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COMBAT ZONE

Featured This Month:

RIOBOTZ COMBOT TUTORIAL SUMMARIZED

HammerBots

● Summarized by Kevin M. Berry

Professor Marco Antonio Meggiolaro, of the Pontifical Catholic University of Rio de Janeiro, Brazil, has translated his popular book — the *RioBotz Combot Tutorial* — into English. In May's Combat Zone, *SERVO* summarized the "LaunchBot" portion of his exhaustive chapter on weapons. Chapter 6 — Weapon Design — is a college level textbook on the design and operational theory of today's combat weapon systems. In this article, we present a much simplified version of the HammerBots section of this chapter. Marco's book is available free for download at **www.riobotz.com.br/en/tutorial.html**, and for hard copy purchase (at no profit to Marco) on Amazon, published by CreateSpace. All information here is provided courtesy of Professor Meggiolaro and RioBotz.

HammerBot Design

Hammers usually need to be pneumatically powered to be effective. This is because they have to reach their maximum speed in only 180 degrees of rotation. Since most pneumatic actuators are linear cylinders, you'll need some type of transmission to convert linear into rotary motion. This can be done in several ways. One of the lightest solutions — adopted by the super heavyweight The Judge — is implemented using a pair of opposing heavy-duty chains (colored in red and blue in **Figure 1**). When the right port of the cylinder in the figure is pressurized, it makes the piston move to the left and pull the red chain which generates a rotary motion in the hammer.

The hammer can have a spring mechanism to move back to its starting position after an attack. The best solution, though, is to have a double-acting cylinder to retract the hammer at high speeds, with the aid of the blue chain shown in the **photo**. This allows the hammer to get ready in less time for the next attack. Also — and most importantly — it guarantees enough torque to the hammer in both directions to work as a self-righting mechanism in case the robot gets flipped upside down.

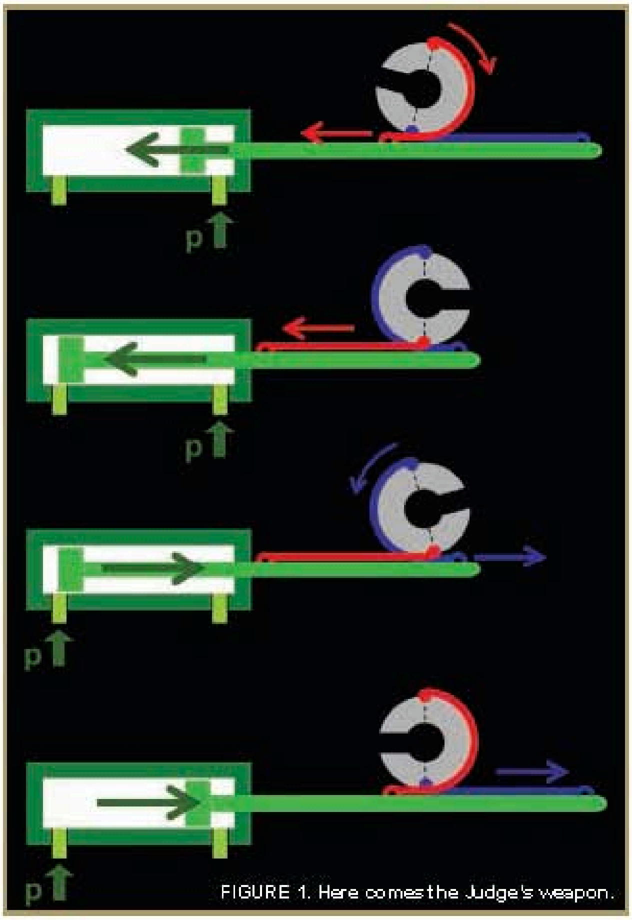


FIGURE 1. Here comes the Judge's weapon.

Hammer Energy

No matter which mechanism you use to generate a rotary motion, it is not difficult to estimate the energy and the top angular speed of the hammer in a pneumatic robot. If we assume no energy loss due to friction or pneumatic leaks, then the energy delivered by the cylinder is approximately equal to its operating pressure times its internal volume. If the hammer has much more inertia than the cylinder piston and the transmission mechanisms, then we can say that this energy is entirely converted into kinetic energy in the hammer.

Through a rather long — but not particularly difficult — mathematical proof, Prof Mathmatico, er, make that Meggiolaro, shows that it is slightly better to design the transmission system such that the hammer hits when the piston is extended or "pushing," rather than retracting or "pulling." Depending on the transmission design, this might place the cylinder in the front of the robot (more exposed to attacks) and limit the reach of the hammer head. These are details best understood by reading section 6.7.1 of the tutorial.

Hammer Impact

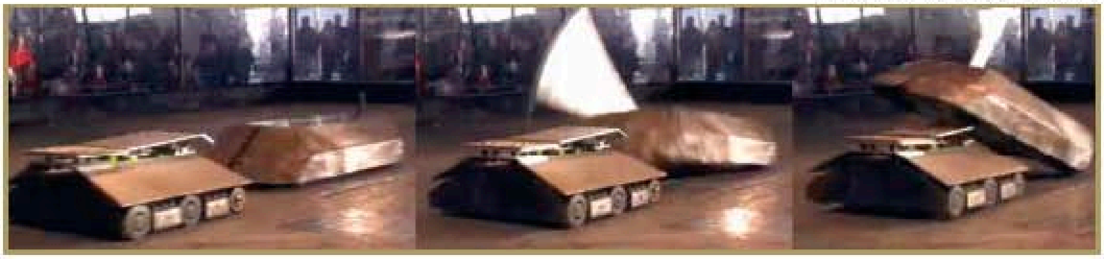
The sample system used for calculations is:

- 1,000 PSI system
- 4" bore cylinder with a 1.25" piston
- 8" piston stroke with 6.5" used before contacting the opponent
- Hammer handle is 36" long with a mass of 15 lb, with a 10 lb hammer head

If we place the cylinder in the back of the robot, using the mechanism from **Figure 1** then the energy from the pulling motion would accelerate the hammer up to 521 RPM, resulting in a hammer head speed of 111 MPH! (Editor's note: This is why The Judge is one of the most feared bots in combat robot history — imagine armoring the TOP of your bot for this magnitude of impact!)

Note that the robot will tend to move backwards during the acceleration of the hammer. Therefore, it needs to compensate for that by braking its wheels. The chassis will also tend to tilt backwards from the reaction force of the hammer accelerating forward. Powerful hammerbots may even see their front wheels lift off the ground because of that, as shown in **Figure 2**. You can see The Judge tilting backwards right before it even touches the opponent. Excessive tilting may leave it vulnerable to wedges or launchers

FIGURE 2. The Judge vs. Ziggy.



that might sneak in underneath (as shown in the right side of **Figure 2**, just before The Judge was launched by Ziggy). To avoid that, it is a good idea to move the center of mass of the hammerbot forward.

The right portion of **Figure 2** shows that the tilting angle of the chassis is increased even more after the hit, due to the reaction impulse from the impact. The speeds after the impact and all the involved impact energies can be calculated from the very same equations used for spinners. Since the attacked robot is hammered against the arena floor, it usually does not move its center of mass, it only deforms due to the attack. This impact problem is similar to an offset bar spinner hitting a flexible but very heavy wall as shown in **Figure 3**.

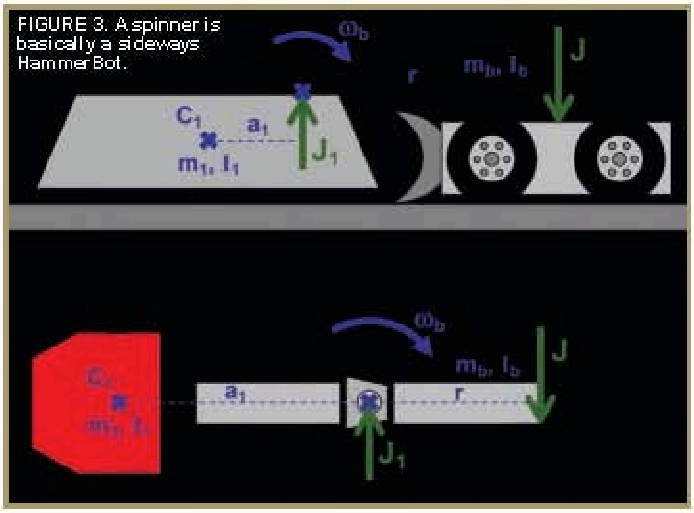


FIGURE 3. A spinner is basically a sideways HammerBot.

The attacked robot would then have an infinite effective mass (not exactly infinite, but that of the Planet Earth!), while the hammerbot's effective mass would work like an offset spinner. The speed of the attacked robot after the hammering is, of course, zero. The hammerbot chassis gains vertical speed and may, in fact, spin backwards.

Note that if the back wheels of the hammerbot are still in contact with the ground immediately after the impact against the opponent, then a second impact will probably occur. With the back wheels gaining a downward speed after the initial impulse, they will press against the arena floor and receive a vertical reaction impulse. This back wheel impulse is good for the hammerbot, because it prevents its chassis from tilting backwards too much. The final linear and angular speeds of the hammerbot chassis can be calculated using the same equations from the second impact that happens when a robot is hit by a drumbot or vertical spinner. (These proofs are fully developed in the Tutorial.)

Summary

In this mere 1,000 words, I've managed to grossly simplify the treatment of this subject from the Tutorial. A longer article on ThwackBots — a close cousin to HammerBots — is in the offing, which should serve to provide a more thorough understanding of the mechanics of this interesting and scary weapons system. **SV**

BUILD REPORT: A Reintroduction to Wedges

● by Thomas Kenney

In mid 2007, I began the construction of Gilbert — MH Robotics' first antweight. The bot has gone through many revisions over the years, beginning as an inertia-labs kit with sheet metal bent over the top to form a wedge, and going on to become one of the flagships of our fleet of overpowered bricks sporting hinged wedges. The second revision of our hinged wedge design involved a titanium shaft supporting two to three blocks of UHMW or aluminum, to which was secured the wedge piece itself. This general design suffered from a few issues before it was applied to more of our bots; most of these


FIGURE 1. Our original hinged wedge assembly, including the shaft, 7075 aluminum plate, and UHMW blocks.