Team 12.5

Crown Automated Assembly Cell

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Customer Background

Since 1960 Crown has been an industry leader in world-class forklift design and material handling. Up to 85 percent of lift truck components are designed and manufactured by Crown. When it says Crown on the outside, it's a Crown on the inside.

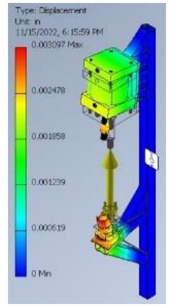
Problem Statement/ Scope of Work

Crown Equipment Corporation of Greencastle, Indiana needed an automated work cell capable of seating and crimping bearings into a steering column assembly. The need for this cell stemmed from the desire to reduce the possibility of a workplace injury that previous process presented. As a result, this project focused on the design, build, and implementation of an automated solution.

Requirements

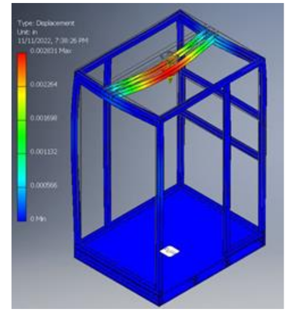
Req. #	DESIGN REQUIREMENTS	DESIGN TARGETS	VALIDATION
	RATIONAL		
1	Used UR10 cobot.	Yes/No	Is there a UR10 utilized in the cell? (Observation)
	It's provided by the client.		
2	The operator is only required to load and unload parts.	Yes/No	Is the operator only needed for load and unload? (Observation)
	The entire process should be automated besides load and unload.		
3	The press can apply 500lbs of force.	500lbs min	Measure the force the press can produce and observe that the part is located correctly per print.
	The press must supply the proper forces to seat and crimp the part correctly.		
4	The cell must be mobile.	Yes/No	Must be able to be lifted by a forklift in the air by 6 inches.
	This is a requirement from the client. The cell must be mobile to account for possible layout changes in the future.		
5	The work cell must have safety fencing in accordance with the ANSI/RIA R15.08-1-2020 Safety Requirements	Yes/No	Does the safety fencing comply with the safety standard? (Observation)
	This is required for RIA compliance and is a Crown standard.		
6	The cell is to continuously run if it is loaded with the correct parts.	Yes/No	Functionality Test-Ensure Robot runs with parts and stops when there are no parts.
	The client would like for the robot to never have down time.		
7	The robot cell needs to be easily accessed for maintenance.	Yes/No	When properly locked out, facility maintenance should be able to reach every serviceable component.
	It is common for robotic cells to need maintenance		
8	The cell needs to have the ability to be bolted to the floor.	Yes/No	Observation: Can the cell be bolted to the floor
	The robot cell should not be portable when it is running.		
9	All cell components must be plc controlled	Yes/No	Observation: Can you control and monitor all components with the robot's internal plc?
	This allows all the devices to communicate.		
10	The cell entrance must have a safety sensor	Yes/No	Testing functionality of all sensors. Observation: Can someone enter the cell when they are not supposed to?
	This will prevent people from entering the cell when the robot is running.		
11	There is no loss in quality of the parts	Each measurement is to print.	Testing: Each dimension of a new part will be measured and compared to the print to see if the part is conforming.
	Makes sure the new cell functions as well as the old cell		

Experimentation and Concepts



Bearing Press Frame Analysis

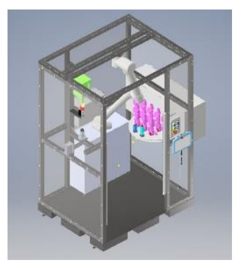
- Tested at a max force of 2800 lbs.
- Even distribution of force throughout press.
- Maximum displacement of 0.003 inches.



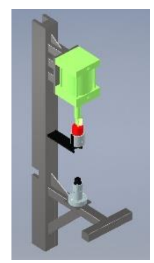
Robot Frame Support Analysis

- Force of 70 pounds for weight of robot and parts.
- Maximum displacement of 0.0028 inches.
- Verified to hold robot through physical testing.

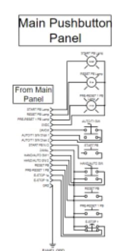
Final Design

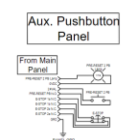


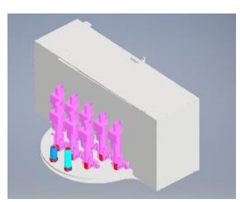
Full Assembly



Press Assembly

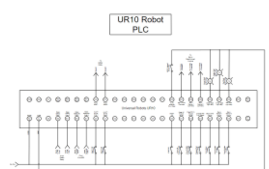






Turn Table Assembly

Final Product



FMEA

STRUCTURE ANALYSIS: Next Higher Level	Focus Element	Next Lower-Level	FUNCTION ANALYSIS: Next Higher-Level Function and Requirement	Focus Element Function and Requirement	Next Lower-Level Function and Requirement	FAILURE ANALYSIS: Failure Effects (FE) to the next Higher-Level Element	Severity (S) of FE	Failure Mode (FM) of the Focus Element	Failure Cause (FC) of the Next Lower Element	RISK ANALYSIS: Current Prevention Control (PC) of FC	Occurrence (O) of FC	Current Detection Controls (DC) of FC or FM	Detection (D) of FC/FM	DFMEA AP
Frame	Support Beams	Structural Integrity of support beams	Moves parts around the cell for automated assembly	Supports the UR10 Cobot during its operation	The strength of the beams.	The cell will not be able to run autonomously	10	The UR10 Cobot can not be suspended in the air for operation	Materials aren't strong enough	Simulations of the force analysis.	3	Test for deformation	1	L
Press	Press Frame	Structural Integrity of frame	Hold the piston and parts in place	Prevents deflection during operation.	Frames supports press during operation	Bearings aren't pressed properly	10	Bearings could no longer be pressed	Materials aren't strong enough	Simulations of the force analysis.	3	Test for deformation	3	L
Press	Pneumatic Piston	Not strong enough to seat bearings	Seat and crimp bearings	Turns the pneumatic force into a mechanical pressing force	Piston must be strong enough for operation	Bearings aren't pressed properly	10	The press is not strong enough to press in the bearings	Piston isn't powerful enough	Choosing largest available piston	1	Determine the force needed	3	L
Frame	Lifting Base	Structural integrity when lifted	Cell is lifted by a forklift at the base	Ensures the cell can be mobile	Base strong enough	The base could break	10	The floor would bend.	Base would not hold the weight	Design with parameters in mind	3	Simulate stress analysis	1	L
Frame	Press Mounting	Structural integrity of press mount	holds the press during operation	Ensures the robot can reach the same spot	Mounting does not change over time.	Does not hold press frame properly	10	Press would be misaligned	Mounts failed to hold press	Design with parameters in mind	3	Simulate stress analysis	1	L
Control System	E-Stop	E-Stop Button	Opens or closes contacts based on actuation	Switches internal contacts based on operator input	Must open internal contacts when button is pushed	The cell operates when button is pressed	10	The button fails to open the internal contacts	Button has failed internally	Choose quality manufacturer	2	Test Estop operation.	4	L

Testing

Step	Test	Details	Outcome
System Testing			
1	Bearing Press	Test to see if the press is capable of both pressing in bearings and crimping metal.	The press was able to press both bearings but was only capable of partially crimping the tube.
2	Turntable	Test to see if the servo can drive the turntable.	The servo could drive the turntable.
3	Electrical System	Test if electrical system can properly control the work cell.	We do not have all components due to supply issues, however all components currently work.
4	Frame	Hold all components in place properly and allow for robot to reach the same position.	The frame can hold all components in place with no issue.
Program Testing			
1	Bearing Picking	The robot was programmed to pick each of the two types of bearings from the turntable.	The robot was able to consistently grab bearings from the turntable, any issues could be solved by point touchup.
2	Tube picking	The robot was programmed to pick the tubes from the turntable.	The robot gripper did not have enough friction between the tube and rubber pads to hold the tube without slipping.
3	Bearing placement	The robot was programmed to place the bearings on both the lower die and tube.	The robot was able to place the bearing on the press tooling, however, the gripper design did not allow for placement of the upper bearing due to interference with the press.
4	Tube placement	The robot was programmed to place the tube onto the lower die.	The robot, if gipping the part, could place the tube on the lower bearing.