Senior Capstone Project: A Gantry Crane Utilizing Fluid Power

Students: Emily Theisen, Ian Meissner and Romulo Siqueira.
Advisors: Dr. Selin Arslan, Dr. Liping Liu and Dr. James Mynderse.
Sponsor: National Fluid Power Association.

Objective

Gantry cranes are used to move large loads horizontally and vertically. In industrial applications gantry cranes are an important part of the fabrication and production process as they aid in the transportation of materials to and from work cells. The use of overhead gantry cranes can reduce labor costs and can improve working conditions and safety.

Figure 1: An industrial gantry crane

The objective of this project is to design and fabricate a classroom-scaled gantry crane for material handling. The crane must be fluid powered and be capable of supporting at least a 50 lb. load while moving across a 10 ft. work space. The crane will be able to lift to a height of at least 2 ft. and move horizontally in a single axis. The structure will be disassembled for storage. Operation of the crane will be controlled by a human interface system. In future semesters, the gantry crane will serve as a test bed and instructional tool in fluid mechanics, instrumentation, and control theory at both the undergraduate and graduate level.

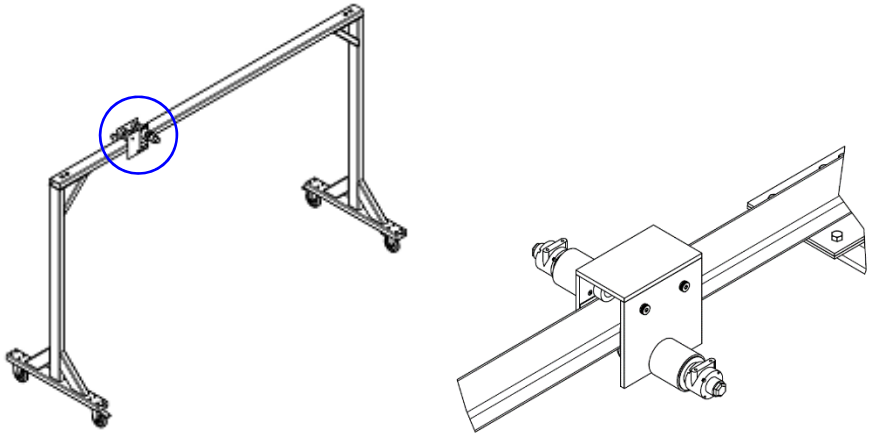
Fluid Power

Early in the design process, pneumatic power was selected for actuation. While hydraulic power is more realistic for an industrial-sized gantry crane, the classroom application favored pneumatic power. In our smaller scale application, the high power density of hydraulics is not necessary, but the cleanliness of pneumatics will significantly improve disassembly for storage. Pneumatic power is also more cost effective than hydraulic power for this application.

Mechanical Design

The structure design of this project consists of two T-frame sides with a beam connecting them together at the topmost point (Fig. 2a). This frame structure has locking swivel caster rollers at the base that will allow for easy movement and positioning of the crane. The frame structure will be fabricated from 2×4 rectangular aluminum tube. The top beam will be attached with four bolts and will be removeable from the sides for easy storage. The columns will be 2 in wide by 6 ft. tall and will support the top beam which measures 9 ft. by 4 in. A shelf will be attached to one of the T-frames to support the air compressor.

A trolley (Fig. 2b) will be located on the top beam and will house two low speed pneumatic motors (Fig. 3). One motor will be attached to a pulley responsible for the vertical movement of the load. The second motor will be responsible for the horizontal movement and will be attached to two 3-in wheels, which will drive the trolley horizontally.



(a) (b)

Figure 2: (a) Gantry crane structure; (b) Magnified trolley section

Pneumatic Motor Control

Pneumatic H-bridges (Fig. 4) will provide both speed and directional control of the trolley and crane hook via a tethered remote and Arduino microcontroller. The pneumatic H-bridge was prototyped on a Festo pneumatic testbed in Lawrence Technological University's Mechatronics Lab. The microcontroller and accompanying electrical circuit were used to control the Festo solenoid valves. The pneumatic H-bridge system was demonstrated to provide bi-directional motor control.

Figure 3: Low Speed Pneumatic Motor

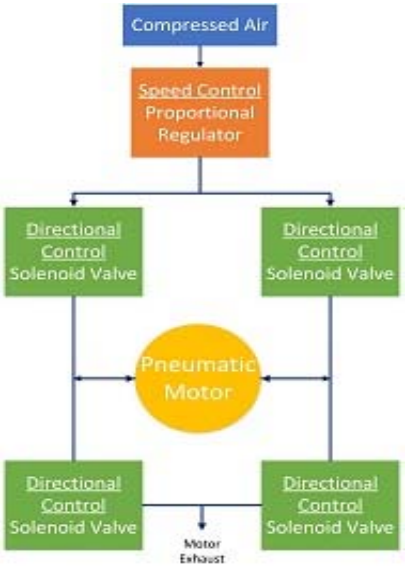


Figure 4: Pneumatic H-Bridge

The operator will control the direction of the crane hook with 5 pushbuttons on the tethered remote. The first button will function as a safety enable button that must be pressed at all times in order to allow for any motion. The other four buttons will be directional control for the trolley: up, down, left, and right motion. The overall speed of the system will be controlled with a proportional regulator located on the main pneumatic line just after the air compressor. This will allow the operator to control the speed of the crane hook by controlling the pressure being supplied to the motors. This adjustment can be made by the operator using the potentiometer located on the tethered remote.

Future Work

During the Spring 2014 semester, students will purchase materials and fabricate the designed gantry crane. After the operation of the crane is validated and all performance specifications are met, the crane will be presented to the department.