



## **DESIGN OF A MOBILE CRANE TO LIFT DAMAGED VEHICLES WITH A CAPACITY OF 6 TONS**

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### **Abstract**

This study discusses the design of a mobile crane to lift damaged vehicles with a capacity of 6 tons with the aim of analyzing the planning of the lifting system used ; planning the rope to be used ; transmission system ; calculation of the components of the lifting equipment used ; calculation of power to rotate the drum ; the tool designed is a mobile crane with a capacity of 6 tons to 6 tons ; and calculating the lifting time. assembly . **Type of drive motor with** Combustion engine = internal combustion engine , Drive motor power = 192.36 Hp , Drive motor rotation = 2740 rpm , Max lifting capacity = ton , Lifting height = 3 m . **Drum with** Drum diameter = 300 mm , Drum pitch = 16 mm , Drum length = 300 mm , Maximum compressive stress of material = 1600 kg/cm<sup>2</sup> The maximum compressive stress that occurs = 1173.6 kg/cm<sup>2</sup> . **Steel rope** ( Rope type = 6 x 9 x 1 fc , Rope cross-sectional area = 1173.6 kg/cm<sup>2</sup> . = 2.9 cm<sup>2</sup> , Wire diameter = 1.18 mm , Diameter of steel rope = 26.3 mm , Actual fracture stress = 180/199 kg/mm<sup>2</sup> , Fracture loading = 39100 kg/mm<sup>2</sup> , U nut rope usage = 88.2 months ) ; **Pulley** ( Type of pulley = fixed pulley , pulley diameter = 4.8 cm , Width of the pulley = 2.2 cm ) ; **Hook** ( Hook type = single hook with thread , Thread type on hook = M 42. Length of threaded hook = 42 mm , Number of threads on the hook = 9 threads , Distance between threads = 4.5 mm , Outer diameter on thread = 42 mm , Effective diameter on the thread = 39 mm , Core diameter on thread = 37.129 mm , Hook material = wrought carbon steel SF 60 , Permissible contact stress = 3 kg/mm<sup>2</sup> , The contact stress that occurs = 2.7 kg/mm<sup>2</sup> ) ; **Boom** ( Boom type = boom with fixed arm , Number of booms = 2 pieces , Boom length = 4 m , Boom weight = 1568.66 kg , Boom material = steel pipe , Tensile strength of the material = 40 kg/mm<sup>2</sup> , Tensile strength that occurs on the boom = 10 kg/mm<sup>2</sup> ) ; **Gears** ( Types of gears = worm gear , type of gear on the shaft material = cross gear , Type of chain used = hinge chain , chain weight per meter = 16.5 kg )

## **1. INTRODUCTION**

### **1.1 Background Behind**

In our environment, there is a need to move a damaged vehicle, an accident, or a vehicle that has fallen into a ravine from its original location to the desired



destination. In the workplace, for example, in urban areas , on highways , toll roads , and in other similar areas, special equipment is needed to move vehicles of various shapes and sizes that cannot be moved by human power. To make the job easier, a material handling machine is needed that functions to lift and move materials. the.

One of them is on the toll road, there is no proportional lifting equipment for damaged cars , but the available lifting equipment is not proportional because this lifting equipment is only designed to lift loads, not to lift and... move.

As we know, the number of vehicles is increasing day by day, and it's not keeping pace with the growth of motorized vehicles. Therefore, this increasing number of vehicles often causes unexpected traffic jams both in cities and on highways. Therefore, congestion is a problem in itself that requires serious handling. Likewise, when a car being driven experiences engine failure that renders the vehicle immobile. Of course, if the road is congested, it will only exacerbate the already complicated traffic congestion on the highway.

Considering the potential situations mentioned above, an instrument is needed that can handle these issues quickly, thus making it easier for drivers experiencing vehicle problems. There are many other situations, such as a vehicle being involved in a collision or falling into a ravine. However, this does not mean that all lifting equipment used for every purpose must be designed according to the location of its operation, considering that an accident or damage can cause congestion that can hinder public activities.

Therefore, the author decided to plan a mobile crane that could answer the problems that arise in urban life and in a relatively short time.

### **1.2 Formulation of the problem**

In any planning process, problems will always arise. Likewise, in crane planning, there are several issues , including:

Planning costs.

Selection of appropriate lifting equipment.

Lifting system design.

Transmission system design.

Calculation of the main components of the lifting system.

Maintenance costs.

Power calculation for rotating the drum.

Etc.

### **1.3 Limitation Problem**

In writing this thesis, of course, we must be limited by the capabilities, situation, conditions, costs, and time available. The topics discussed in the construction of a crane are:

Planning of the lifting system used.

Planning the rope to be used.

transmission system.

Calculation of the components of the lifting aircraft used.

Power calculation for rotating the drum.

The tool designed is a mobile crane with a capacity of 6 tons to 6 tons.

Counting time assembly pe .

#### **1.4 Writing purpose**

The purpose of writing this thesis can be described as follows :

In general, studying about machine construction.  
Can choose the appropriate material for making crane equipment.  
Can calculate the time required to manufacture a crane.  
Can calculate the cost of manufacturing a crane.  
Can find out what components are used to make crane equipment.

#### **1.5 Benefits of Planning**

The benefits of this planning are:

1. For the author to increase the author's insight into designing elevators and as evidence for the author's final assignment.
2. For the campus to increase insight for active students who are preparing their final assignments who want to take the same design title as starting material to start their final assignment.
3. The benefit of this design is to help solve the system of moving materials or damaged cars which is an obstacle in urban areas , as well as increasing insight and applying the knowledge learned during lectures and can help the world of transportation to make it easier and reduce the workload related to transportation.

## **2. LITERATURE REVIEW**

### **2.1 Lift and Transport Aircraft**

A device is a collection of several devices, either grouped or stand-alone, that generate mechanical or non-mechanical power and can be used for a specific purpose. Lifting equipment is equipment constructed or made specifically for lifting and lowering loads.

### **2.2 General View of the Lifting Aircraft**

A transport aircraft is a lifting device used to move materials from one location to another, with a specific capacity. It is commonly used in factories, toll road areas, warehouses, and so on.

The transfer of a load is carried out using a force greater than the weight of the load to be moved from one location to the desired location. This transfer process includes loading and unloading.

When selecting a lifting machine, you need to know the following things :

- Hourly load transfer capacity;
- Specific local conditions including the size and shape of the work area;
  - Type and size of load lifted
  - Basics of Selecting Lifting/Transporting Equipment

In every industrial company or workshop that handles heavy equipment operations, the use of lifting equipment is a crucial requirement. Selecting the right type of lifting equipment requires specialized design knowledge and must be tailored to its capabilities and operation.

### **2.3 Basics of Selecting Lifting/Transporting Equipment**

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right type of lifting equipment requires specialized design knowledge and must be tailored to its capabilities and operation.

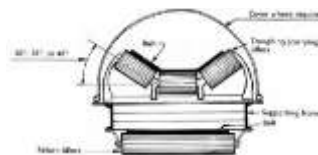
#### 2.4 Basic Group of Lifting Aircraft

Based on its design, lifting equipment can be divided into three basic groups, namely:

1. *Hoisting* equipment



2. *Conveyor* equipment



3. Surface equipment and overhead equipment ( *survival* and *overhead equipment* )

*unit* loads such as: various machine parts, building materials, metal, castings, etc.

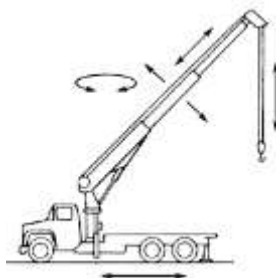
#### 2.5 Types of Lifting/Transporting Aircraft

According to the mechanism, the lifting equipment used during operation can be divided into two parts, namely:

- Lifting tools
- Lifting machines

#### 2.6 Mobile Crane

A mobile crane is a device used to lift or lower heavy materials and move them horizontally. A mobile crane is a crane mounted directly on a truck, allowing it to be transported directly to the work site. For example, on a toll road or in a factory. at material storage areas, construction sites, storage and unloading areas, and workshops.



#### 2.7 Mobile Crane Functions and Applications

In today's industrial era, we see rapid industrial development. Naturally, all of this requires support from facilities and equipment. Among the equipment mentioned above is the lifting machine.



A mobile *crane* is a type of lifting device that can lift and move loads over long distances. This type of mobile crane can move quickly compared to other types of lifting devices. However, this type of mobile crane has a weakness, namely its very limited lifting capacity, because it is only supported by four wheels (meaning no outriggers are used). The lifting capacity of this mobile *crane* ranges from 5 to 6 tons. And on this occasion, according to the specifications that the author will plan, namely a capacity of 6 tons (6000 kg), including medium loads.

The primary application and use of mobile cranes is on the highway, where they are used to lift vehicles that have fallen into ravines or to tow vehicles that have been immobilized due to accidents. These cranes are also often used to lift scrap metal from one location to another or from other storage areas.

### **3. IMPLEMENTATION METHOD**

#### **3.1 General Characteristics of Mobile Cranes**

The main technical parameters of this *crane* are

- a. Capacity ( *lifting capacity* )
- b. Dead weight of the aircraft
- c. Speed of various speeds.

The dimensions and geometry of the aircraft, such as: span , reach, and so on.

### **4. RESULTS AND DISCUSSION**

#### **4.1 Design Drawing**



#### **4.2 Types of Ropes Used**

In general, ropes can be divided into two, namely:

1. Non-metallic rope
2. steel rope

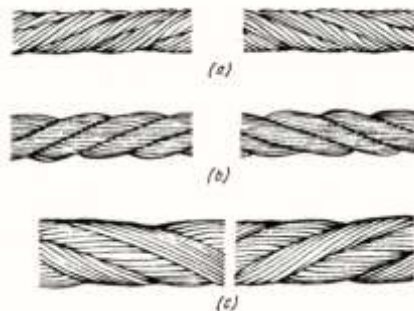
In this planning, steel rope was chosen because it has many advantages compared to other ropes and chains, namely it is lighter, better, more flexible, more resistant to shocks, and does not tangle.

Steel rope is a rope constructed from a collection of interwoven steel fibers. First, several fibers are twisted into a single strand, then several strands are woven into a single core, as shown in the figure.



### 4.3 Rope Planning

In order for the rope to be designed with the rope and its safe use, it depends on the weight of the load that can cause tension on the rope. From the previous chapter (lifting mechanisms), the following data was obtained:



### 4.4 Rope Durability

Ropes that have been used repeatedly will eventually become damaged (worn out) due to friction between them, or between them and the disc or drum. Or, it can also be caused by repeated bending. Therefore, the rope's lifespan should be calculated by calculating the number of bends the rope can tolerate.

$$A = D/d = m \cdot \sigma \cdot c \cdot c_1 \cdot c_2$$

### 4.5 Types and Maintenance of Discs (Pulses) Used

In everyday language, this disc is called a pulley, which is made with grooves to hold the rope. According to its position, the pulley can be divided into two parts:

- a. *Fixed* pulley
- b. Free Pulley ( *movable pulley* )



### 4.6 Drum Strength Check

The drum material is selected from cast steel ( *steel casting* ), so the maximum allowable compressive stress (max) is 1600 kg/cm<sup>2</sup>.

While the maximum voltage that occurs:

$$\sigma_{\max} = \frac{s}{w \cdot s}$$

$$\sigma_{\max} = \frac{3676}{1,6 \times 2,93} = 784 \text{ kg/cm}^2$$

#### 4.7 Hook Planning

In daily use, the hook that is often used is the single hook. On this crane, the hook used is a threaded hook with a short-handle thread type. Even the hooks are selected from cast carbon steel SF 60 with the following chemical composition:

0.035% P, 0.40% S ..... So the tensile strength that occurs is:

$$\sigma_t = \frac{\sigma_t}{K} \dots \dots \dots \text{Where:}$$

K = safety factor = taken as 8

So the tensile strength that occurs is:

$$\sigma_t = \frac{70}{8} = 8.75 \text{ kg/mm}^2$$

#### 4.8 Gear Planning

##### 4.8.1 Types and Maintenance of Gears Used

Gears are a transmission device used to transfer power and rotation from one shaft to another. This transfer of power or rotation occurs due to the contact of gears. Using gears as a transmission has several advantages, including:

- a. Requires little space
- b. Can transfer large power and rotation with high efficiency.

##### 4.8.2 How the Transmission System Works

The power source for this mobile crane is a diesel engine, which also serves as the vehicle's propulsion system. Thus, the rotational power for the lifting mechanism's transmission is provided by the drive motor via a shaft and chain, which is equipped with a clutch.

##### 4.8.3 Type and Maintenance of Chain Used

Broadly speaking, the chain can be divided into two parts, namely:

- a. Skiam chain ( *welded load chain* )
- b. Hinge chain ( *roller chain* )

The slam chain is made of long, cylindrical steel, commonly used in lifting equipment. Meanwhile, the hinge chain consists of plate strips *connected* to each other by pins ( *joint pins* ) used as a transmission device. To more clearly distinguish between the two types of chain, see the image below.

In this design, the chain functions as a means of transmitting rotation and power, so in this case a hinge chain ( *single loader chain* ) was chosen. The advantages of using this chain compared to belts and other chains are as follows:

1. No slip ( *lost* ) occurred
2. Can operate in water conditions
3. Easy to replace because it has a pin connection.

#### 4.9 Motor Drive Planning

##### 4.9.1 Type of Drive Motor

The driving force used to move a lifting machine is of various types, namely:

1. Hydraulic drive power
2. Pneumatic driving force
3. Steam motive power
4. Electric driving force
5. Internal combustion propulsion

#### 4.9.2 Rolling Resistance

Rolling resistance is the resistance that occurs due to friction between a vehicle's tires and the road surface. The amount of rolling resistance can be found using the formula:

$$R_r = G_1 \cdot C_r$$

Where:

$$G_1 = \begin{aligned} &\text{empty vehicle weight} = 3500 \text{ kg} \\ &\text{Maximum planned load} = 6000 \text{ kg} \\ &\text{Passenger weight } (75 \times 3) = 225 \end{aligned}$$

$$C_1 = \text{rolling resistance coefficient (selected} = 0.011)$$

So the rolling resistance that occurs is:

$$\begin{aligned} R_r &= G_1 \cdot C_r \\ R_r &= 12757 \times 0.011 \\ &= 140 \text{ kg} \end{aligned}$$

#### 4.9.3 Air Resistance (water resistance)

Air resistance is the resistance that occurs due to the layer of air that the vehicle must penetrate when moving. So, the air resistance that occurs is:

$$R_r = \frac{1}{2} \cdot r \cdot C_a \cdot A \cdot V_r^2$$

Where :

$$\begin{aligned} R &= \text{air density} = 0.125 \text{ kg.s/m}^4 \\ V_r^2 &= \text{relative speed of vehicle to air} = 38.88 \text{ m/s} \\ C_a &= \text{coefficient of air friction} = 0.29 \\ A &= \text{projected area of the vehicle exposed to air} = 4,307 \text{ m}^2 \end{aligned}$$

So :

$$\begin{aligned} R_r &= \frac{1}{2} \cdot r \cdot C_a \cdot A \cdot V_r^2 \\ R_r &= \frac{1}{2} \cdot 0.125 \cdot 4,307 \cdot (38,888)^2 \\ &= 118 \text{ kg} \end{aligned}$$

#### 4.9.4 Motor Rotation Selection

To determine the rotation that occurs on the tire is:

$$N_b = \frac{v_{max}}{\pi \cdot D_b}$$

Where :

$$\begin{aligned} v_{max} &= \text{maximum vehicle speed} = 120 \text{ km/h} \\ D_b &= \text{outer diameter of tire} = 40 \text{ inches} \end{aligned}$$

So:

$$\begin{aligned} N_b &= \frac{v_{max}}{\pi \cdot D_b} \\ N_b &= \frac{120 \times 1000}{3,14 \times 1,016 \times 60} \\ &= 626.91 \text{ rpm} \end{aligned}$$

While the drive motor rotates

$$N_{max} = I_{tot} \cdot N_b$$

## 5. CONCLUSION

From the design results above, several conclusions were obtained from the calculations of the planned crane car, namely:

### 1. Type of drive motor

- a. Internal combustion engine =

internal combustion engine

- b. Drive motor power = 192.36 Hp
- c. Drive motor rotation = 2740 rpm
- d. Max lifting capacity =  
6 tons
- e. Lifting height = 3 m

## 2. Drum

- a. Drum diameter = 300 mm
- b. Drum pitch = 16 mm
- c. Drum length = 300 mm

- d. Maximum compressive stress of material = 1600 kg/cm<sup>2</sup>
- e. The maximum compressive stress that occurs = 1173.6 kg/cm<sup>2</sup>

## 3. steel rope

- a. Rope type = 6 x 9 x 1 fc
- b. Cross-sectional area of the rope = 2.9 cm<sup>2</sup>
- c. Wire diameter = 1.18 mm
- d. Steel rope diameter = 26.3 mm
- e. Actual fracture stress = 180/199 kg/mm<sup>2</sup>
- f. Fracture load = 39100 kg/mm<sup>2</sup>
- g. Age of use of the rope = 88.2 months

## 4. Pulley

- a. Pulley type = fixed pulley
- b. Pulley diameter = 4.8 cm
- c. Pulley width = 2.2 cm

## 5. Hook

- a. Hook type = single hook with thread
- b. Thread type on hook = M 42
- c. Length of threaded hook = 42 mm
- d. Number of threads on the hook = 9 threads
- e. Thread pitch = 4.5 mm
- f. Outside diameter on thread = 42 mm
- g. Effective diameter on thread = 39 mm
- h. Core diameter on thread = 37.129 mm
- i. Hook material = forged carbon steel SF 60
- j. Permissible contact stress = 3 kg/mm<sup>2</sup>
- k. The contact stress that occurs = 2.7 kg/mm<sup>2</sup>

## 6. Boom

- a. Boom type = boom with fixed arm
- b. Number of booms = 2 pieces
- c. Boom length = 4 m
- d. Boom weight = 1568.66 kg
- e. Boom material = steel pipe
- f. Tensile strength of material = 40 kg/mm<sup>2</sup>
- g. The tensile strength that occurs on the boom = 10 kg/mm<sup>2</sup>

## 7. Gears

- a. Type of gear = worm gear
- b. Type of gear on shaft material = cross gear
- c. Type of chain used = hinge chain
- d. Chain weight per meter = 16.5 kg

## 5.2 Suggestion

After making a conclusion, the author also provides suggestions in this final assignment, the suggestion is that in " *designing a mobile crane to lift damaged vehicles*" it is very necessary to be precise and accurate in calculating the load capacity, tensile stress, bending stress, drive motor, pulley, hook and others. Where if these are known, then we can determine and choose the material that is suitable and resistant to receive the load.

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