

Manipulation of C27 Cylinder Heads

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Abstract. The CAMTAC plant in Guelph, Ontario manufactures a number of cylinder heads for Caterpillar machines. The C27 is the largest cylinder head manufactured at the plant, weighing approximately 270kg. At the C27 rework station technicians currently use a metal bar to manually flip the cylinder head to access the opposite side, causing excessive strain on the shoulder and back. A design solution is proposed for the mechanical manipulation of CAMTAC C27 cylinder heads. The design utilizes specially designed mounting brackets combined with a motorized lift table and a high-torque electric motor to rotate the cylinder head 180° about its long axis and safely return it to resting position. The design is expected to cost approximately \$5500

Key words: industrial manipulation, cylinder heads, Caterpillar, CAMTAC, ergonomics

1 Introduction

One of major factor influencing productivity is the comfort of workers as they perform their tasks. Ergonomic conditions are one of the most important aspects which ensure a physical task can be done repeatedly without injury. However, there are no comprehensive injury statistics which can be used to estimate the economic loss caused by these injuries [1].

The CAMTAC plant manufactures cylinder heads of various sizes that are used in Caterpillar machines. Specifically, the C27 rework station has been identified as having ergonomic issues. The C27 is the largest cylinder head that is assembled at the CAMTAC plant, weighing approximately 270kg. At the rework station, the worker must manually flip the head with a short (approx. 60cm) metal bar in order to access both sides. Currently this action causes unacceptable strain (above the Canadian Centre for Occupational Health and Safety limit of 202N [1]) on the shoulders and lower back. Thus, the goal of this design is to devise a more ergonomically sound method of flipping the C27 cylinder head.

It was decided that the best way to improve the operation was to automate it, and remove use of the workers physical strength from the flipping procedure. The automation of this operation will allow the employees to work without injury and with less fatigue, which in the long run, will benefit the plant.

The design of the automated flipping mechanism required mechanical analysis of the locking, lifting, and rotating procedures. A motorized lifting mechanism and a

high-torque electric motor had to be selected based on the requirements of the system. Structural analysis was also performed on the assembly to confirm that no individual component was at risk of failure.

2 Methods

2.1 Structural Analysis

The design was analyzed for structural integrity since it would be handling large loads. This was accomplished by determining the axial stress, shear stress and bending moments at various points of stress concentration.

The point of maximum stress concentration was found to be located at the support bearings (the supports for the drive shaft). The stress at these points was determined by calculating the forces present and the area of contact between the drive shaft and the support bearing (equation 1).

$$\sigma = \frac{F}{A} \quad (1)$$

2.2 Motor Analysis

The torque requirement for the motor was determined by considering the location of the cylinder head's centre of gravity with respect to the centerline of rotation. Because the centre of gravity could not be located precisely, a reasonable interval was assumed and a sensitivity analysis was performed. Equation 2 was then used to determine the required output torque from the motor.

$$T = F \times d \quad (2)$$

3 Design Overview

The completed unit consists of a pair of specially designed mounting brackets which are manually secured to either end of the C27 cylinder head. These mounting brackets are locked into place using a slide-lock mechanism. To ensure that the brackets make contact with the cylinder head, there is a groove built into the table to guide the head into alignment.

Once the head is locked in place, the motorized lift table that supported the cylinder head is lowered to achieve sufficient clearance. The high-torque electric motor then engages to turn the drive shaft and rotate the cylinder head. After a rotation of 180° the motor is stopped and

two disc brakes engage to secure the drive shaft. The lift table is raised and the mounting brackets can be unlocked and retracted.

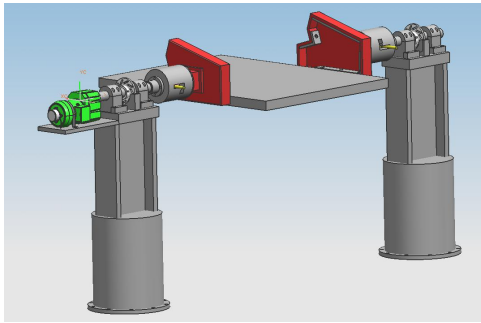


Fig. 1. Overview of proposed design

3.1 Gripping

The cylinder head is held in place by a mounting bracket at each end. Figure 2 shows this system in detail. The mounting bracket is a metal compartment that is lined with a styrene butadiene rubber to allow a tight and secure fit. The brackets have a depth of 6cm to ensure that the head is completely secured.

Note that by requiring that the technician manually secure each bracket to the cylinder head, we decrease the possibility of an automated system misaligning the brackets and risking damage to the mechanism, or worse, injury to the worker.

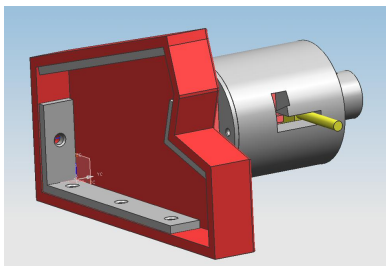


Fig. 2. Mounting bracket detail

The locking assembly consists of a housing, slider, and spring, as shown in figure 3. The housing is directly attached to the drive shaft and the complete system rotates along with the motor. To secure the head, the handles of the locking mechanism are pushed towards the cylinder head until the mounting bracket is in place. Once the bracket has reached its final position the handles of the locking mechanism are rotated clockwise until the spring pushes the handles back into the locking grooves.

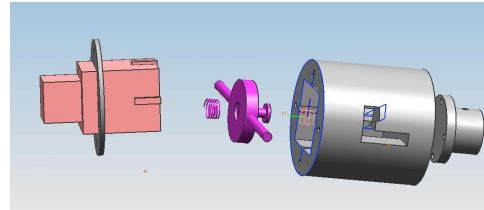


Fig. 3. Locking mechanism detail

3.2 Lifting

With the cylinder head safely held in place by the mounting brackets, the motorized lift table can be lowered to give the cylinder head the needed clearance for rotation. A contact switch ensures that the drive shaft motor cannot engage until the table is fully lowered.

3.3 Rotation

Once suspended above the rework table the cylinder head can be rotated by the motor (shown in green in figure 4). This allows the cylinder head to be rotated at a speed that is both safe and practical. After rotation the motor stops and the brakes engage.

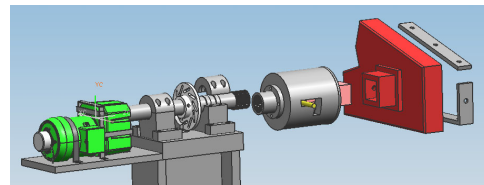


Fig. 4. Assembly view

The pneumatic disc brakes are engaged whenever the rotation motor is not in use. The braking system can be seen in figure 4 between the motor and the locking mechanism.

Following rotation, the hydraulic lift can be raised to support the cylinder head again. The mounting brackets can then be unlocked and retracted.

4 Acknowledgements

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References

1. Canadian Centre for Occupational Health & Safety - Pushing and Pulling. <http://www.ccohs.ca/oshanswers/ergonomics/push1.html> Accessed Apr. 2, 2008.