Ergonomic Improvements on a Cylinder Head Production Line

Matt Brunsting, Cody Murray, and Deneb Ragbar

Abstract. Presented in this paper is an ergonomically based design for the purpose of flipping a 102 kg engine cylinder head 90 degrees atop a conveyor belt for an automotive company. The design consists of 2 components: adjustable modified pry bars which utilize both of the worker’s arms and a lowering mechanism. The two pry bars cater to varying heights to allow the best ergonomic and comfortable positions and thereby distribute the applied forces more evenly since both arms are utilized. These prybars replace the current method which is a single handed method. The second component is a damped lowering system which lowers the cylinder head onto the conveyor belt. The results of force analysis on the system demonstrate consistent reductions in force, ranging from 55-80% per arm, that the workers had to exert to complete the task. The complete cost of the entire system is $200.68.

Key words: Automotive Industry, Conveyor, Ergonomics, Work Related Musculoskeletal Disorders

1 Introduction

The Linamar Corporation’s CAMTAC Guelph plant specializes in manufacturing cast iron cylinder heads. Currently, factory workers must manually flip cylinder heads of 102kg approximately 80-100 times a day. Presently, this is accomplished by inserting a metal rod into the holes of the cylinder heads and using one hand to manipulate the rod like a lever and turn the cylinder head 90 degrees \[1\]. Ergonomically speaking, this places workers in a hazardous situation where the repetitive motions may cause injuries due to unequal cyclic loading of their arms, shoulders, and backs. Some constraints applied to the design included no exposed pulleys or cables, easily retrofit to the existing workstation, could not slow down the production line, and had to be safe and operable by a single worker. The major criterion was simplicity as it was desired that the design be easy and non-cumbersome for workers to use. The proposed pry bar and lowering system also satisfies the criterion that the worker exerts minimal force, thereby reducing the chances of developing work related musculoskeletal disorders .

2 Conceptual Design

The main components of the design are two modified pry-bars and a damped lowering system.

The overall procedure combines manual force and damping features. The prongs of the modified pry bar are inserted into two openings in the side of the cylinder head and these are used as lever points to rotate the system. The damped lowering system lowers the cylinder head the final 20 degrees of rotation onto the conveyor. By grasping the handlebars of the prybar and exerting an upward force while stepping forward, the head is flipped a total of 90 degrees. Once the cylinder head is turned 70 degrees, the prybar can be removed and the damping system compresses due to gravitational force thereby lowering the cylinder head onto the rollers of the conveyor.

Figure 1 demonstrates an accurate representation of the position of the worker in relation to the conveyor height. The worker can be seen in their starting and final positions.

3 Detailed Design

3.1 Modified Pry Bars

The handlebars are made of aluminum alloy 6061 T-8 round tubing and the remainder of the bar is rectangular aluminum alloy tubing. Rubber grips envelop the handlebars. The handlebars and the middle arm of the prybar are constructed separately and connected with three 1/4 inch pins to adjust the length of the bar, as shown in Figure 2. The smaller bar adjusts for workers with shoulder heights of 138-148cm and the larger bar for 151-161cm. Both bars accommodate shoulder widths from 33-48cm.

The first error to be addressed was whether the prybar could be used by workers with various body dimensions. To ensure the best ergonomic design, it was necessary
to redesign the bar with adjustable sections to cater to all workers. The best solution was to create a secondary pry bar for shorter workers and use another for taller employees. In addition, the damping system was analyzed to ensure that an acceptable combination of gas spring force and damping features was utilized.

### 3.2 Damping System

The damping system is fixed underneath the conveyor belt on a platform (not shown). It consists of two gas springs hinged to rollers on which the cylinder head will sit. When compressed, the rollers will sit at 90 degrees to the gas springs and the supporting arms opposite the gas springs along the rollers as seen in Figure 3. When extended, the rollers sit at 20 degrees to the horizontal. When the cylinder head has been manually rotated through 70 degrees, gravity takes over and the gas springs compress lowering the cylinder head onto the conveyor in approximately 3 s. The cylinder head exerts an average force of 414N on each gas spring when it is being lowered as illustrated in Figure 4. The system is made primarily of steel 1045 which is bought in stock sizes and cut or machined to size. Steel hinges are required in 6 places. A connecting bar joins the hinges at the base of the system so that the gas springs act in a synchronized fashion. Double-damped gas springs are used which ideally exert an average of 50N of force on an 80mm stroke and have exhibit damping behaviour such that the damping constant is 5888 Ns/m.

![Damping System Design](image3)

**Fig. 3.** Damping System Design

![Loaded Damping System](image4)

**Fig. 4.** Loaded Damping System

### 4 Discussion

Engineering this design taught the importance and necessity of ergonomics along with the details and regulations that must be satisfied under Canadian government guidelines governing workplace safety.

Future recommendations would be to design the pry bar so that it could be used for any size cylinder head on any of the CAMTAC assembly lines. Also, it is possible that a simpler lowering system could be conceptualized since the lowering system only functions over 20 degrees and the gas springs only operate over a stroke length of 80mm.

The cost for both pry bars is $127.72. This includes the price of aluminum alloy, the handle grips and protective padding. Combined with the lowering mechanism which costs $72.96, the entire system costs $200.68.

### 5 Conclusion

In conclusion, it can be said that ergonomics is a vital aspect of the workplace. Redesigning processes to be ergonomically correct leads to healthier workers and more efficient methods of production.

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### References

1. Course website - [http://courselink.uoguelph.ca](http://courselink.uoguelph.ca)