BREATH OF HOPE

HopeFlo

Introduction

HopeFlo is a high flow nasal cannula (HFNC) system for respiratory failure associated with low blood oxygen levels. We have designed it in a simple and easily manufacturable manner. At the heart of the system is an air-oxygen blending mechanism to control FiO2 (Fraction of inspired oxygen) and the total/peak flow rate. Other components in the system are a humidifier, heater, pressure sensor, Human Machine Interface, micro controller and a drive mechanism to control the valves. Please refer to the section on system design for details.

In phase I, we will build the heart of the system, FiO2 and Flow control, prototype and test it. In phase II, we will build the remaining modules and make it a fully functional unit. HopeFlo is an IoT device, with the objective of reducing exposure of medical personnel to aerosols. This is done by allowing adjustment of bedside settings remotely.

The HopeFlo project is part of the BreathOfHope initiative. The vision of BreathOfHope is to strengthen the culture of social innovation. A culture where people from different walks of life come together to fight societal challenges. BreathOfHope projects share a few common traits:

1. Open Source. (CERN OHL-P v2.0.)
2. We encourage our volunteers to get to know each other, resulting in strong networks of innovators from multiple disciplines.
3. We encourage social startups to take our work to its beneficiaries.
4. Global outlook. We seek participation and use from teams worldwide.

Design Concept

We started with the idea of a varying diameter venturi that could be adjusted based on flow requirements. After a few iterations and virtual prototyping, we arrived at a simpler concept.

The new concept which is presented below, involves two separate passages for air as well as oxygen. Each passage will have separate flow control valves that are driven by stepper motors. The opening of valves will be based on multiple factors like input pressure of oxygen, air, peak FiO2 and flow rate (set by the Doctor).

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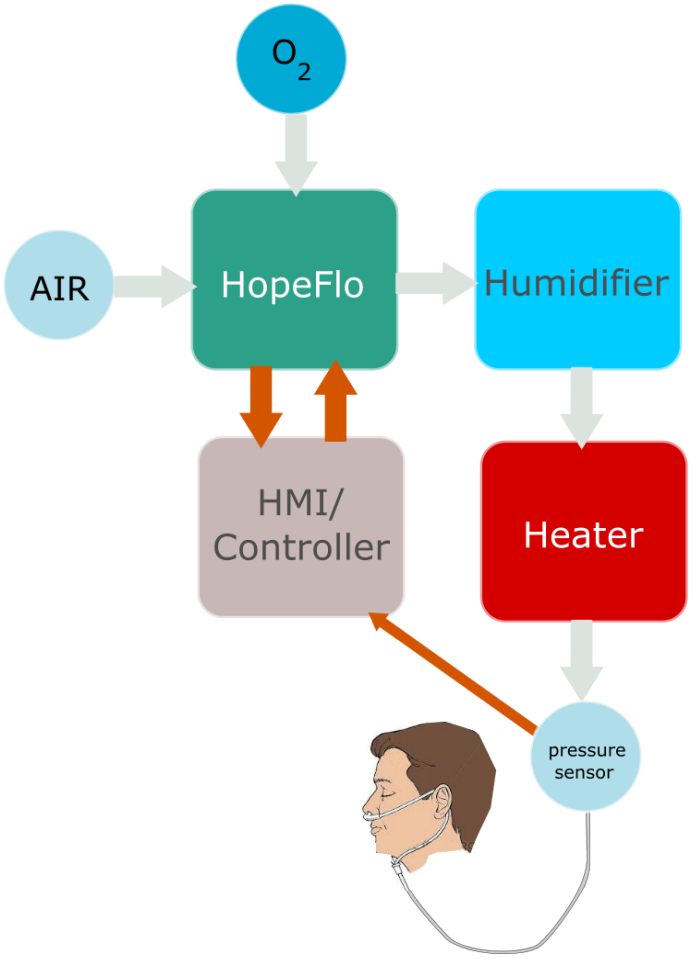
HopeFlo

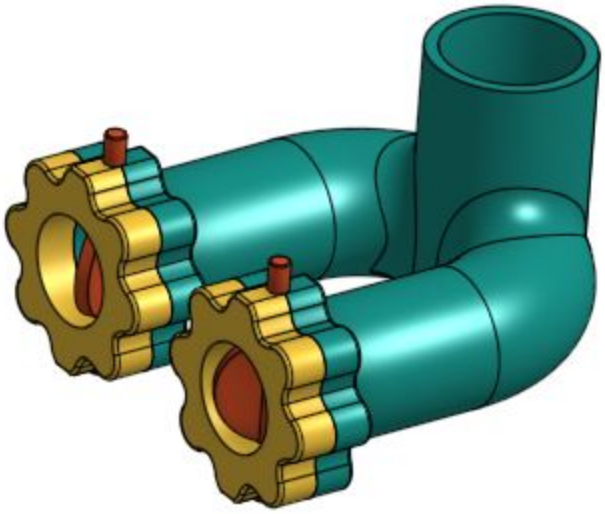
System Design



The heart of the system is the HopeFlo module. This module receives air and oxygen from the hospital supply lines. In the eventuality of air not being available, it can be set to fully closed, to allow the system to operate with only oxygen, at a lower flow rate. The Controller module receives input from the HMI, where the doctor sets two parameters - flow rate, and FiO2. Based on these settings, the controller chooses the right opening angles for the two butterfly valves. The HopeFlo module also enhances complete blending of air, by means of a spiral pattern inside the outlet.

The blended air-oxygen mixture is then passed through a humidifier and heater combination, to achieve the humidity and temperature controls set by the doctor. Finally the output air is fed to the patient through a comfortable nasal cannula. The pressure at the nasal end is a dependent variable generated when the set flow meets the resistance of the patient's respiratory passages. From the patient end, the pressure is monitored to ensure that the system is working correctly, and to alert the nurse if required. This is not a pressure controlled system unlike continuous positive airway pressure (CPAP) systems.

HopeFlo module

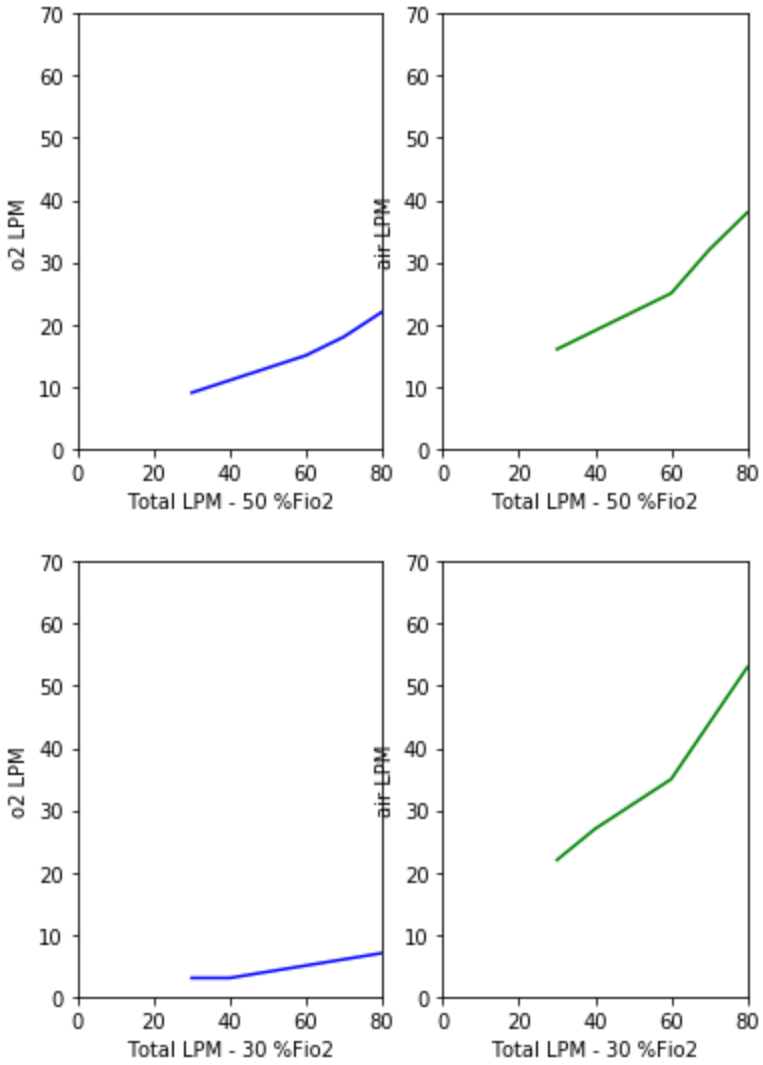


The HopeFlo module consists of two passages with butterfly valves on each to control the flow by changing the angle from 0 to 90 degrees as mentioned in the concepts section. The outlet portion will be connected to the nasal cannula tube. The two inlets will be connected to oxygen and air respectively which are assumed to be at 2 bar. The valves are controlled separately by two stepper motors. A control system will set the valve opening based on the values of Fio2 and flow rate set by the user. A pressure sensor at the outlet (before the cannula) will also be checked to monitor the generated pressure in the circuit. The output channel of the module has spiral guides that blend the air and oxygen during flow.

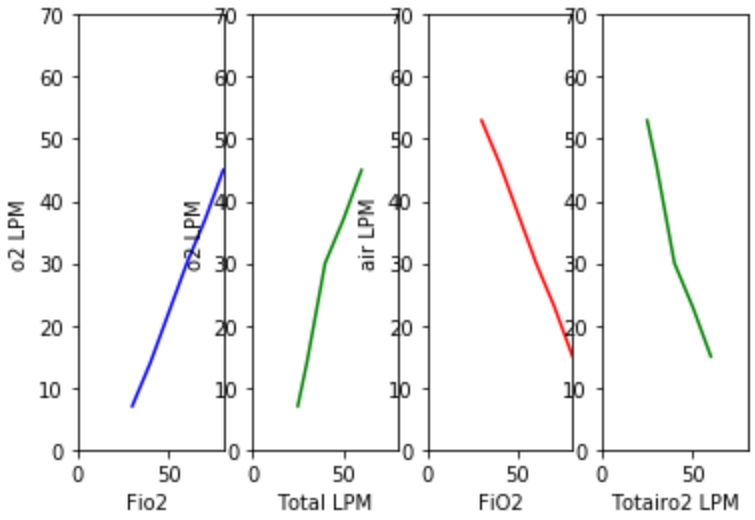
Simulation Studies

Here we present results from simulation studies. This gives an early picture of how the actual device will perform.

Relation between FiO2, Total flow with air flow and oxygen flow

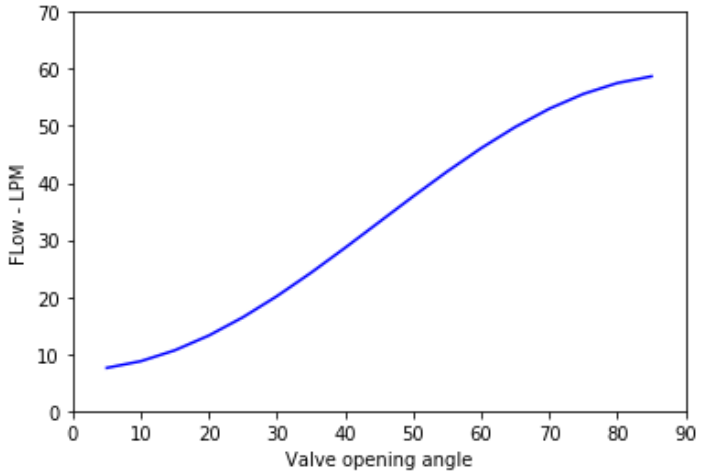


Change of oxygen flow and air flow w.r.t FiO2 and Total Flow



Relation between flow rate and valve opening angle

We have arrived at a relation between the opening angle of the valve and the flow rate which is as given in the image below. The total opening is 90 degrees. So we have made a map between the angle and the flow rate. Maximum flow rate would be 60 LPM.



Timeline

	Tasks	**Est. Date**
Phase 1	Core module (HopeFlo module) design and simulations - FiO2 and flow settings, blending	20/04/2020
Phase 2	Prototyping and testing of HopeFlo module Controller, electronics design and prototyping	25/04/2020
Phase 3	Heater + Humidifier, controllable air temp and humidity, temp sensing Testing at a third party test facility	01/05/2020
Phase 4	Design for mass production	07/05/2020

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