Title: Swirling Mixer Mechanism

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1. Introduction:

The Swirling Mixer Mechanism is designed to mix reagents in a beaker without any direct contact between the mixing elements and the liquid. The primary objective of this mechanism is to achieve optimal mixing through the controlled movement of the beaker, while preventing any spillage. The mechanism must be compatible with the provided servomotor assembly, which consists of three stationary connectors and a rotary connector driven by a servomotor. This report details the design, assembly, and operation of the mechanism, alongside the analysis and testing outcomes.

2. Design Specifications:

- **Material and Dimensions:** There are no restrictions on the choice of materials for the mechanism. The overall dimensions, including the servomotor assembly, must not exceed 100 mm x 100 mm x 100 mm.
- **Mechanism Configuration:** The mechanism does not need to be monolithic and can consist of multiple interconnected rigid or flexible structures. However, it is restricted to being driven solely by the servomotor's rotary connector.
- **Kinematic Mounting:** The beaker must be positioned consistently at the same location on the mechanism using kinematic mounting principles, without the use of adhesives or other attachment aids.
- **Servomotor Actuation:** The mechanism's movement is actuated by a servo motor interfaced via Arduino, with the motion sequence programmed to last no longer than 15 seconds.

3. Mechanism Design and Assembly:

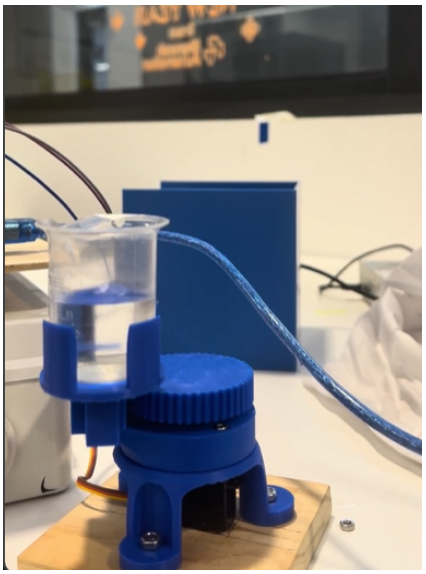

Figure 1: 3d printed design

The mechanism features a linear rail platform that engages with the servomotor’s rotary connector via a rack and pinion system. The platform is designed with custom grooves that align precisely with the beaker’s base to ensure consistent placement. Raised edges on the platform prevent the beaker from slipping during operation. Stability is further ensured by anchoring the mechanism to the servomotor assembly via three stationary connectors. All components, except for the ball bearings, are 3D printed, allowing for straightforward assembly post-mounting.

The assembly of the mechanism is very easy and clear, it has to be done only once. After that there is no need to remove any parts of the mechanism to take the beaker or to remove the mechanism from the base

To prevent spillage during operation, the mechanism is designed to move the beaker in a controlled Linear path, which encourages swirling without causing liquid to rise above the beaker's rim. The Linear path is achieved by programming the servo motor to alternate between slow and rapid rotations, creating a sloshing motion conducive to mixing.

CAD design:

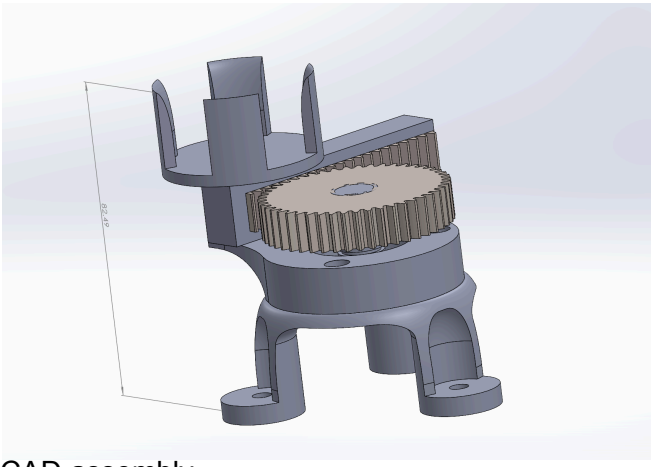

Figure 2: CAD assembly

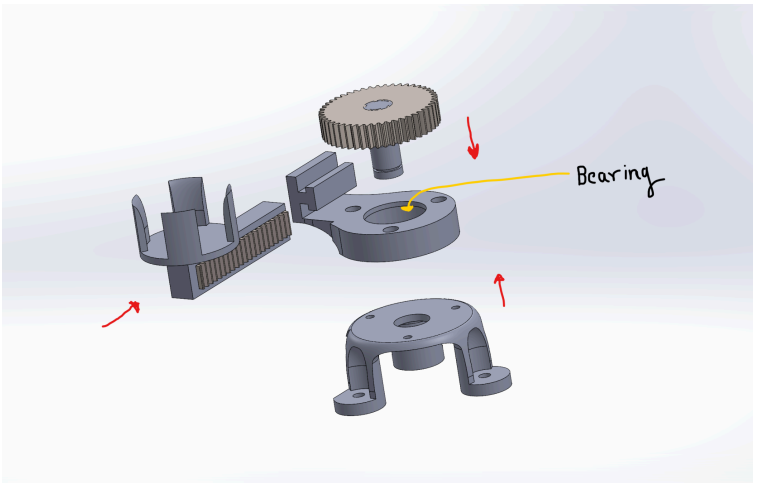

Figure 3: CAD assembly parts

4. Operation and Control:

The servomotor is interfaced with an Arduino microcontroller, programmed to execute a sequence of rotations designed to induce mixing. The motion sequence is limited to 15 seconds, with a series of alternating slow and rapid movements. The slow rotations help create a swirling motion, while the rapid rotations briefly accelerate the beaker's contents, enhancing mixing efficiency without causing spillage.

5. Analysis and Evaluation:

- **Mobility Analysis (Kutzbach Criterion):**

$$n \text{ —>no. of links = 2 gear and the rail}$$

$$j_1 \text{ —> no. of single DOF joints = 2}$$

$$m = 3(n-1) - (j_1)$$

$$m = 3(2-1) - 2$$

$$m = 1$$

The mechanism's mobility was analysed using the Kutzbach criterion, confirming that it has the necessary degrees of freedom for the desired motion which is 1 degrees. The mechanism's configuration ensures that the beaker can only move in a controlled linear direction , repeatable manner, achieving the required kinematic constraints.

- **Kinematic Constraint:** The mechanism successfully maintains the beaker's position due to the specific alignment grooves on the platform, ensuring that the beaker remains in place even during rapid movements. This satisfies the kinematic constraint requirements outlined in the project brief.

- **Manufacturability:** The mechanism is designed for easy manufacturing. The inclusion of a ball bearing on the gear shaft minimises wear, and the replaceable rack can be swapped for a genuine linear rail if required. Components are suitable for fabrication via CNC or plastic moulding.

6. Testing and Results:

The Swirling Mixer Mechanism was tested with 20 mL of water in the beaker. The mechanism was then operated according to the programmed motion sequence. The following observations were made:

- **Mixing Effectiveness:** The liquid in the beaker demonstrated effective swirling.
- **Spillage Prevention:** No spillage was observed during the test, confirming the mechanism's ability to contain the liquid within the beaker throughout the mixing process.
- **Robustness and Stability:** The mechanism remained stable and intact during and after operation, demonstrating robustness in design. It could be easily attached and removed from the servomotor assembly without requiring any special tools or adjustments.

7. Conclusion:

The Swirling Mixer Mechanism successfully meets the design criteria by providing an innovative, non-contact mixing method driven by a servomotor. The design ensures precise beaker positioning, effective mixing, and spillage prevention. Its robust and modular construction supports reliable operation in reagent mixing applications.

8. Recommendations for Future Improvements:

Future enhancements could include integrating sensors to monitor and dynamically adjust the mixing process based on real-time feedback. Additionally, developing interchangeable platforms could accommodate various beaker sizes or more complex mixing tasks, expanding the mechanism's applicability.