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Short Bar Removal

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NUCOR SHORT BAR REMOVAL PROJECT

SPONSOR: NUCOR

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GROUP MEMBERS: AUSTIN KASAP, RODRIGO MUNOZ, CONNOR MEDINA

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BACKGROUND

NUCOR
NUCOR STEEL KANKAKEE, INC.

This Project was brought to ONU by Nucor, a steel production company in Bourbonnais IL

- They produce rebar, angle, channel, flats, rounds, and square bars.
    - Steel bars ready for packaging roll down the production line, but some bars are shorter than the customer specification
    - Short bars removed by workers
    - The company values safety and would like to replace the unsafe labor process with a safer alternative

"Whipping" Process used On rebar

Shaft with lifting arms that discard the short bar

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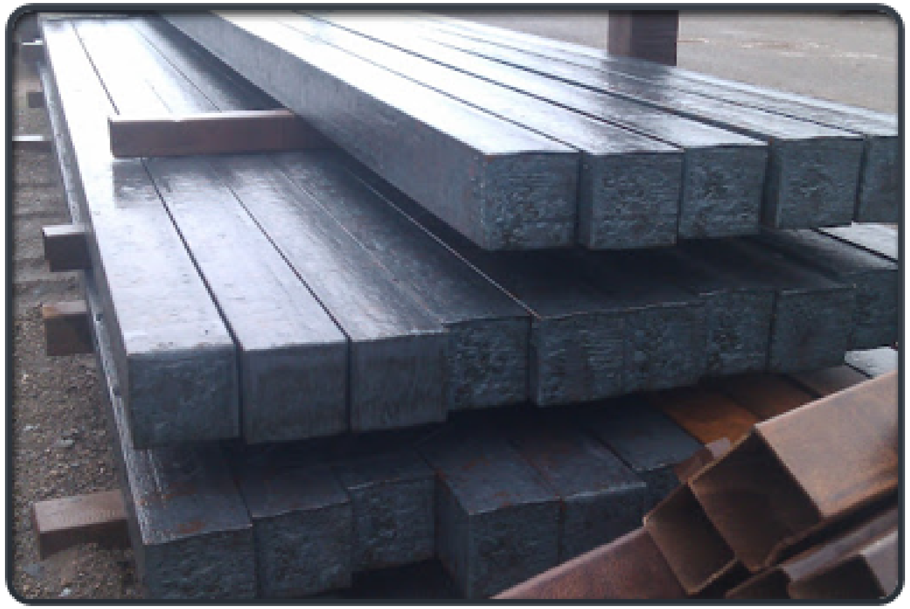
PROBLEM STATEMENT



- STEEL BILLETS ARE HEATED UP AND FORMED INTO VARIOUS STEEL BAR SHAPES

- WHEN THE BILLET RUNS OUT OF MATERIAL TAIL ENDS ARE CREATED WHICH RESULT IN SHORT BARS

- THE SHORT BARS RESULT IN A LOWERED PRODUCTION CAPACITY BECAUSE OF THE TIME IT TAKES TO REMOVE THE SHORT BARS

VIDEO OF "WHIPPING" PROCESS

REMOVING BAR TO DISCARD PILE

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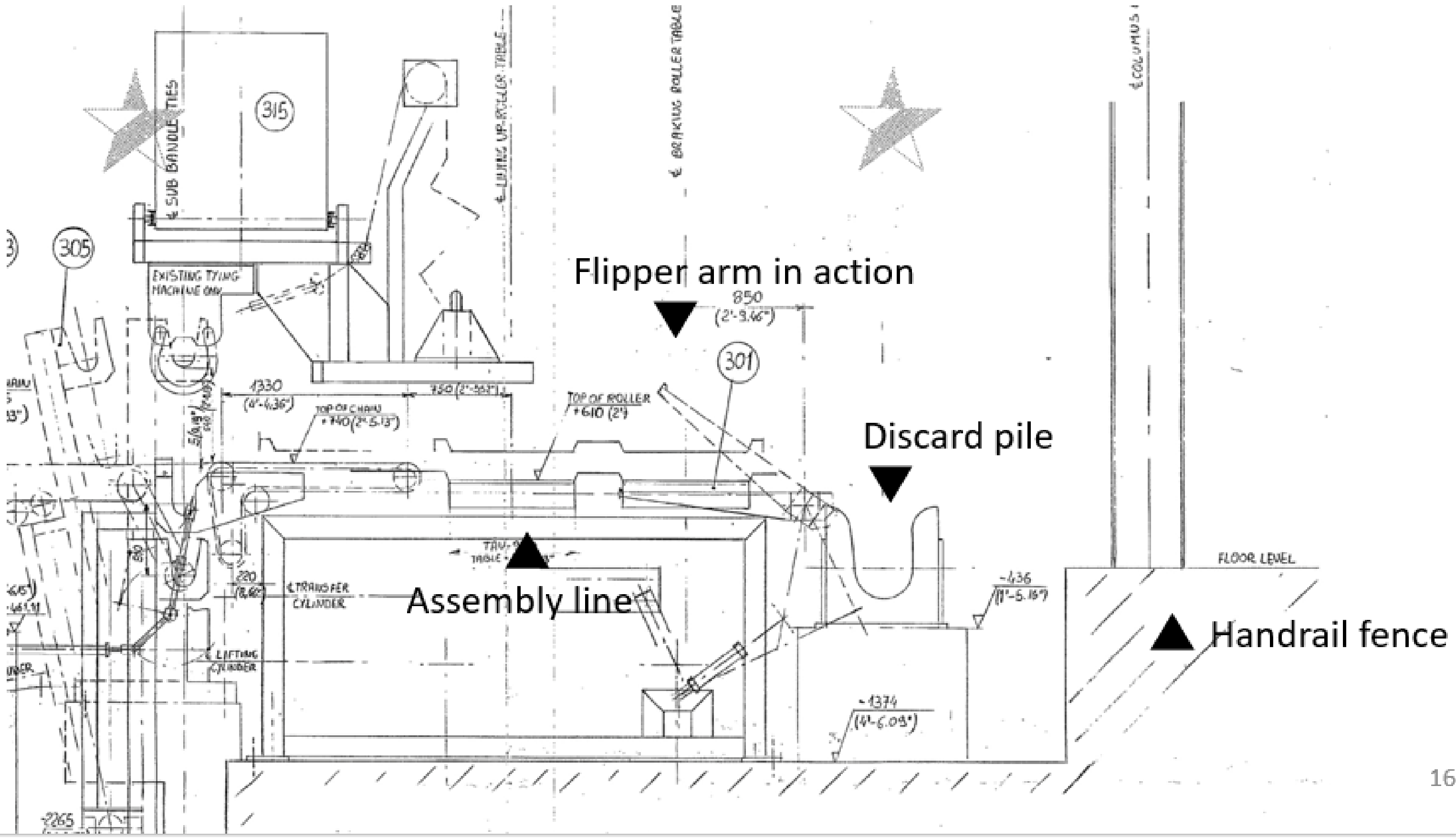
FLOOR PLAN

- Side view



DESIGN OBJECTIVES

- Improve the safety of the facility
- Our design must remove the bars in a timely manner
- Nucor would like if the process is fully automated, Manual is still a success
- The product should be very reliable with minimum maintenance required
- It should be easy to use with little training required

FUNCTIONAL REQUIREMENTS

- Must be able to remove steel bars of various lengths, shapes, weights, and sizes from the production line
- Must also remove the short bars safely into a discard pile with autonomy or using a manual process that is not labor-intensive
- Must Move out of the way of the overhead crane while not in operation.

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DESIGN CONSTRAINTS

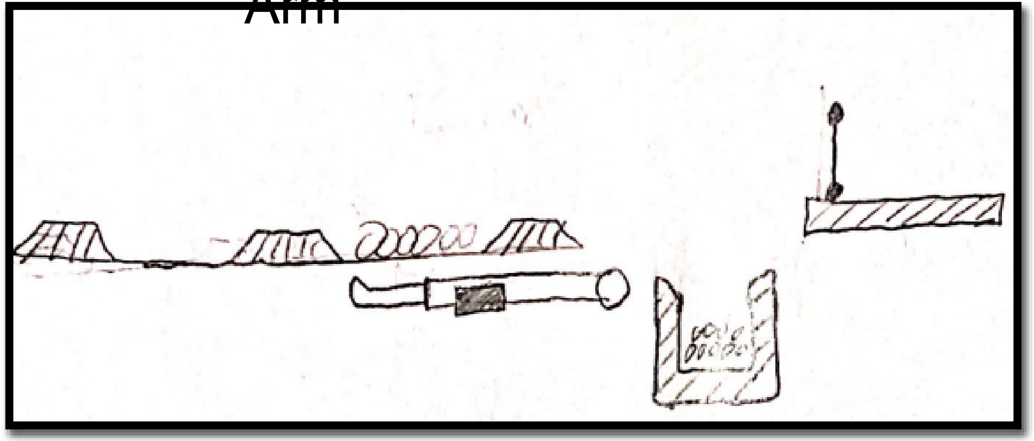
- Must be extremely compact due to limited space
- Design must be able to withstand temperatures as high as 900°F without deforming or deteriorating
- Must be able to remove bars that vary in length from 20' up to 60'
- Must be able to remove bars that vary in shape: angle iron, circular pipe, square pipe, channel, and rebar
- Must be able to remove bars ranging from 30lbs to 350lbs
- Cost must be less than $200,000 although a design less than $50,000 is preferred

DELIVERABLES

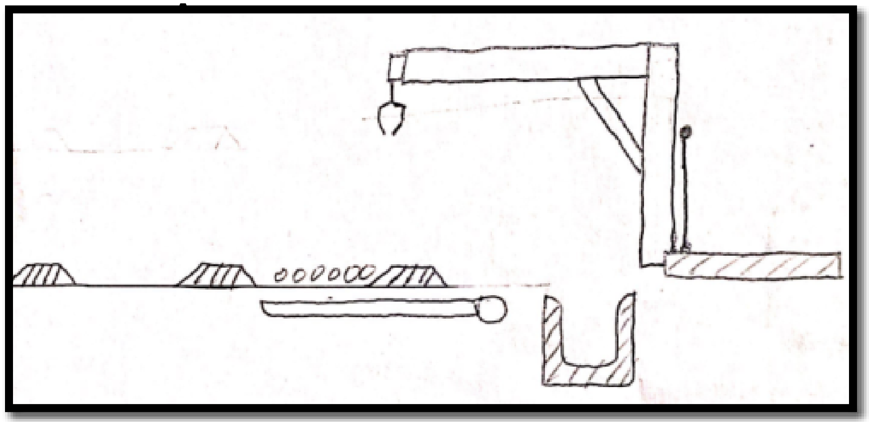
- Nucor is asking for a design concept that they can potentially use as a solution to this issue
- Deliverables include engineering models, bill of materials, machine instruction, and estimated cost
- Three-dimensional models and drawings of the design are highly desired

DESIGN ALTERNATIVES

Retractable Flipper Arm

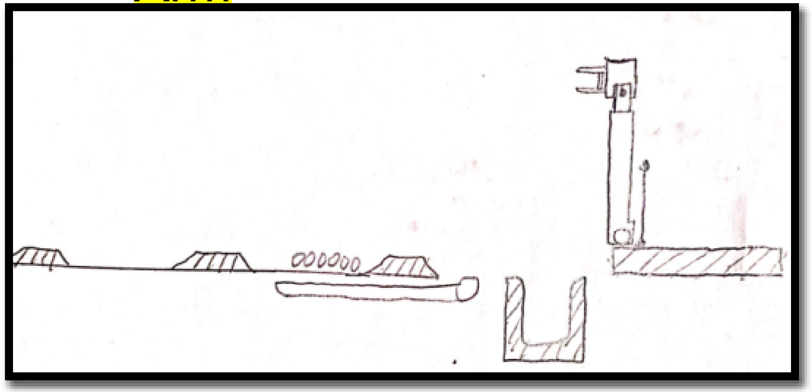


Collapsible Crane

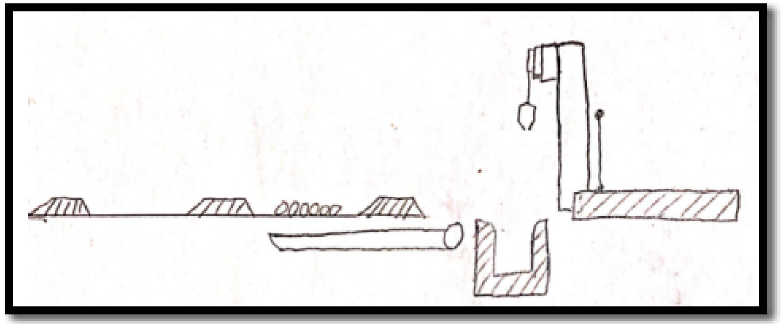


DESIGN ALTERNATIVES

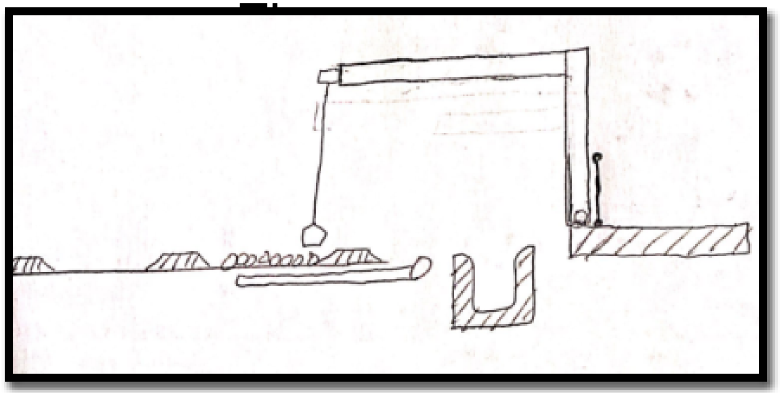
Overhead Rotating Arm



Retractable overhead crane



Crane



FEASIBILITY AND CHALLENGES

Challenges encountered:

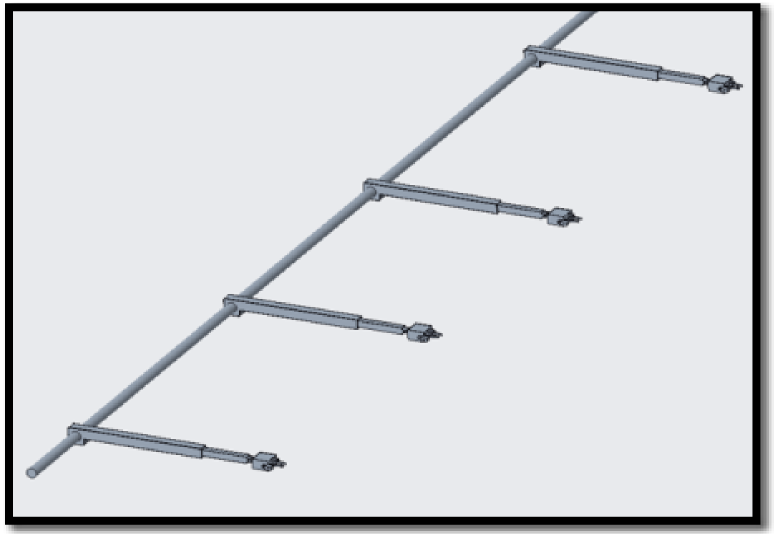
- Limited space to work with to implement our design
- Position of the short bar on the rolling assembly line
    - Changed design
- Variety of product rolling through assembly line
    - Can be problem for our grabbing mechanism

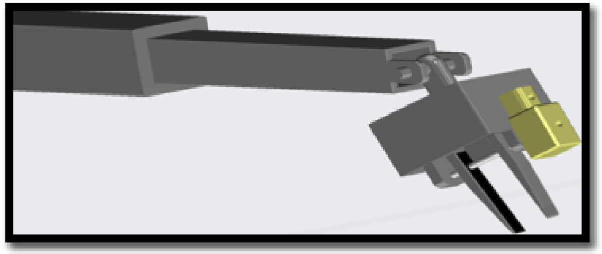
DESIGN SELECTION

	Collapsible Crane Arm	Crane Zipper	Overhead Rotating Arm	Retractable Flipper Arm	Retractable Overhead Crane
Feasibility	6	4	9	1	3
Functionality	8	7	8	8	6
Performance	7	6	8	8	8
Connections/ Interfaces	4	3	9	9	4
Safety	5	3	7	7	3
Manufacturing/ Logistics	6	4	6	6	5
Maintenance/ Support	7	4	7	7	6
Totals	43	31	54	46	35

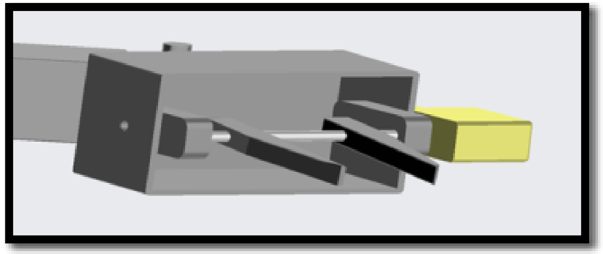
Fall Design Status

Old Design





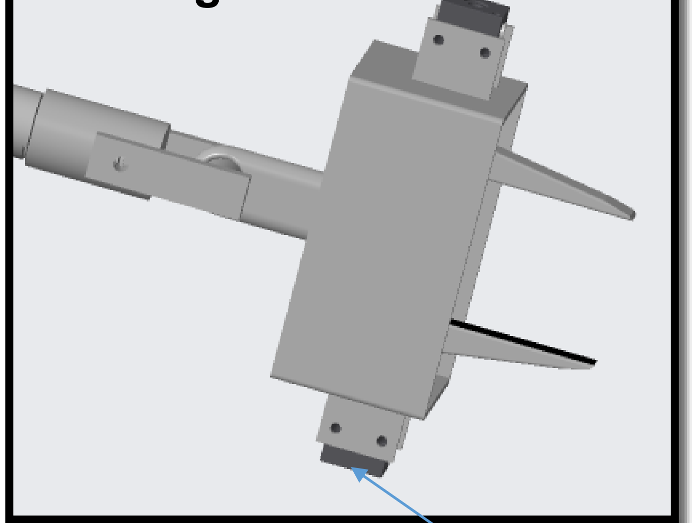
Old Grabbing
Mechanism
Utilizing Ball Screw



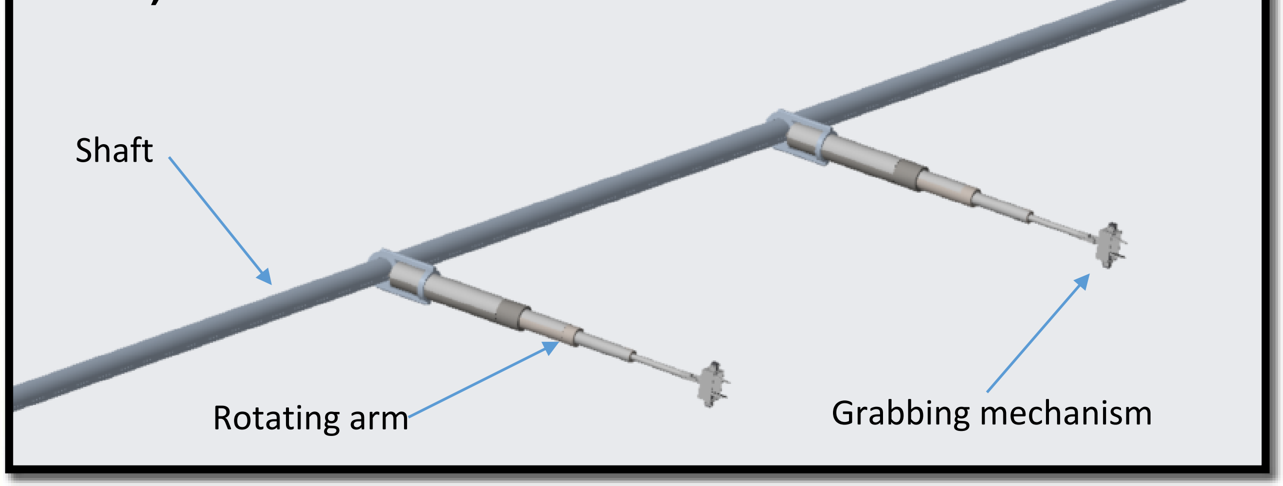
FINAL DESIGN

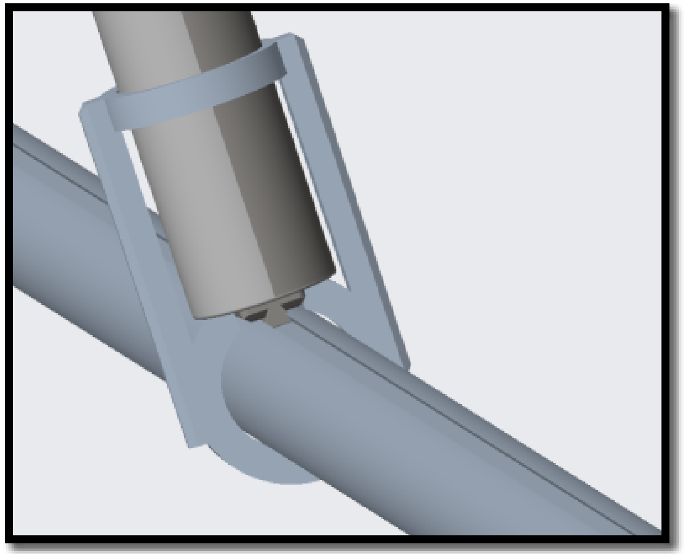
Re-designed the structure of the rotating arm from rectangular to circular

Grabbing Mechanism



20 ft apart configuration of rotating arms (for 60 ft bar)

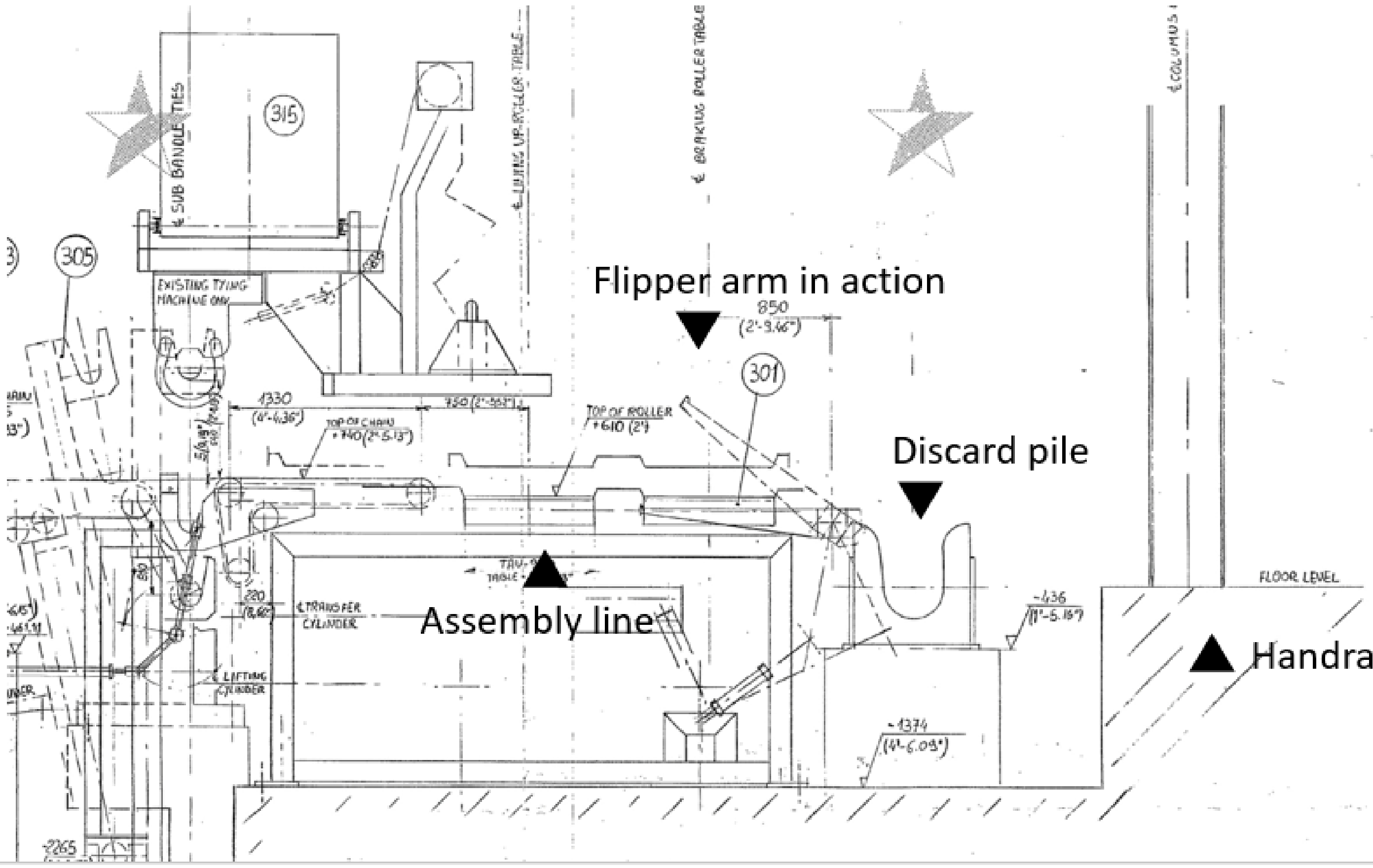




Rotating arm collar and pin set

FLOOR PLAN

- Side view



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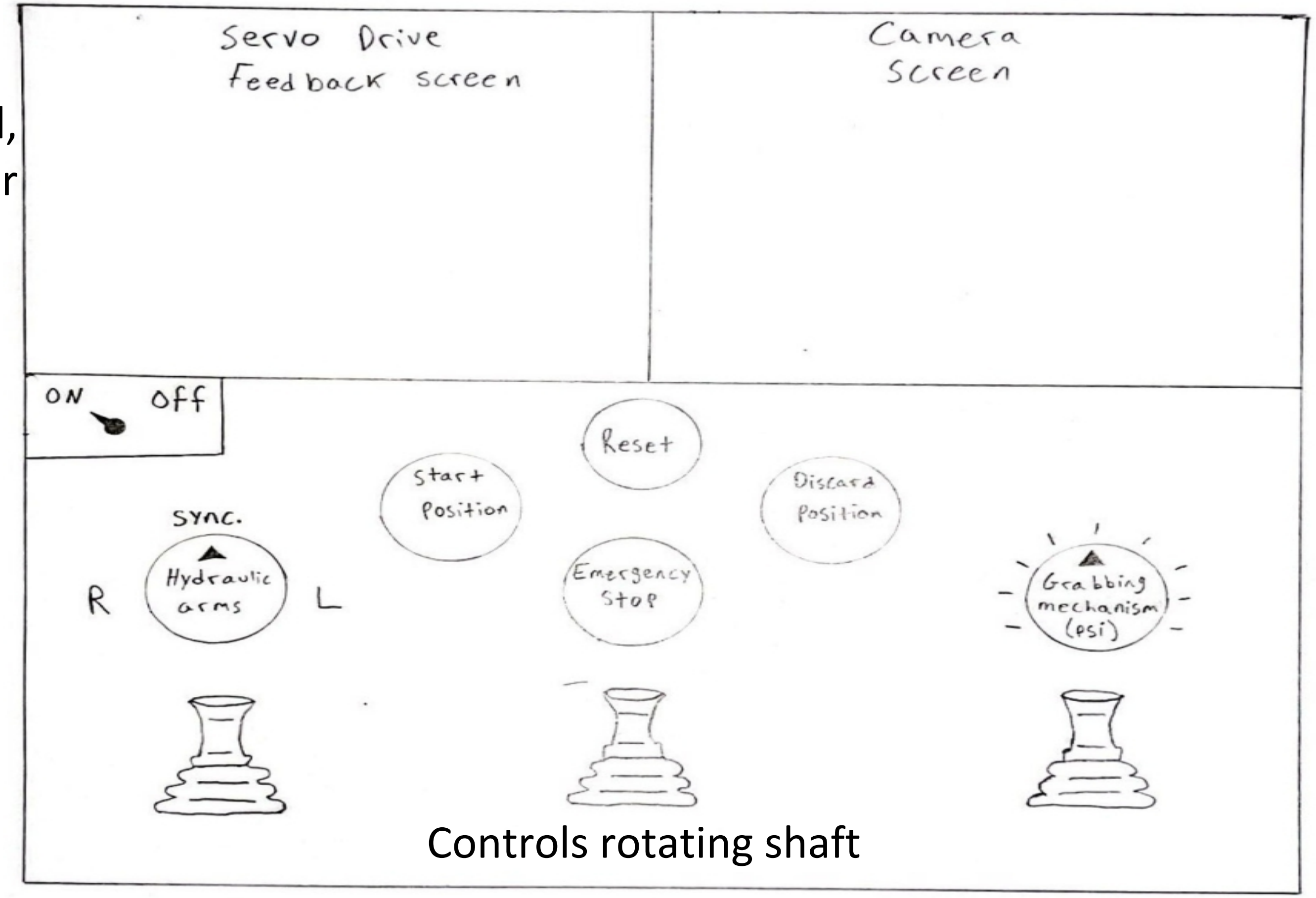
CONTROL SYSTEM

Feedback on speed, position, and motor conditions



Side and top view of assembly line

Controls hydraulic arms

Controls rotating shaft

Controls grabbing mechanism

ENGINEERING CONTENT AND ANALYSIS

Required clamping force for grabbing mechanism

$$\Sigma F = 0 = 360\ \text{lb} - 2*F\mu$$

$$F = 257\ \text{lb on each side}$$

Maximum torque applied to the rotating shaft from lifting heaviest bar and including the weight of the rotating arm

$$\Sigma M_{max} = 0 = (360\text{lb})(8.304\text{ft}) + (150\text{lb})(8.304\text{ft}) - T$$

$$T = 4{,}235\ \text{lbf*ft}$$

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ENGINEERING CONTENT AND ANALSYSIS

- Motor Selection: 480V Servo Motor
    - HPK-B1307C (23 HP)
    - 5700 Kinetix Drive
- Gear ratio (400:1)
    - Decrease the speed (rpm)
        - To 3.75 rpm
        - For precision
    - Increase the torque (lbs*ft)
        - To 35,000 lbs*ft
        - Covers the maximum torque needed = 4,235 lbs*ft

Kinetix HPK (460V) Motor Performance with Kinetix 5700 (400V-class) Drives

Rotary Motor Cat. No.	Rated Speed rpm	Maximum Speed rpm	System Continuous Stall Current A 0-pk	System Continuous Stall Torque N•m (lb•in)	System Peak Stall Current A 0-pk	System Peak Stall Torque N•m (lb•in)	Motor Rated Output kW (Hp)	Kinetix 5700 (480V AC input)
HPK-B1307C			48.2	112 (991)	113.0	260 (2301)	17.1 (22.9)	2198-S086-ERSx
HPK-B1308C	1500	3000	58.6	141 (1246)	119.3	262 (2319)	21.6 (28.9)	2198-S086-ERSx
HPK-B1310C			64.9	155 (1372)	144.0	325 (2876)	23.8 (31.9)	2198-S130-ERSx
HPK-B1613C			109.8	271 (2398)	217.0	542 (4797)	41.7 (55.9)	2198-S160-ERSx
HPK-B1307E			81.0	96.0 (849)	146.6	165 (1460)	29.8 (39.9)	2198-S130-ERSx
HPK-B1308E	3000	5000	91.4	115 (1018)	190.3	230 (2036)	35.7 (47.8)	2198-S160-ERSx
HPK-B1609E			120.2	150 (1327)	217.0	270 (2390)	46.5 (62.3)	2198-S160-ERSx
HPK-B1611E	3000	5000	149.0	183 (1619)	338.4	400 (3540)	57.0 (76.4)	2198-S263-ERSx
HPK-B1815C	1500	3000	153.7	360 (3186)	402.0	850 (7523)	55.9 (74.9)	2198-S312-ERSx
HPK-B1613E	3000	5000	191.0	237 (2097)	440.0	520 (4602)	73.7 (98.8)	2198-S312-ERSx
HPK-B2010C	1500	3000	196.4	482 (4266)	440.0	970 (8585)	75.0 (100.5)	2198-S312-ERSx
HPK-B2010E	3000	5000	254.0	295 (2611)	440.0	500 (4425)	92.0 (123.4)	2198-S312-ERSx
HPK-B2212C	1500	3000	254.0	607 (5372)	440.0	1105 (9780)	94.0 (126.1)	2198-S312-ERSx

Performance specification data and curves reflect nominal system performance of a typical system with the motor ambient at 40 °C (104 °F), drive ambient at 50 °C (122 °F), and rated line voltage. For additional information on ambient and line conditions, refer to Motion Analyzer software.

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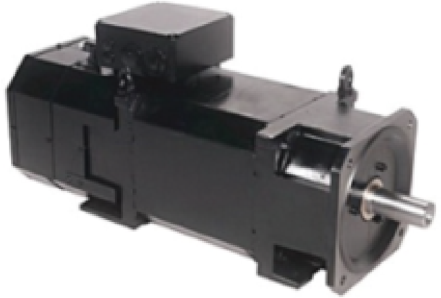
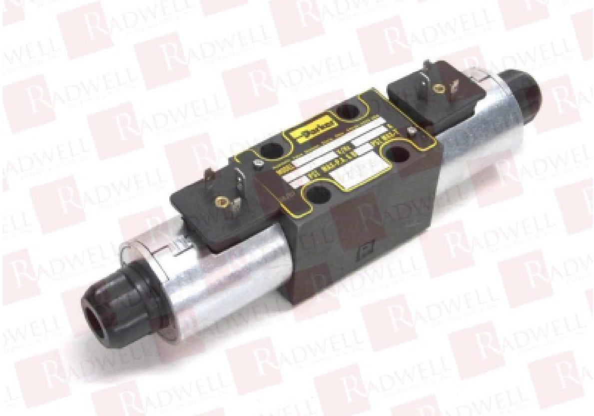
LIST OF PRODUCTS

- 23 Horsepower Servo motor (HPK-B1307C)
    - $13,000
- Kinetix 5700 drive
    - $5,000
- 3 position solenoid valves (2)
    - $1,400 (total)



2198-S086-ERS3 Allen-Bradley



LIST OF PRODUCTS

- Gear Reduction Box (100:1 and 4:1)
  - $2,000

Total cost for raw materials = $42,357.30

Hydraulic Cylinder Clamp

- 4 @ $374 Each, $1,496 total

DESIGN VALIDATION

Table 8.1 Design Validation Summary

Requirement	Inspection	Test	Analysis	Pass/Fail
Cost: less than $200,000, less than $50,000 is preferred		x	x	PASS
Withstands temperatures up to 800°F	x		x	PASS
Remove various shaped bars	x		x	PASS
Structural design allows factor of safety equal to 2		x	x	PASS
Reduces employee physical involvement	x		x	PASS
Height must be less than 10 feet	x		x	PASS
Minimum maintenance: must not require down time to maintain	x			N/A
Efficiency: must remove the bars quicker than the current method				N/A
Training: all employees, regardless of previous education/experience must be able to operate this equipment				N/A

CONCLUSION

Benefits

- Improves the safety of Nucor's workplace

Next Actions

- Programming the control system

Acknowledgements

- We would like to thank Dustin Land, Ben Ticen, and all Nucor employees who heled us with our project

- We would also like to thank our faculty mentor Dr. Joeseh Schroeder for being with us every step of the way

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Questions?