Automated Bioanalytical Sample Tube Uncapping Device

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Bioanalytical testing is a billion dollar industry around the world. Extensive protocols require considerable manpower to complete the usually repetitive tasks. One such task is uncapping and recapping small sample tubes. Technicians at the client's laboratory currently uncap 500-700 tubes a day, which requires a repetitive twisting motion that causes significant strain on their hands and impedes their workflow.

Several sample tube uncapping devices are already on the market that are capable of fully-automatically removing the caps from a rectangular rack of tubes in a very short period of time. The majority of the work, besides manually loading the rack, is done by small rotating head(s) located above the rack. These heads perfectly fit into the socket in the top of the sample tube cup, allowing them to easily insert and generate enough torque to remove the cap. Despite their intended function, many laboratories are unable to use such products as they require all sample tubes to be uniform. Not only does each tube need an identical socket, but each needs to be of exact height/diameter in order for the head to fit. This is the main problem for the client, as the sample tubes they are testing come in from a variety of different sources, none of which have sockets for easy cap removal. The differing tube dimensions necessitate a more versatile uncapping mechanism where slight changes in height and cap diameter do not compromise the functionality of the device.

Not only did the design have to be tailored to the lab's sample tubes, but also to the Hamilton test tube rack utilized by the technicians. In terms of workflow, the tubes are originally held in the rack, lifted out to manually remove the cap, and placed back in the rack, as that holds the tubes in place for the pipetting device that is next in line. This led the team to develop a device that removes the caps while the tubes stay in the rack, saving both the time and manual effort of taking the tubes out to uncap them individually.

The premise of the design is that the rack will be slid through the device, which has two high-friction, cylindrical rollers on opposite sides of the opening. As the rack is pushed through, the caps of the tubes contact the rollers, which act in a direction to twist them off. As the rack passes through, each cap is sequentially removed, leaving just the tube bodies sitting in the rack after exiting the device, ready for the technician to use with the bioanalyzer. The mechanism is unique based on the both the dimensions and form of the rack used by the lab.

The device is more one-of-a-kind than capable of being commercialized, as it has been specially designed both around the specific tools (test tubes, rack) and workflow already used in the lab. The team has stayed in contact with the client, asking for the preferences of the technician when critical decisions must be made. Though it is catered to their specific wants and needs, any bioanalysis company using the same Hamilton brand racks and similar work patterns as the client may find benefit in the product.

Testing the prototype determined how efficiently and successfully the device removed the caps from a rack of tubes. Comparing the time required by the technician and the device to uncap one rack of 32 tubes allowed the team to determine whether utilizing the product impacted workflow. The success of the design was evaluated by determining the percentage of caps that were successfully removed, and comparing it to the success rate of the technician. Finally, analysis was executed on the contents of the sample tubes before and after uncapping to detect any contamination caused by the use of the device. Success in these aspects of the design reinforced that the device will save the technician time, save the company money, and significantly decrease the likelihood of injury due to repetitive motion, all without impacting the workflow of the client.