. Not all airway damage is due to this issue with the core compress, airways can be damaged vary easily before the brazing is complete. But making this system more efficient will inevitably reduce the cost of this scrappage. See figure 2.3.

Figure 2-3 - Cost of Damages to cores



Good clear reasoning as to why the project needs to have a closed loop control system with the airway height. Grammar needs a lot of adjustment...

2.1 Project proposal

The solution to be chosen must be able to measure the airway height while it is compressing the core down to fit the tube plates on. This will have to be fitted to core-builder (CB8).

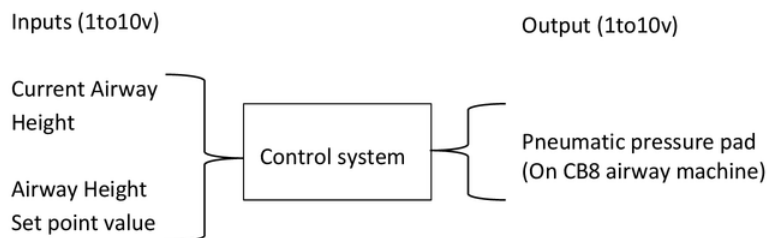
The new solution will have to have some method of feeding back the current airway height into the can comparing to a set point value, depending on the value the system will then have to adjust the back tension on the airway machine to either increase or reduce the airway height. This can be done using a PID control if necessary.

2.2 Proposal Speciation *Specification?*

The input from the core compress must be in a 1 to 10V format, the method of getting this voltage will be decided by the chosen solution. This input will have to be tested on the machine to ensure that it is functioning correctly.

If a PID system is to be used then it will have to be created on the Allen Bradley SLC 5/04 PLC, the reason for this is that then is the PLC fitted to the machine. For the Allen Bradley there is a standard function for a PID control that may be able to be used for this new solution. The PID system will have to be able to use one analogue input and compare it to a fixed set point and then adjust its analogue output to the back tension unit accordingly. The program will have to be tested fully before it is fitted to the machine to ensure it is working correctly.

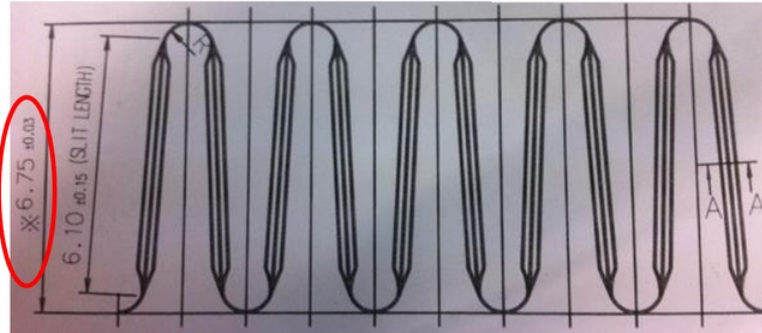
Figure 2-4 - Basic example of control system



The system will have to be powered using a 240V supply, this will have to be done to ensure that it can be implemented anywhere on the site.

Figure 2-5 - airway Specification

The set point for the airway height will have to be set at 6.75mm, as this is the airway height stated on the specification for the CB8 airway, see figure 3.2 below



General specification given at this point.

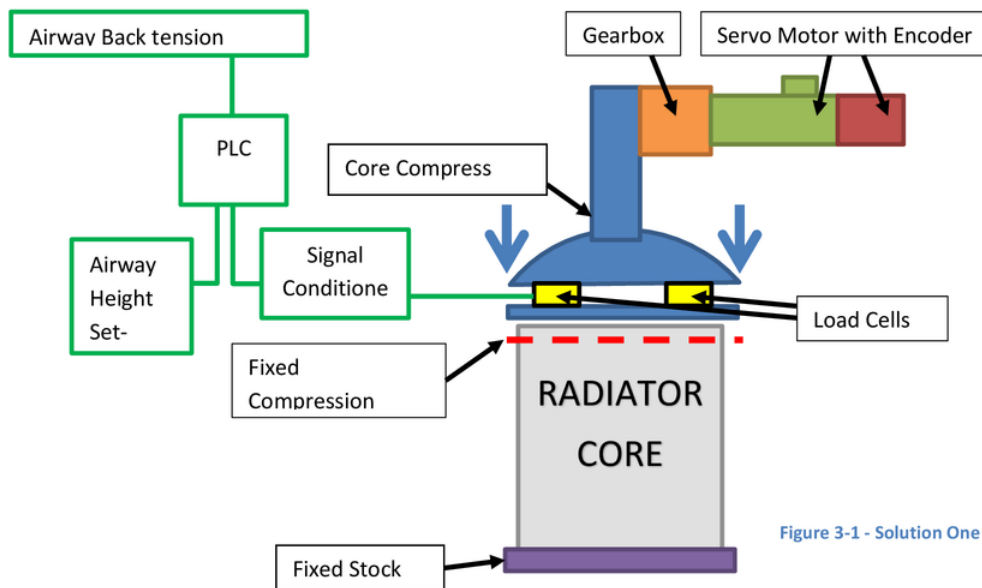
3. Literature Review

3.1 Three potential solutions

There has been three possible solutions chosen for this project, all three will solve the issue of measuring and controlling the airway height and all three would satisfy the specification laid out for the project.

3.1.1 Solution One (Load Cell)

The first solution to be considered consists of a similar setup to the current system. The difference is that load cells will be fitted in to the core compress arm to measure the amount of load it takes to compress the core to the set position. A drawing of this can be seen below



The drawing above shows how the hardware will have to be constructed for this solution. This solution uses two load cells that will be built into the compression arm, this load cells will then measure the amount of load it takes for the servo motor to drive the arm to the set compress position. The cells will work by changing resistance as the load is applied to them, from this the system will then determine whether the airway is too height or low. The more load required to compress core means that the airway height is higher as it will have to compress for longer to get to the set position, if the load cells pick up that less load was needed then this means that the airway height is low. The resistance from the load cells will then have to be converted into a 1 to 10V input signal, this will be done using a signal conditioner. Once this has been done it can be entered into the PLC.

Once the PLC has the input signal it will then have to compare it to a fixed value that represents an airway height of 6.75mm (correct to spec). From this the PLC will have to decide if the height is over or under and then control the output to the back tension system accordingly using a PID system within the programme. The PLC for this system will be an Allen-Bradley Control Logix, as this is already installed on this machine.

The advantages of this solution is that it does not require a major change on the machine, the only part that needs changing is the compression arm, for one with two load cells integrated into it. This means that it will not affect the process for the end product majorly so should not affect the product. Also another advantage is that all of the parts that are mentioned (except for the compression arm) are parts that are already stocked in Calsonic's stores, this means that there will not have to be extra parts ordered in to stock the stores with spares.

The disadvantage of the solution is that the cost of making the arm will be very high but still within budget, it just will be the majority of the budget as that will have to be two purchased as one will have to be kept as a spare in case the original is damaged.

3.1.2 Solution One Hardware

3.1.2.1 Load Cells

Load cells are transducers that create an electrical signal that is directly proportional to the force being applied to it. There are many different types of load cells available depending on the task to be done

The load cell works by measuring the mechanical strain being applied to the strain gauge. The strain gauge will then measure the deformation by changing the electrical resistance of the cell. A load cell normally contains four strain gauges that are wired into a wheatstone bridge configuration. A load cell will normally only output a couple millivolts, this means that the load cell will need an amplifier is needed to boost the output voltage to 10v max.

(Williams, 2016)

Figure 3-2 - Load Cell - www.dataweigh.com



(Data Weighing Systems, 2017)

The most common use of load cells is in industry, these load cells are normally a stiffer set up and are normally very responsive to load changes. The stiffer load cells tend to have a longer

life span as they are less affected by the loads applied to them. A normal place to mount a load cell is on a beam or structure that will typically deform then the load is applied to it. It is good practice to use four load cells on one strain point. Two of these will be placed on the strain point and the other two will be used to measure the background forces that can affect the cells, for example temperature changes. This has to be done to take this effects out of account when measuring.

For this project the most suitable load cell to be used is a 'compression load cell', this load cell is designed to be fixed to solid surface have the load applied to it in a compression method.

The issue with using load cells is that it must be mounted correctly to the surface, you must also ensure that the load to be measured is only going through the part of the load cell that will deform and measure the change is resistance.

(Hugo, 2014)

3.1.2.2 Allen-Bradley Control Logix PLC

In this project the PLC to be used is the Allen-Bradley Control Logix PLC. This is a rack mounted PLC and this is purchased in separate parts from the suppliers. For these PLC's you must first choose the chassis, there are many different sized chassis available depending on how many cards you need to perform the tasks.

(Smith, 2017)

Figure 3-3 - Control Logix - www.atn.org



(ATN, 2016)

The next step is to choose the correct CPU, the power of the CPU depends on the tasks that you want to perform. The PLC is current being implemented on the machine so this CPU is large enough to complete the machines normal tasks will performing this new control system for the airway height. This will allow us to use a PID control system. The CPU has a 64K words of configurable data and program memory, it is also capable of controlling up to 4096 input and 4096 output signals.

The next step is to choose the power supply for the PLC, there are many different supplies available depending on what mains supplies you have available on site. For this one the 240V power supply is the most suitable.

Finally the input and output cards must be selected for the chassis. For this project there will have to be an analogue input and output card as the input and outputs will be an analogue 1 to 10V signal. For this the card (1756-VF4FXOF2F) can be used, this is an analogue input/output card with two inputs and two outputs. It is also critical that the voltage cards are purchased and not the current (I) cards.

(Jones, 2015)

Good detail shown which has been well researched.

3.1.3 Solution Two (Current Feedback)

The second solution will consist of the PLC measuring the Current feedback from the Servo Motor, doing this will allow us to know how much torque the motor is applying to compress the core to the set position. The drawing for this can be seen below is figure 4.2.

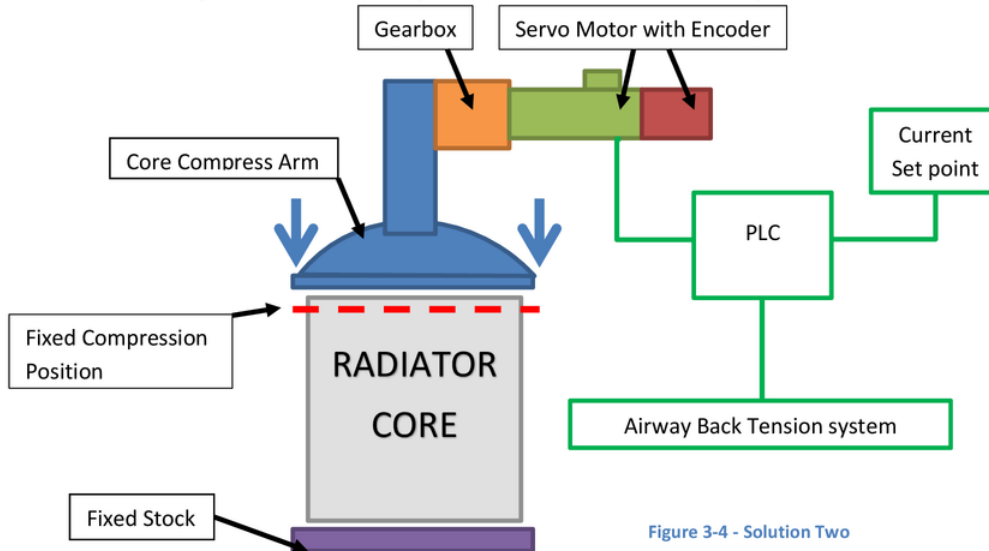


Figure 3-4 - Solution Two

As can be seen in the image above this solution will rely on using the current feedback from the servo motor that moves the compression arm. For this to work there can be two options, the first can be a current clamp fitted to the power cable going to the motor. Within this clamp there will be a signal condition circuit that will output a 1 to 10V output for the PLC. For this an analogue input card will have to be used on the PLC. The second being that the drive controller (control Technique) has an internal system for measuring the current values at the point of compression.

The PLC will then have to take the input and compare it to a set point airway height, from this the PLC program will decide whether the airway higher or lower than the set point. From this the PLC will then adjust the back tension of the airway machine to improve the airway height.

The advantage of using this solution is that it will be the cheapest to implement, this is due to there being no modification needed to the machine. For this solution there only will have to be a current clamp fitted to the machine. This means that the project will be implemented quickly.

The disadvantage of this solution is that measuring the current on a servo motor can be seen as erratic, this is due to the way a servo motor moves. As this is the case it may make it difficult for the plc to track the current from the motor and adjust the back tension accordingly.

3.1.4 Solution Two Hardware

3.1.4.1 Current Sensor

A current sensor is a piece of equipment that is used to measure current flowing through a cable to a device, for example a motors. These current sensors can work on both AC and DC voltages, the current sensor has the ability to generate an output voltage that is directly proportional to the current running through the cables. The output from the sensor can be either a 1 to 10V output or a 4 to 20mA output.

(Giovino, 2017)

(Knight, 2015)



Figure 3-5 - Current Sensor - uk.rs-online.com

(RS Components, 2017)

Again very good detail shown in how this solution could be implemented.

3.1.5 Solution Three (Hydraulic Pressure)

For the final solution this will consist of a hydraulic system that will be used to drive the compression arm, the drawing for this can be seen in figure 4.3.

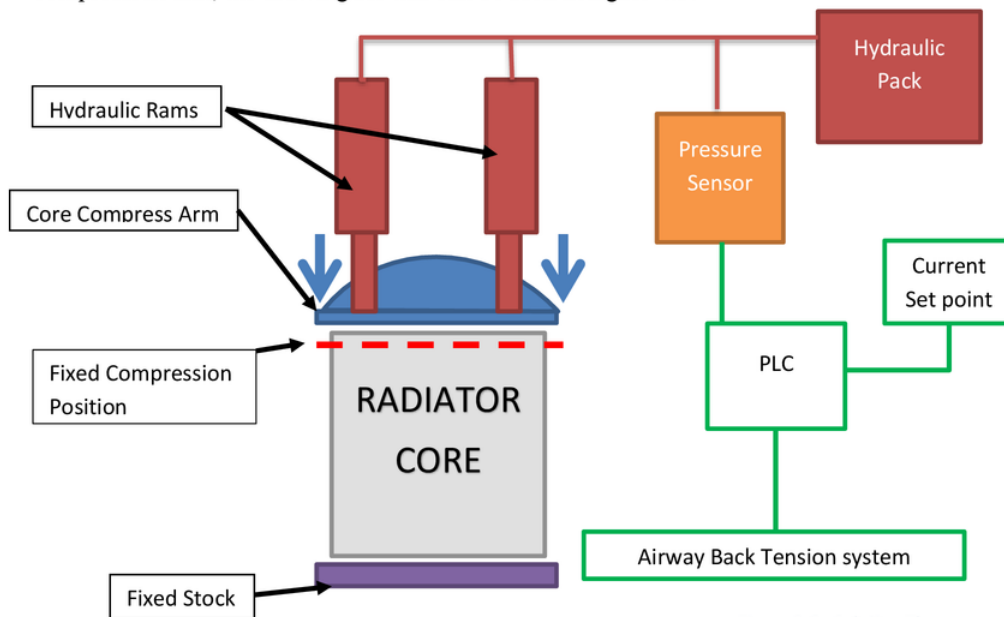


Figure 3-6 - Solution Three

For this solution the current system of compression using a servo motor would have to be replaced with a hydraulic pack and cylinders. This means that the servo motor drive will also be removed and the control within the PLC can be programmed out.

The solution will work by using the hydraulic pack to generate hydraulic pressure to drive the cylinders to compress the core. To stop the compression at the correct position there will have to be stops added to the machine. During this there will be a pressure sensor used on the hydraulic line. This sensor will then feedback to the PLC a 1 to 10V analogue input, using this sensor the PLC will be able to tell if it took more or less load to compress the core to the fixed compression point. Therefore if the hydraulic pressure is higher than the airway height will be high as it takes more load to compress it to the fixed point. And if the pressure is lower than the set-point, then the airway height is low. The PLC will use this information to adjust the back tension on the airway machine.

The advantages of using this solution is that it will be the easiest to implement, this is because it will not contain complex programming as the sensor will contain all of the conditioning.

The disadvantage of this solution is that it will require the current machine to be fully redesigned to fit the hydraulic pack and cylinders. This means that the solution will take a long time to implement and will cost the more that the other two solutions.

3.1.6 Solution Three Hardware

3.1.6.1 Hydraulic Pressure Sensor

A pressure sensor is used to measure pressures on a systems gas or liquid. It can measure the pressure as this is an expression of force applied to it. A pressure sensor works as a transducer that generates a signal *proportional to pressure* as the pressure is changed on it.

(Rees, 2017)

Figure 3-7 - Pressure Sensor - burkhart-engineering.com



(SMG, 2017)

These are used for control and monitoring systems, there are many different designs and technologies used in pressure sensors. Listed below are different methods of measuring pressures.

- Absolute pressure sensor – this is a sensor that measures a pressure that is relative to a perfect vacuum.
- Gauge Pressure Sensor – this sensor works by measuring pressure relative to the atmospheric pressure. For example a tire pressure sensor works using this principle.
- Vacuum Pressure Sensor – this sensor is used to measure pressures caused by vacuums
- Differential Pressure Sensor – this sensor is used to measure the difference between two different pressures.
- Sealed Pressure Sensor – this sensor works in the same way as the gauge pressure, the difference is that it compares the pressure to a fixed pressure.

(Jain, 2017)

Very good detail again

3.2 Solution Costings

3.2.1 Solution One (Load Cell)

Solution One (Load Cell)			
Item	Part number	Supplier	Cost (£)
FAST ANALOGUE 4 CUR VOLT IN/2 CUR OUT	1756-IF4FXOF2F	Allen-Bradley	£1,450.00
ControLogix 5580 Controller 10MB	1756-L83E	Allen-Bradley	£7,430.00
LOGIX POWER SUPPLY 85-265VAC 5V at 10a	1756-PA72	Allen-Bradley	£564.00
LOGIX 4 SLOT CHASSIS	1756-A4	Allen-Bradley	£205.00
Low Profile Load Cell Ranges up to 50kN	100 Series	Load Cell Shop	£409.85
RS Pro 4 Core Industrial Cable 0.22 mm ² CSA	660-0435	RS Components	£23.25
New Compression Arm	-	Toolroom	£1,750.00
Total			£11,832.10

Figure 3-8 - Solution One Costs

3.2.2 Solution Two (Current Feedback)

Solution Two (Current Feedback)			
Item	Part number	Supplier	Cost (£)
FAST ANALOGUE 4 CUR VOLT IN/2 CUR OUT	1756-IF4FXOF2F	Allen-Bradley	£1,450.00
ControLogix 5580 Controller 10MB	1756-L83E	Allen-Bradley	£7,430.00
LOGIX POWER SUPPLY 85-265VAC 5V at 10a	1756-PA72	Allen-Bradley	£564.00
LOGIX 4 SLOT CHASSIS	1756-A4	Allen-Bradley	£205.00
1394 AC SERVO CONTROLLER AXIS MODULE 3KW	1394-AM04 74102-665-53	Allen-Bradley	£602.57
RS Pro 4 Core Industrial Cable 0.22 mm ² CSA	660-0435	RS Components	£23.25
Total			£10,274.82

Figure 3-9 - Solution Two Costs

3.2.3 Solution Three (Hydraulic)

Solution Two (Current Feedback)			
Item	Part number	Supplier	Cost (£)
FAST ANALOGUE 4 CUR VOLT IN/2 CUR OUT	1756-IF4FXOF2F	Allen-Bradley	£1,450.00
ControLogix 5580 Controller 10MB	1756-L83E	Allen-Bradley	£7,430.00
LOGIX POWER SUPPLY 85-265VAC 5V at 10a	1756-PA72	Allen-Bradley	£564.00
LOGIX 4 SLOT CHASSIS	1756-A4	Allen-Bradley	£205.00
RS Pro 4 Core Industrial Cable 0.22 mm ² CSA	660-0435	RS Components	£23.25
Double Acting Cylinder 50mm Bore Rams	HP-DAP5030150	Hydra Part	£70.98
Double Acting Cylinder 50mm Bore Rams	HP-DAP5030150	Hydra Part	£70.98
HPU 210Bar @ 2L/Min 20ltr Tank C/W Pressure & Return Filter	ZZ00001199	Phoenix	£960.00
Steel Tube Hydraulic 12m x 2mm x 28mm	363913	Pipestock	£442.90
Directional Spool Valve Bosch Rexroth, R900052392, CK, 24V dc	386-8088	RS Components	£392.29
Directional Spool Valve Bosch Rexroth, R900052392, CK, 24V dc	386-8089	RS Components	£393.29
Parker Hydraulic Pressure Sensor PTDVB2501B1C2, M12, 0 → 5V dc, 0bar to 250bar	561-057	RS Components	£199.90
Total			£12,202.59

Figure 3-10 - Solution Three Costs

Good costing exercise carried out for the 3 solutions and used in the choice comparison matrix.

3.3 Solution Comparison

For this section of the project all three solutions will have to be compared to see which one will be the most viable option. These solutions will be compared using different areas. To compare the solutions a scoring sheet has been generate (figure 3.8).

Scoring Sheet for solutions						
Criteria	Solutions					
	Load Cell (1)	Current Feedback (2)	Hydraulic (3)			
Cost (For parts required for solution)	3	5	1		Key:	
Parts Availability (Currently used on site)	5	5	1		POOR	0
Parts Availability (Having to purchase new parts)	5	5	3		FAIR	1
Installation time (including down time of machine)	5	3	1		GOOD	3
Man power (required for installation)	5	5	3		EXCELLENT	5
Least Impact to production	3	1	1			
Reliability (data sourced from other machine)	5	1	3			
Total Score	31	25	13			

Figure 3-11 - Solution Comparison table

3.3.1 Costs

All the costs for the three solutions have been calculated and can be found in section 3.2 solution Costings.

As can be seen in the table the solution with the lowest cost is solution 2 (current feedback). The reason that it is the cheapest solution is that it requires the least amount of new parts for the machine, in most cases the current parts can be used on the machine. The second cheapest solution is solution 1 and the most expensive will be solution 3. This is the most expensive as it requires the machine to be fully rebuilt.

3.3.2 Parts availability

For this section both solution 1 and 2 scores the full 5 marks as both use parts that are currently used on other machines and therefore are available in the stores, this means that there will be no need to order extra parts to go in the stores as that are already in there.

The third solution has scores the lowest as it requires the company to order new parts that are currently not stocked in the stores. This will increase the cost of installation.

3.3.3 Installation time

As can be seen the solution one has been scored the highest as this will take the least amount of time to install the solution compared to the others. The reason for this is that the only part to be swapped is the compression arm, as this is the only part that contains the affected parts.

The second solution scores in second place as it will take longer to make the changes to the machine, as it will not be a simple swap. The third solution scores the lowest as it will require the machine to be fully redesigned and that will take a very long time to install.

3.3.4 Man Power

For this section solution 1 and 2 has the lowest man power (highest score) required to install both solutions. The solutions only requires at most two people to install them. The third solution will require at least four people as it requires a full overhaul of the machine to install the new parts.

3.3.5 Least impact to production

For this section of the comparison all three solutions didn't score highly as they all will have an effect on production, as the machine will have to be stopped to install the solution and this will temporarily will reduce the productivity of this machine. As solution 1 and 2 have the lowest installation time so will have a lesser impact on the productivity when compared to the solution 3 that has a longer installation time so will affect the production more.

3.3.6 Reliability

For this the reliability data has been gathered from machines that are currently using the three solutions being suggested. As can be seen solution 1 has the best reliability as it is used on many machines and there are very little to no issues with the system on the other machines, this means it is very reliable. Solution 3 scores second on this, as it is a reasonably reliable system on other machines. The second solution scored lowly on this as it has proven to be a difficult system to implement on certain machines.

3.3.7 Chosen solution

Using the scoring system that can be seen in the table we can see that the most suitable solution for this issue is the solution 1 (Load Cell). The reason this was the case was that it proved to be the most suitable for each criteria. The only two areas that it did not score the highest on was cost, if we take all of the areas into account though then we can see that having a higher cost can be tolerated if the reliability and implementation is much better.

Good, detailed comparison made.

4. Specification

For this project to be deemed as a success it must satisfy all of the criteria asked for in the specification

4.1 Technical Specification

The chosen solution (Load cells) must be able to control the amount of load the compression arm is applying to the core, this must be done to maintain a fixed load.

The new solution must take in two analogue inputs and use a proportional integral derivative (PID) instruction to maintain a good load on the compression arm.

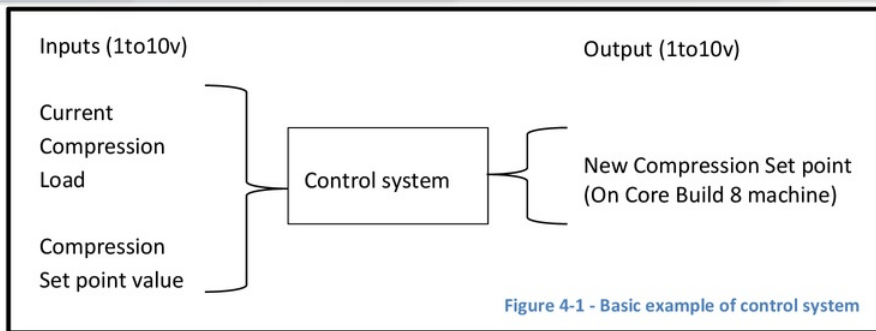
The first analogue input will be from a compression load cell (this will be located in the compression arm on the machine). The second input to the PID will be the set-point for the compression load. The inputs will have to be a 1 to 10v signal. The input signals will have to be measured during the testing to ensure that it is functioning correctly.

The input from the core compress must be in a 1 to 10V format, the method of getting this voltage will be decided by the chosen solution. This input will have to be tested on the machine to ensure that it is functioning correctly.

The PID system will be created on an Allen Bradley control logix PLC, the reason for this is that this PLC is already installed on the machine. The AB Control logix has a function used to create PID control functions, this can be used for the solutions. The PID control will have to be able to take an analogue input and compare it to a set-point that can be adjusted according the needed compression load. The programme will have to be tested before it is fitted to the machine to ensure it is functioning correctly.

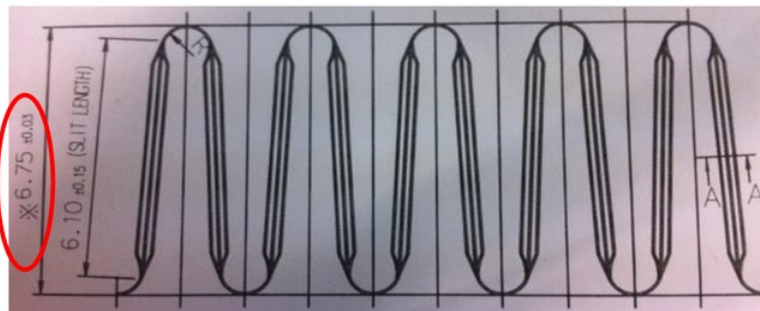
There is also an option to create the control system using LabVIEW and a National Instruments MyRIO board. This can be done to make the system more of a 'Plug and Play' system that can be used on multiple machines. Both the PLC and LabVIEW methods will be carried forward and will be tested against each other to see which one is the best to use.

Options should be in literature review, not in the specification!



The system must be powered using a 240V supply, this is to ensure that it can be implemented anywhere on the site.

Figure 4-2 - airway Specification



The set point for the airway height will have to be set at 6.75mm, as this is the airway height stated on the specification for the CB8 airway, see figure 3.2 below

4.2 Testing Procedure

For this section of the specification the testing procedure will have to be laid out, this will include the criteria that the system must achieve for it to be classed as a success.

4.2.1 Safety

Before any testing can be started all appropriate Health and safety must be followed, this includes the correct PPE. The work must be performed in a safe manner, see Health and Safety statement at www.calsonickansei.co.jp/en/csr/social/employee/health-and-safety.

4.2.2 Test Spec Specification

The following table shows what testing will have to be completed for all three test phases and also the criteria that must be met at each phase for the testing to continue to the next step.

	Test to be Performed	Expected outcome	Outcome from test	Satisfactory (Y/N)	If not, Reason for?	Solution
Phase One	Test Load Cell on Bench	See if it reacts to varying load and outputs 1 to 10V				
	Test PLC program on bench	see if the PID control reacts to 1 to 10V input, to see if it outputs 1 to 10V				
	Test NI program on bench	see if the PID control reacts to the 1 to 10V input, to see if it outputs 1 to 10V				
	test the PLC program on the bench with the Load cell	see if it works (outputs 1 to 10V) to the Analogue input on the drive				
	test the NI program on the bench with the Load cell	see if it works (outputs 1 to 10V) to the Analogue input on the drive				
Phase Two	test the PLC program on the machine with the Load cell	see if it works (outputs 1 to 10V) on lower priority machine and attached to the compression drive				
	test the NI program on the Machine with the Load cell	see if it works (outputs 1 to 10V) attached to the compression drive				
Phase Three	test the PLC program on the CB8 with the Load cell to <i>What?</i>	see if it works (outputs 1 to 10V) attached to the compression drive. This will have to be a test at full run up rate				
	test the NI program on the CB8 with the Load cell to <i>What?</i>	see if it works (outputs 1 to 10V) attached to the compression drive. This will have to be a test at full run up rate				

Figure 4-3 - Testing Table

Some of this table is not complete and grammatically incorrect!

5. Timing

For this project to be successful it must be fully completed by April 2018. There will have to be an action plan created for the project. This action plan can be seen below.

5.1 Planning structure

For the planning structure all the steps for the project will have to be identified so that the goals can be accomplished. These will then be entered into fields and the steps will have to be broken down into smaller more manageable timed and allocated tasks

The planning structure will be made up of the following titles:

- **Action Step** – what will have to be done (detail tasks)?
- **Responsible person** – who is in charge of the task to see it is completed?
 - J.Stallard – project author (student).
 - A.Williams – Project supervisor.
 - Tool room
 - Management
- **Dead Line** – date the task must be completed by.
- **Resources needed to complete step** – what do you need to complete the step people/money/tools etc?
- **Potential barrier issue** – what could get in the way of completing the step?
- **Action to resolve barrier issue** – what action can be taken to resolve the barrier that has occurred?
- **Success Criteria** – has the step been completed yes or no?

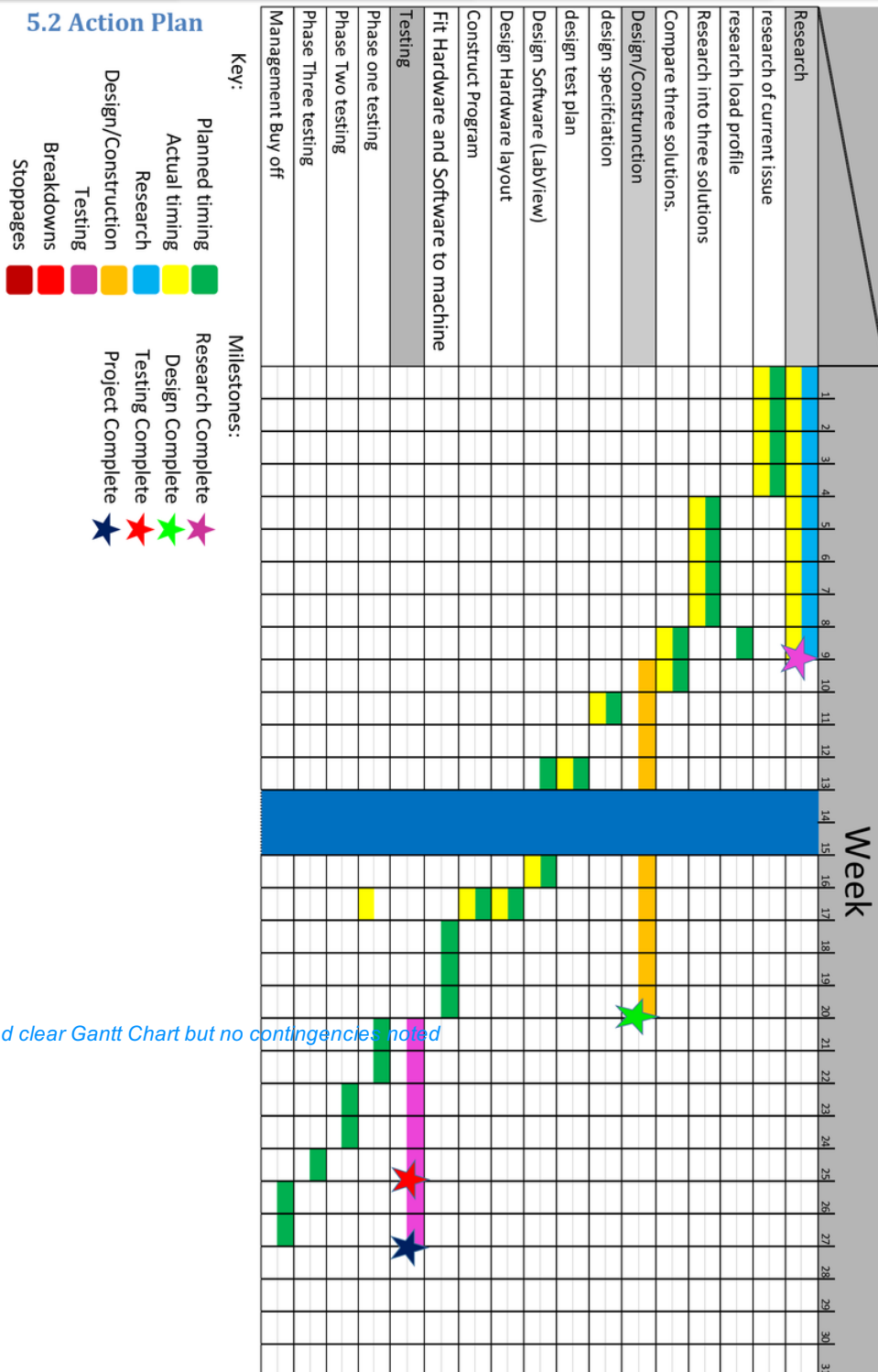
The planning structure has been drawn up for the project, this includes all of the steps that are required for this project to ensure it is completed successfully on time and within budget.

This can be seen on the next page, from this an action plan has been generated in the form of a gantt chart to give a more visual representation of the timings. To simplify the identified tasks both charts use the same colour keys

Action Plan					
Action Steps	Responsible person	Dead Line	Resources needed to complete step	Potential Barrier Issue	Action to resolve barrier issue
Research current issues	J. Stallard	15/10/2017	.Access to Corebuild 8 (1-2 hours) to assess issue .Look at current Scrappage costs (due to issue)	Lack of time to stop machine due to production demands	Reschedule to look at machine at different time
Research Load Profile	J. Stallard	19/11/2017	.Access to Corebuild 8 (1-2 hours) .Laptop to record data.	Lack of time to stop machine due to production demands	Reschedule to look at machine at different time
Research Solution 1	J. Stallard	22/10/2017	.Access to the internet for research and costings .Access to work literature	Lack of time to perform research due to other work responsibilities/unforeseen emergencies	Reschedule to perform research at a different time
Research solution 2	J. Stallard	29/10/2017	.Access to the internet for research and costings .Access to work literature	Lack of time to perform research due to other work responsibilities/unforeseen emergencies	Reschedule to perform research at a different time
Research solution 3	J. Stallard	12/11/2017	.Access to the internet for research and costings .Access to work literature	Lack of time to perform research due to other work responsibilities/unforeseen emergencies	Reschedule to perform research at a different time
Compare and Choose Solution	J. Stallard	26/11/2017	.Costings for all three solutions and information gathered during the research, draw up scoring matrix, evaluation sheet	Lack of time to perform comparison due to work responsibilities	Reschedule to perform comparison at a different time
Create Specification	J. Stallard/A. Williams	03/12/2017	.Meeting with Engineer for projects to draw up detailed specification .Inclusion of data from chosen solution	failure to arrange meeting with Engineer within this time frame	Reschedule meeting for different time
Create project plan	J. Stallard/A. Williams	17/12/2017	.Draw up detailed action plan will have to be completed	Action plan has not been completed	This will have to be completed early in the project as it is high priority
Design Software	J. Stallard	07/01/2018	.Access to LabVIEW software (purchased) .Access to a NI MyRIO (purchased)	.No time to design the software .No access to the MyRIO	Continue on to design the hardware layout - extend time for designing
Design hardware layout	J. Stallard	14/01/2018	.Access to CAD design software, both mechanical and Electrical	No access to the needed software	extend time for designing
Construct Program	J. Stallard	14/01/2018	.Access to LabVIEW software (purchased) .Access to a NI MyRIO (purchased)	.Time to design the software .Access to the MyRIO due to lead times	Continue on to have the new parts created - extend time for construction
New parts to be made	Tool room	14/01/2018	.Access to a member of the Tool room to create new parts for machine	No access to tool room due to higher priority work coming in	Reschedule for work to be done when the tool room is not booked
Fit hardware and software	J. Stallard (Electrical Fitter) /Mechanical Fitter	04/02/2018	.Software will have to be constructed .Hardware Layout will have to be Designed .New parts will have to be completed by Tool room	delay due to software, Hardware and or new parts have not been completed	The fitter will have to be delayed until all resources are available
Phase one testing	J. Stallard	18/02/2018	.Appropriate tools and equipment .The solution will have to be fitted to the machine .Access to a laptop to record the data	delay due to software, Hardware and or new parts have not been completed	The testing will have to be delayed until all resources are available
Phase Two testing	J. Stallard	04/03/2018	.Phase one testing must have been completed .Access to a laptop to record the data	Phase one testing has not been completed	The testing will have to be delayed until phase one testing is complete
Phase Three testing	J. Stallard	11/03/2018	.Phase two testing must have been completed .Access to a laptop to record the data	Phase two testing has not been completed	The testing will have to be delayed until phase two testing is complete
Management sign off	Management	19/03/2018	.Phase three testing must have been completed .the conclusion and evaluation from this report	.Issues highlighted by management .Management rejects sign off	More testing will be required to prove for sign off or other data required for more informed decision

Figure 5-1 - Planning Structure

Figure 5-2 - Action Plan / Gantt Chart



6. Budget

For the project I have quoted that I need a budget of £15000, I have given this as a rough budget because the most expensive resolution will cost £12000. This money will only be released if I can justify it using the results from the testing, conclusion and evaluation of this report. This will be used to implement the proposal. This budget will be for purchasing parts and for the project and also having parts bespoke for this project. There is no need for training costs for the operators as this system will work without any input from them. Also there is no need for extra training for any members of maintenance as this project will be completed on a PLC that is will used on plant. The plan is that this project will self-financing and cost neutral within a year on the machine as it should reduce the overall cost of scrappage. *Try not to use the first person...*

- £2000 – will be assigned for any bespoke parts that may have to be made for the project
- £11,000 – will be for purchasing all of the hardware needed for the project.
- £1000 - this will be for stocking the stores with spares parts of the project that are not current stock items (this will include bespoke parts)
- £1000 – for any unforeseen cost that may occur during the project

The total budget costs will be reviewed later in the project but to complete the justification, I have been given a budget of £600. This will be for purchase of materials and hardware that will be needed for the testing.

Good general detail

7. Testing and Results

Now that the solution has been chosen the next step is to perform tests on this. This must be done to ensure that the system is working correctly. The testing will be done as shown the testing table. This has to be done so that the project can be signed off.

7.1 Hardware Testing

The first testing to be done is the hardware testing, this has to be done to check that the hardware used in the solution is working correctly and as expected. The load cell will be tested by setting up a Voltmeter to read the 1 to 10V output.

7.1.1 Load Cell

For this testing the load cell can be tested on the bench so there is no need to fit it to the machine at this time. The load cell has been supplied with a 24V supply from a power supply. The output from the signal conditioner has then been connected to a multi-meter, this will be used to measure the 1 to 10V output signal as the load is varied.

The load on the load cell will be applied using a compression jig. The load will be applied manually and the output voltage from the load cell will have to be measured. The results from this will be placed in a graph.

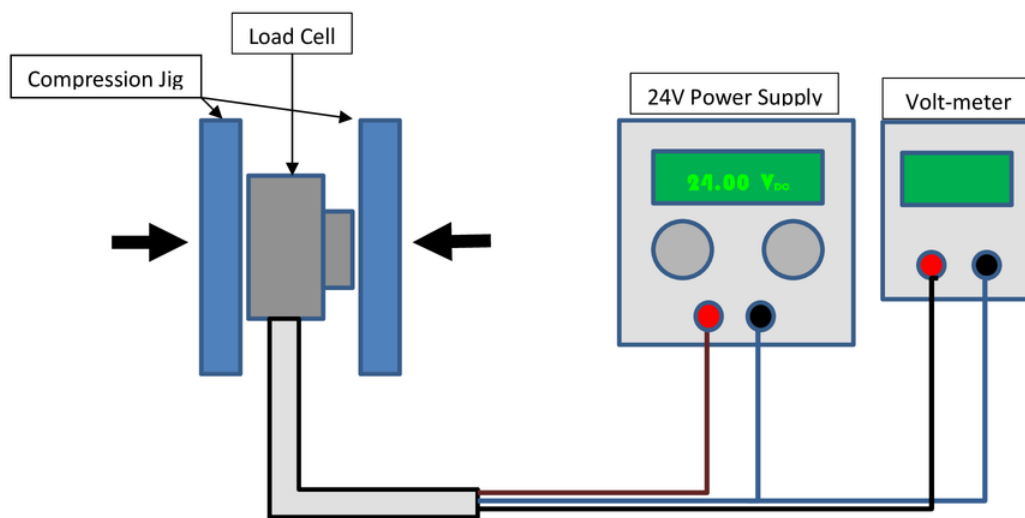


Figure 7-1 - Hardware Testing

Now the testing has been completed the results from this will now be entered into a graph to make the results more visible. The graph can be seen below in figure 7.2

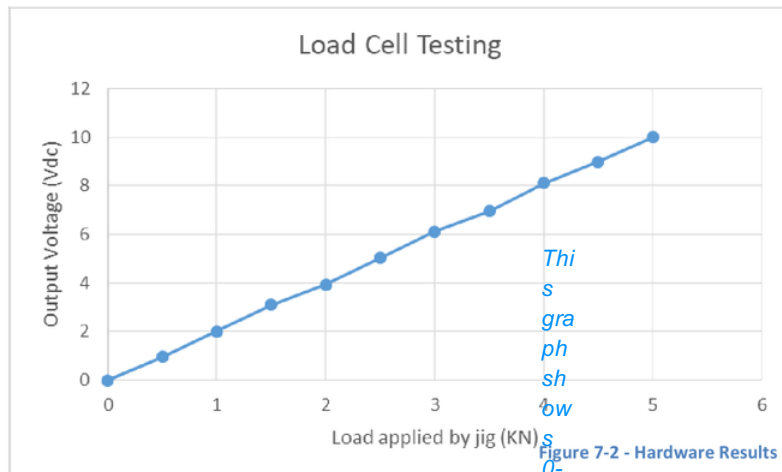


Figure 7-2 - Hardware Results

If we look at the graph above (figure 7.2), we can see that the load cell output is roughly linearly proportional to the load being applied to it, there are slight differences but this might be due to rounding errors and the accuracy of the equipment. This proves that the load cell is working correctly.

Good clear test carried out with an acceptable set of results

7.2 Completed Testing Table

All of the testing will be entered into the testing table. The table can be seen in figure 7.3.

	Test to be Performed	Expected outcome	Outcome from test	Satisfactory (Y/N)	If not, Reason for?	Solution
Phase One	Test Load Cell on Bench	See if it reacts to varying load and outputs 1 to 10V	the Load cell outputs a linear output depending on the load applied	Yes	N/A	N/A
	Test PLC program on bench	see if the PID control reacts to 1 to 10V input, to see if it outputs 1 to 10V				
	Test NI program on bench	see if the PID control reacts to the 1 to 10V input, to see if it outputs 1 to 10V				
	test the PLC program on the bench with the Load cell	see if it works (outputs 1 to 10V) to the Analogue input on the drive				
	test the NI program on the bench with the Load cell	see if it works (outputs 1 to 10V) to the Analogue input on the drive				
Phase Two	test the PLC program on the machine with the Load cell	see if it works (outputs 1 to 10V) on lower priority machine and attached to the compression drive	Upgrade this test table please....			
	test the NI program on the Machine with the Load cell	see if it works (outputs 1 to 10V) attached to the compression drive				
Phase Three	test the PLC program on the CB8 with the Load cell to	see if it works (outputs 1 to 10V) attached to the compression drive. This will have to be a test at full run up rate				
	test the NI program on the CB8 with the Load cell to	see if it works (outputs 1 to 10V) attached to the compression drive. This will have to be a test at full run up rate				

Figure 7-3 - Completed Testing Table

8. Conclusion and Evaluation

In this interim report there has been work done into how to solve the issue of controlling the amount of load applied to the compression arm during the building sequence. To do this there has been research carried out into the current issue, this includes what the issue is and how much it cost the company in losses.

There was then research performed into different solutions that can be used to solve the issue. The research included how the solution would work, the hardware that will have to be used and the cost of each. For a solution to qualify for this report it had to be a viable option.

The three solutions were then compared to see which one would be the most suitable to solve the current issue. For the comparison there were many areas looked at, for example man power or cost. This was then entered into a scoring table, from this the solution one (load cells) was chosen and it had the highest score.

From the chosen solution a specification had to be created so that the solution can be tested against criteria, this has been made so the solution can be tested. Finally the timing plan and budget has been created for the project.

8.1 Recommendations

The next step for the project is to construct the solution, this will have to include the software programming and the hardware construction that will have to be done for all the testing phases.

For the testing there will be three phases that will have to be done in sequence. The first phase of testing will have to be done on the bench, this testing will have to start with testing the hardware to ensure it works as expected. For this the load cell and software will have to be tested to see if it outputs 1 to 10V. The two parts will then have to be tested together to ensure it is working on the bench to ensure they are working together. For the second phase of testing the hardware will have to be added to a lower priority machine so that fine tweaks can be made. Once this has been done the final phases of the testing will have to be done on Core-build 8, this will have to be done to tune the system to work with this machine. From the testing the project will be evaluated to see if it can be implemented.

Good, clear conclusion which does include some reflection on how the project has gone to date, and what is left to do.

9. Approval Signatures

	Student	Industrial Supervisor	College Supervisor
Name			
Signature			
Date			

10. Reference List

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James Stallard - Interim Report

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

56/100

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

Text Comment. specification

Text Comment. Introduction to the existing problem seems a bit muddled in terms of airway height control.

PAGE 6

Text Comment. The

Text Comment. Very clear

PAGE 7

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Text Comment. Good clear reasoning as to why the project needs to have a closed loop control system with the airway height. Grammar needs a lot of adjustment...

PAGE 8

Text Comment. Specification?

PAGE 9

Text Comment. General specification given at this point.

PAGE 10

PAGE 11

PAGE 12

PAGE 13

Text Comment. Good detail shown which has been well researched.

PAGE 14

PAGE 15

Text Comment. Again very good detail shown in how this solution could be implemented.

PAGE 16

PAGE 17

Text Comment. proportional to pressure

Text Comment. Very good detail again

PAGE 18

Text Comment. Good costing exercise carried out for the 3 solutions and used in the choice comparison matrix.

PAGE 19

PAGE 20

Text Comment. Good, detailed comparison made.

PAGE 21

Text Comment. Options should be in literature review, not in the specification!

PAGE 22

Text Comment. Summary please!

Text Comment. Specification

PAGE 23

Text Comment. What?

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Text Comment. Some of this table is not complete and grammatically incorrect!

PAGE 24

PAGE 25

Text Comment. Very detailed WBS

PAGE 26

Text Comment. Good clear Gantt Chart but no contingencies noted

PAGE 27

Text Comment. Try not to use the first person...

Text Comment. Good general detail

PAGE 28

PAGE 29

Text Comment. This graph shows 0-10V and NOT 1-10V.

Text Comment. Good clear test carried out with an acceptable set of results

PAGE 30

Text Comment. Upgrade this test table please....

PAGE 31

Text Comment. Good, clear conclusion which does include some reflection on how the project has gone to date, and what is left to do.

PAGE 32

PAGE 33

Text Comment. Good, varied list of references cited

RESEARCH-INFORMED LITERATURE



Introduction (3/5): A helpful introduction, however, the aims and objectives of the project are inconsistent with those stated later in the report. Background Research (2/4): Generally good. Harvard Referencing (2/4): A good range of sources cited correctly but not listed exactly according to Harvard. Literature Review (5/7): Good levels of research evidenced with detailed comparisons made for the 3 choices noted.

12

KNOWLEDGE AND UNDERSTANDING



WBS (6/10): Good detail, presented in the form of a table instead of a flow diagram. Specification (5/10): Good but unclear about solution with plans that include testing to see which method is to be adopted after solution has already been stated. Contains an error in type of signal and also differs from introduction where tension control is mentioned but here is it compression pressure control. Gantt Chart (6/10): Good but no contingencies noted.

17

ANALYSIS



Analysis of test results (5/10): Some testing carried out with comments and a graph. Note that the signal is 0 to 10V not 1 to 10V. No information

11

given about how the jig load was set. Conclusions (6/10): Good, clear conclusion shown in the report which does include some reflection.

PRACTICAL APPLICATION AND DEP.



Progress to date (2/5): Some progress made reflected in Gantt chart. Presentation of test results (3/5): Good test procedure noted for the load cell with a graphical result noted.

5

SKILLS FOR PROFESSIONAL PRAC.



Recommendations (5/10): : Some reflection on how the project has gone to date and a clear indication of what is left to do. Report Quality (6/10): Well presented and structured. Further marks could have been achieved by spelling, grammar checking and less repetition.

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