Controls of Gearless Wind Energy Transfer

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**ABSTRACT**

The speed control of wind driven hydraulic machinery is challenging, since the intermittent nature of wind imposes the fluctuation on the wind power generation and consequently varies the frequency of voltage. On the other hand, as the load of the generators increases, the frequency of the voltage drops. Therefore, hydraulically connected wind turbine and generator need to be controlled to maintain the frequency and compensate for the power demands. This poster introduces a closed loop gain scheduling flow control technique to maintain a constant frequency at the wind turbine generator. The speed control profile obtained from a gain scheduling PI controller demonstrates a high performance speed regulation. The simulation results demonstrate the effectiveness of both the proposed model and the control technique.

**MATHEMATICAL MODEL**

- The governing equations of the hydraulic machinery are obtained to create a mathematical model of the hydraulic wind energy harvesting system.

\[ P_m = P_{in} + P_{out} \]

- MATLAB Simulink® simulation package is used to create a Simulink model of the system. The model incorporates the governing mathematical equations of every individual hydraulic component in block diagrams.

**SYSTEM DESCRIPTION**

The figures below display a schematic representation of the system:

- The system operation is shown subsequently:

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**MODEL VALIDATION**

- The SimHydraulics toolbox is utilized to create a hydraulic system, which is identical to the proposed hydraulic wind energy harvesting model.

- The most significantly noted dissimilarity between the two models are the 2-way directional valve and pipe models:

1. The pipe block encompasses complex dynamics, which are neglected in the proposed mathematical model.
2. A proportional flow control valve has been used in the proposed model, which distributes hydraulic flow according to an input signal.

- In order to validate the proposed hydraulic model with SimHydraulics, and to analyze the impact of dissimilarities on the simulation outputs and the controls, the models are compared in two configurations:

1. Without Bypass
2. With Bypass

- PI CONTROLLER

  - The objective of the flow control is to compute the angular velocity deviation from the reference and apply a corrective control signal to the valve to adjust the valve opening that allows the flow controls.

  \[ C(s) = \frac{K_p + K_i}{s} \]

- To achieve a fast dynamic response, high proportional and low integration gains are required. To reduce settling time and undershoot and to decrease the steady state tracking error low proportional and high integration gains are applied.

<table>
<thead>
<tr>
<th>Control Gain</th>
<th>Quantity</th>
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**RESULTS AND DISCUSSIONS**

The results show the dynamic response of the hydraulic system to a 1500 rpm angular velocity to the hydraulic pump.

The simulation results verify the effectiveness of the controller in maintaining the primary generator angular velocity.