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"REDUCING THE CYCLE TIME PER CONTAINER IN QUAY CRANE"

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Abstract - QC stands for quay crane also known as container crane. It is widely used in industry and construction sites to handle and transfer heavy loads. Spreader is a quay crane part which is used to hold the containers and move over the hoist. Due to inertia of the container it is hard to set the spreader over the container; wind is also a factor for the unnecessary movement of the spreader that makes it hard for the operator to set the spreader over the container. This increases the cycle time and ideal time and money is wasted. We are trying to resolve this problem by making the container's movement constrained while moving up and down by using a pad with rubber sheet.

***Key Words*:** QC Crane, Spreader, Container, Moment of inertia

1. INTRODUCTION

QC stands for quay crane also known as container crane. It is widely used in industry and construction sites to handle and transfer heavy loads. It was developed in 1959 in Oakland California by PACECO (Pacific Coast Engineering Company).

Fig 1. Quay crane

The crane is driven by an operator who sits in a cabin suspended from the trolley. The trolley runs along rails located on the top or sides of the boom and girder. The operator runs the trolley over the ship to lift the cargo, usually containers. Once the spreader locks onto the container, the container is lifted, moved over the dock, and placed on a truck chassis (trailer) to be taken to the storage yard. The crane also lifts containers from chassis on the dock to load them onto the ship.

Straddle carriers, side lifts, reach stackers, or container Lorries then maneuver underneath the crane base and collect the containers, rapidly moving them away from the dock and to a storage yard. Flatcars or well cars may also be loaded directly beneath the crane base.

Fig 2. Quay Crane

Container cranes consist of a supporting framework that can traverse the length of a quay or yard on a rail track. Instead of a hook, they are equipped with a specialized handling tool called a spreader.

The spreader can be lowered on top of a container and locks onto the container's four locking points ("corner castings") using a twist lock mechanism. Cranes normally transport a single container at once, but some newer cranes have the capability to pick up two to four 20-foot containers at once.

1.1 AIMS AND OBJECTIVE

- Reduce the cycle time for each container.
- Reduce the cost of handling a container.
- Increase the container handling capacity of the plant.
- Making the operation easy and less time consuming.
- Reducing the vessels traffic
- Making the process a sustainable process
- Reducing the fuel consumption per unit container

1.2 PROBLEM FACED IN IDEAL PROCESSING

- Spreader is a quay crane part which is used to hold the containers and move over the hoist.
- Due to inertia of the container it is hard to set the spreader over the container

- Wind is also a factor for the unnecessary movement of the spreader that makes it hard for the operator to set the spreader over the container

1.3 POSSIBLE WAYS TO SOLVE THE PROBLEM

- Making the container's movement constrained while moving up and down using a pad.
- Using damper at the site of loading and unloading to slow down the velocity of the spreader.
- Using magnet mechanism at container and spreader jaws to make it easy to set the spreader over the container.

1.4 WORK PLAN

- Defining the problem.
- Case study of various patents and research paper.
- Possible ways to solve the problem.
- Design and specification of the component.
- Costing of the project.
- Manufacturing of the components and elements.
- Operating the machine and trial.

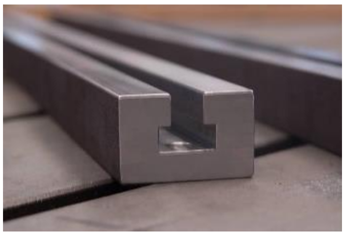
2. MATERIAL REQUIREMENT

- Alloy Steel (PAD):- Used as damper to restrict the motion of the container.

- Natural Rubber (SHEET):- To avoid surface wear on container as well as on pad.

- L angle support plate:- Use to give support to alloy plate & reducing the shearing tress in bolt & clamp.

- Clamping rail: **-** The pad will be fitted to the QC with the help of clamp rail glue to stick the rubber over the steel pad.



- Bolt: - It use to fix the plate & give support to the pad.

- Adhesive glue: **-** Use to stick the rubber over the steel pad.

3 DESIGNS

3.1 LOAD CALCULATION

1. With load of 65 ton in first row on 4th high container.
   - MASS OF CONTAINER = 65000 kg
     - VELOCITY OF TROLLEY (V) = 1.25 m/s
     - TIME = 67.1 sec

- ACCELERATION OF TROLLEY
  (A) = $(V_t - V_i)$/t
  = (1.25-0)/67.1
  =0.01862 m/s2
- Force exerted on pad = m*a
  =65000*0.01862 = 1210.8 N

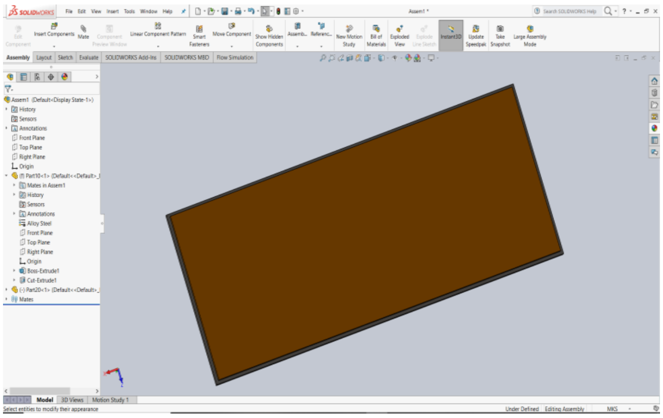
2. Without load of 3.3 ton.
   - MASS OF CONTAINER
     =3300 kg
   - VELOCITY OF TROLLEY (V)
     = 2.5 m/s
   - TIME = 21.6 sec
   - ACCELERATION OF TROLLEY (A) = $(V_t - V_i)$/t
     = (2.5-0)/21.6
     =0.11574 m/s2
   - Force exerted on pad = m*a
     = 3300*0.11574 = 381.94 N

3. Average force (Average load 33 ton)
   - MASS OF CONTAINER = 33000 kg
   - VELOCITY OF TROLLEY (V)
     = 2 m/s
   - TIME = 67.1 sec
   - ACCELERATION OF TROLLEY (A) = $(V_t - V_i)$/t
     = (2-0)/67.1
     =0.029806 m/s2
   - Force exerted on pad = m*a
     = 33000*0.029806 = 983.6065 N

3.2 DESIGN OF PAD

LENGTH = 21feet HEIGHT = 9feet

THICKNESS = (6cm Alloy steel Sheet+1cm Natural Rubber sheet)



3.3 COSTING

Metal Plate cost approx. **5.5 lakhs**

Rubber Sheet cost approx. **18,693 ₹**

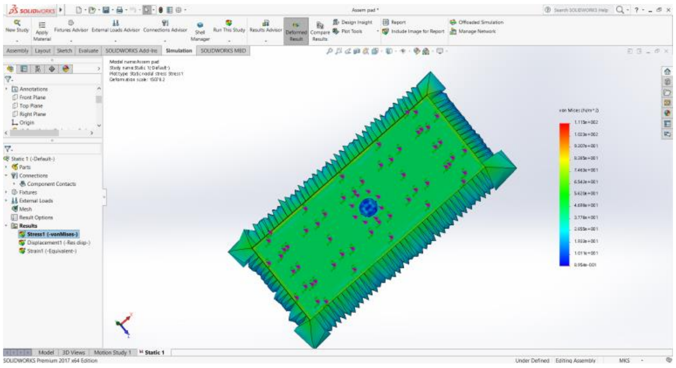
Installation cost around **12,000 ₹ to 15,000 ₹**

Maintenance cost **15,000 ₹**

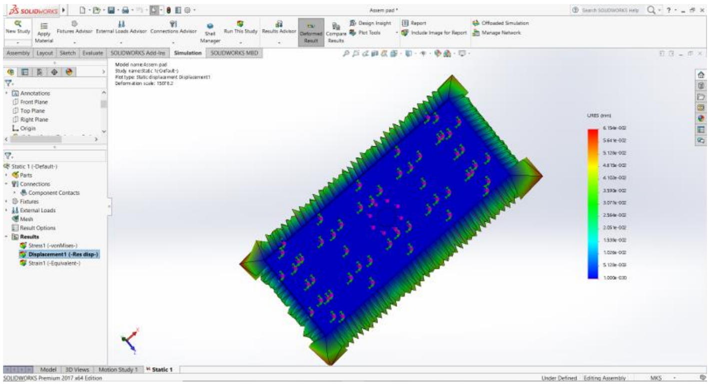
Total Cost approx. **598693 ₹**

4 ANALYSIS

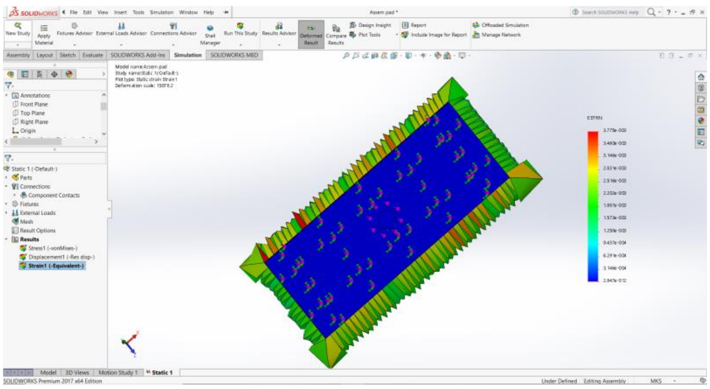
4.1 STRESS (VON MISES)



4.2 DISPLACEMENT



4.3 STRAIN



5 CALCULATIONS

With load of 65 Ton in first raw on 4th high container			
1	Engage container on Warf	2	second
2	Hoist 31.5 meter up	49.6	second
3	Travel 35 meter outboard	17.5	second
4	Lowering 27 meter	43.2	second
5	Disengage container on vessel	2	second
6	Hoist 27 meter up without load	21.6	second
7	Travel 35 meter inboard	17.5	second
	TOTAL TIME	153.4	second

5.1 HOISTS WITH LOAD

Vh	Final velocity	75	m/min (hoist sped)	1.25	m/s
Uh	Initial velocity	0	m/min	0	m/s
Sh	Distance	31.5	Meter		
A	Acceleration Time				
T	Time				
Equation	Vh=Uh+(a *T)				
So,	a=(V-U)/T Acceleration Time = (Final velocity - Initial Velocity)/Time				
Now,	Sh=UhT+1/2aT*T				
	Sh=UhT+1/2[(Vh-Uh)/T]T*T Distance = (Initial velocity* Time) +1/2(Final velocity-Initial velocity)/Time ^2				
So	31.5=0+1/2[1.25T]				
	T=(31.5*2)/1.25				
	T=49.6				

5.2 65 Ton 4th high container

Ideal Timing = 156.1 sec

Actual Timing (Avg) = 4.5mins = 270 sec

Ideal time waste = 270-156.1

= 123.9 sec

Site of wastage of timing

1. Workers skill = 5-10 sec
2. Engage container on wrap = 6-10 sec
3. Lowering and uplifting of hoist = 105 sec

Site to focus

- Uplifting and Lowering of hoist = 90-105 sec
- Actual uplifting and Lowering time = Ideal time + Wastage of time = (49.6+43.2) + 105 = 197.8 sec

5.3 Hoist After placing without load

Vh	Final velocity	150	m/min	2.5	m/s
Uh	Initial velocity	0	m/min	0	m/s
Sh	Distance	27	meter		
A	Acceleration				
T	Time				
Equation	V=U+aT				
So,	a=(V-U)/T				
Now,	Sh=UhT+1/2aT*T				
	Sh=UhT+1/2[(Vh-Uh)/T]T*T				
So	27=0+1/2[2.5T]				
	T=(27*2)/2.5				
	T=21.6				

5.4 Trolley

Vt	Final velocity	240	m/min (Trolley speed)	4	m/s
Ut	Initial velocity	0	m/min	0	m/s
St	Distance	35	meter		
a	Acceleration				
T	Time				
Equation	V=U+aT				
So,	a=(V-U)/T				
Now,	St=UtT+1/2aT*T				
	St=UtT+1/2[(Vt-Ut)/T]T*T				
So	35=0+1/2[4T]				
	T=(35*2)/4				
	T=17.5				

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5.5 Timing after pad mechanism (Uplifting and lowering times)

- Ideal uplift and lower time = (49.6+43.2) = 92.8 sec
- Stability of Container = 2 * 4 = 8 sec
- Stability of Inertia of Container = 4-6 sec
- Constrained motion over pad = 2*2 = 4sec
- Waste of time due to skill of operator = 3-5 sec
- Waste of time due to wind Inertia = 5-9 sec
- Total Time = 121.8 sec

5.6 Time Saved by Pad Mechanism

Time Before pad – Time after pad

= (197.8-121.8)

=76 sec

5.7 Cost Reduction

Cost of One Cycle = 130 ₹

Cost per second = 130/197.8 = 0.657 ₹

Time Saved = 76 sec

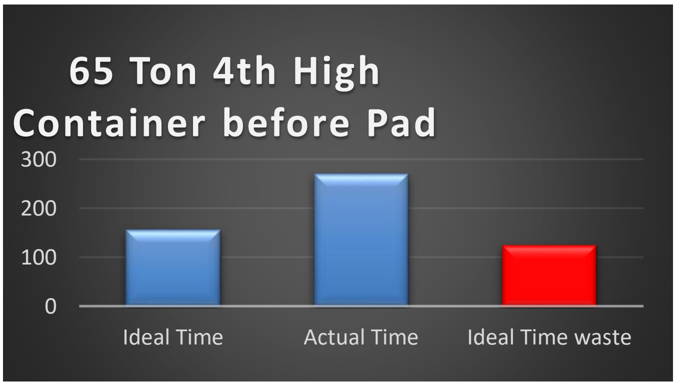
Cost Saved = 76 * 0.657 = 49.932 ₹/cycle

Note: - Company Handle 30 Containers Every Hour

Cost saved every hour = 30 * 49.932 ₹/hour

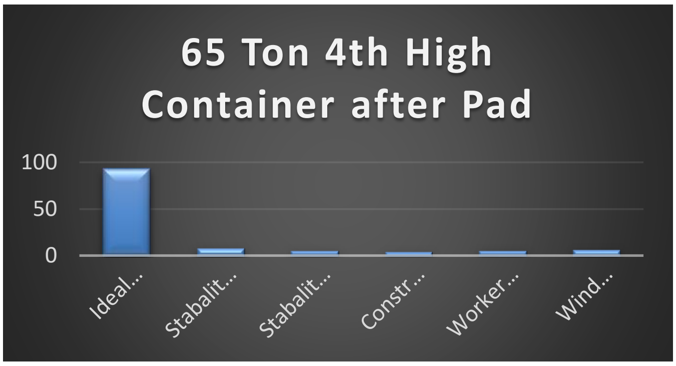
Cost saved per year = 1497 * 365

= 546405 ₹/year



Bar Graph of 65 Ton 4th High Containers before Pad

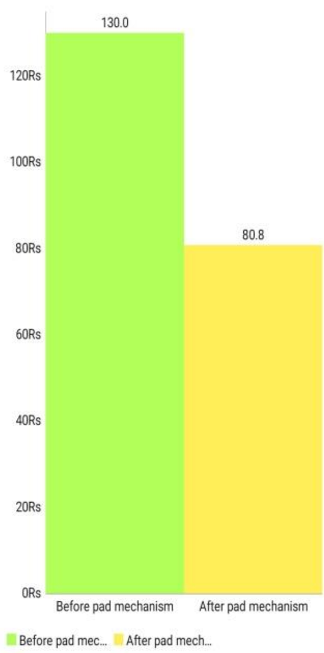
Pie Chart of Site of Wastages

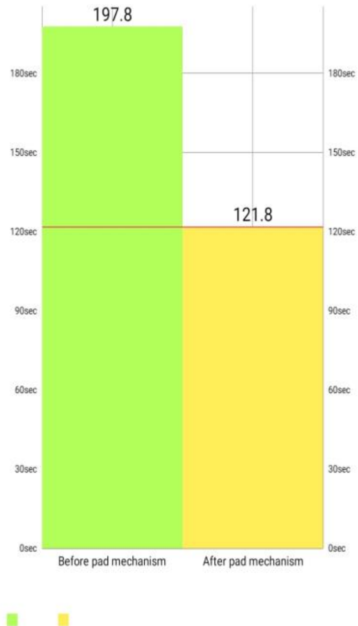


Bar Graph of 65 Ton 4th High Container after pad

6. CONCLUSION

6.1 Final graphical data of reduction in time & cost.





Cost Reduction Time Reduction

6.2 Summary

- Most of the time is wasted at uplifting and lowering of spreader.
- Surrounding condition is a factor for wastage of time.
- Wastage of time is more in loaded container than empty container.
- Inertia and momentum of the container leads to wastage of time.
- Pad mechanism reduces the extra inertia and momentum of the container.
- Ideal Pad mechanism reduces **76 seconds per cycle** of Quay Crane.
- Ideal Pad Mechanism saves **49.9 rupees per cycle** (approx.) and **5.4 lakh/year**.
- This mechanism efficiency depends upon the skills of the operator.
- It helps in maintaining constrained motion of the container.
- This reduces clamping time.
- It is partially independent of the surrounding environment.
- It increases container handling capacity of the plant.

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