Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

Accurate and Reusable Chemotherapy Pump

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Introduction

Chemotherapy is administered in 2–6-week cycles consisting of multiple infusion sessions. The IV pumps used are typically either expensive reusable units with high accuracy or very inexpensive disposable elastomeric units with terrible accuracy. A less expensive, less disposable electro-mechanical pump can deliver high accuracy through feedback motor control and high value through being reusable for the entire treatment cycle.

Objectives

- Create a single-therapy pump for chemotherapy patients
- Ensure 5% flow rate accuracy to compete with leading single-therapy pumps
- Explore different pumping mechanisms to reduce cost
- Pump must be lightweight and small (ambulatory)

The desired specifications are defined in Table 1.

Design Requirements

Table 1. Performance standards and specifications

Metric	Unit	Desired Value	Achieved Value	Relevant Need
Flow rate accuracy	%	< ±5	±1.5	Accuracy
Volumetric flow rate	mL/h	1 - 30	1-30	Accuracy
Cost	$	< 150	$109	Affordability
Zero-Flow Pressure	psi	> 10	12	Safety
Pump weight	lb.	< 1.1	0.39	Ambulatory
Physical volume of pump	in3	< 40	17.95	Ambulatory
Battery life	hours	48 hours	48 hours @ 5 ml/hour	Usability

Methods

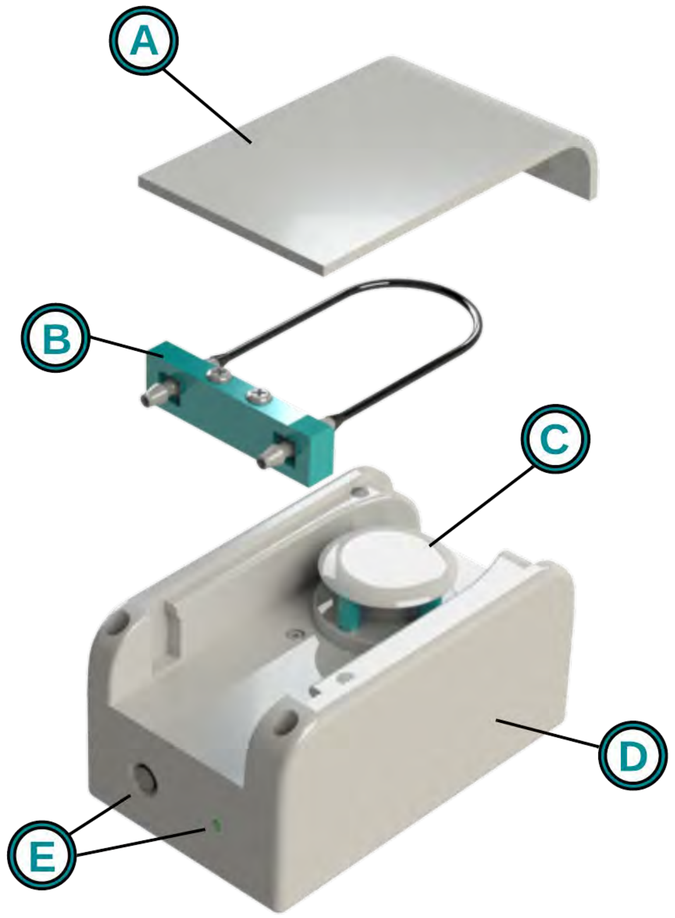
A test bed consisting of an adjustable sliding rail (to control the stretch/tension of the tubing), and a custom rotor was designed to determine the following pump properties:

1. **Tubing properties** – Diameter, Flexibility, Tension, Length
2. **Number of Rollers**
3. **Power Usage**

An additional test was designed to determine:

1. **Volumetric Flow Rate and Accuracy**
2. **Zero-Flow Pressure**

Final Design



Key Design Components

A - Cover to prevent outside debris from entangling between rotor and tubing.

B - Disposable cassette that is fixed in the housing to maintain tube tension.

C - Rotor with 4-roller configuration to ensure the tube is in contact with a roller at all times during the pumping cycle.

D - Pump housing to protect pump interior mechanism.

E - User interface including an infusion start/stop button and led light to show the pump status.

Motor Control Diagram

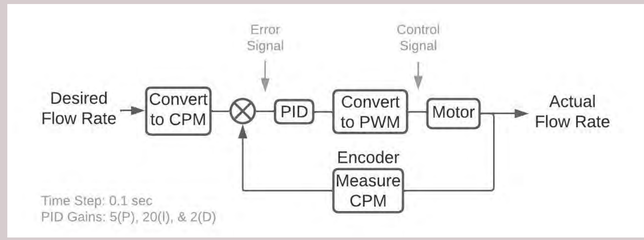


Figure 2: Block diagram of the motor control algorithm that maintains nominal pumping speed

Results

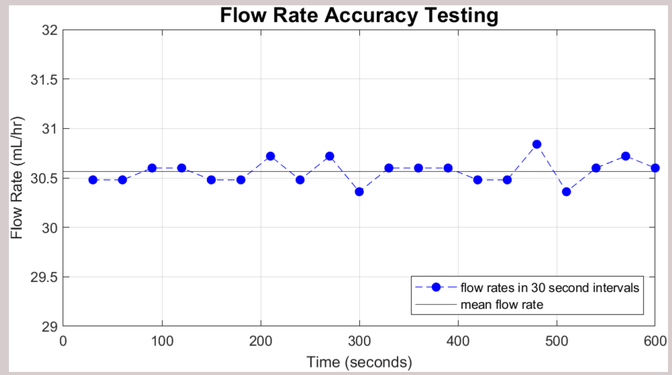


Figure 3. Flow Rate (mL/hr) against time (seconds) collected for accuracy testing

To validate the pump's accuracy, fluid is pumped into a mass scale over a period of time. The data is converted into flow rates (see Figure 3.). The accuracy is determined using statistical confidence intervals. Zero-flow pressure is tested to ensure backflow cannot occur. The test results of these parameters are shown below and are compared to their required specifications.

Table 2. Results of tested values against required metrics

Metric	Unit	Required Value	Tested Value
Flow rate accuracy	%	< ±5	±1.5
Zero-Flow Pressure	psi	> 10	12

The above metrics have been met, validating safe pump operation.

Conclusion

The chemotherapy pump met all specifications. These findings prove that an affordable, accurate, and lightweight single therapy pump is feasible in the realm of medical devices.