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XXXIII Cycle

Innovative Algorithm for Washer Unbalance Detection

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Research context and motivation

Nowadays the demand of washing machines that will be placed in small spaces within the house is increasing and also the interest in reducing to the lowest possible the noise and the vibration of the appliances.

The main targets of this research are:

- Avoid tub interference with the cabinet during tumbling and/or spinning
- Control the force on the bearing to avoid dangerous values that will reduce the lifetime of the bearing
- Vibration reduction during spinning
- Improve stability of the washer during spinning
- Significant reduction of the noise during spinning
- Reduce cycle time by spinning on higher speed
- Increase spinning efficiency
- Place washer on pedestal

Some years ago the maximum load size capacity of the washer was 6kg. Now the standard is 10kg and the trend is to increase it furthermore. The volume of the drum is increasing and the gap between tub and cabinet is reducing. High performance algorithm is required because of space constraints between tub and cabinet.

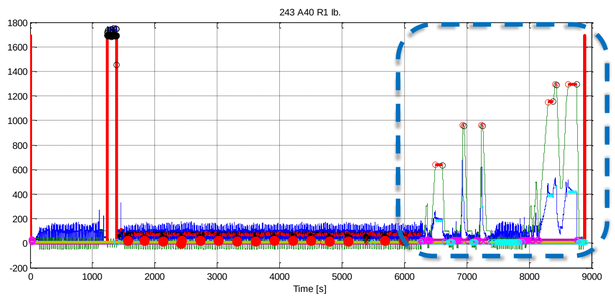
6kg capacity washer

10kg capacity washer

Addressed research questions/problems

The washing cycle can be divided into 3 parts:

- Heating phase
- Tumbling phase (low drum speed 50-60 rpm)
- Rinse and Spin (very high drum speed 1200-1400rpm)



Spinning phase

During the first part of the spinning phase (distribution ramp) the laundry will be distributed inside the drum. At the end of the distribution ramp (usually at 100 rpm) the laundry is satelized and cannot move anymore inside the drum. In addition the water extraction during spinning phase could be not uniform changing the position and the weight of the unbalance.

The unbalance load during spinning phase will affect:

- Mechanical bearings stress
- Noise and vibration
- Energy consumption
- Run to run repeatability (noise and energy)

Problems:

- Cost (domestic appliance cannot afford expensive HW)
- Space constraint between cabinet and drum requires high precision unbalance detection algorithm (50g unbalance load or lower should be detected)

An innovative sensorless algorithm is required to estimate the loading torque with the following resolution:

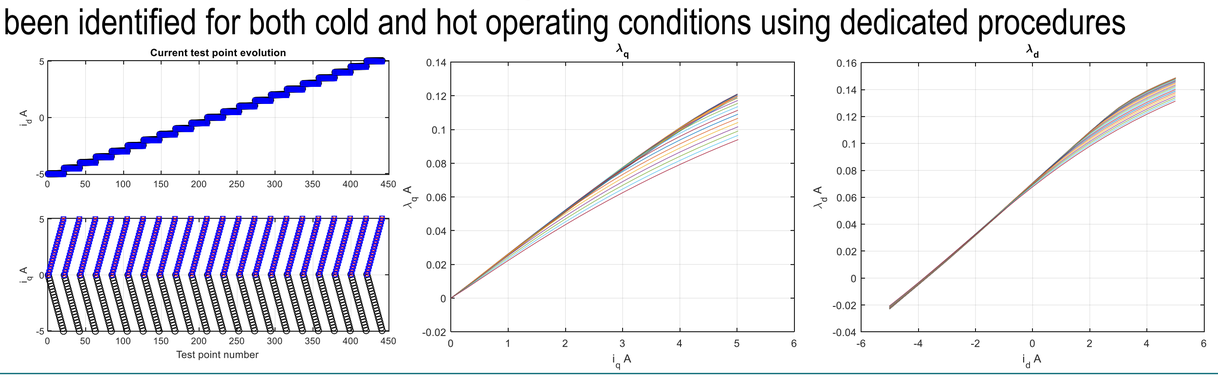
- 100 Nmm for Direct Drive motor
- 10 Nmm for Belt driven motor (assuming pulley ratio = 10)

Novel contributions

Washing machine motor has to be as cheap as possible. Usually the motor working condition is not only in the linear region but even in the non linear region.

The motor magnetic model identification is a key point to estimate the torque according to the required resolution.

Motor temperature could affect the magnetic model estimation so the motor flux maps have been identified for both cold and hot operating conditions using dedicated procedures

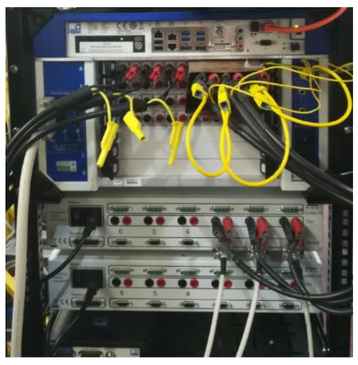


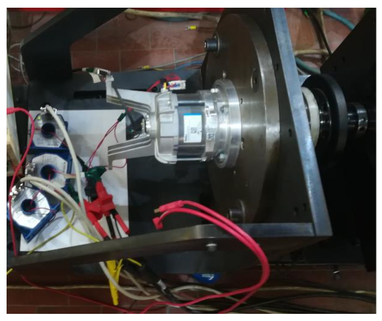
Adopted methodologies

Direct Drive motor and Belt Driven motor were tested using the Politecnico of Torino motor test bench using the following configuration:

- 3 voltage sensors
- 3 current sensors
- Torque sensor
- Position sensor (encoder)

Voltage, current,torque and position are recorded by HBM system and post processed to identify the magnetic model in cold and warm operating condition.





Future work

- Develop an innovative sensorless algorithm to estimate motor speed and motor torque during all the spinning profile.
- Develop an innovative sensorless algorithm to estimate the unbalance during all the spinning profile.
- Use the estimated unbalance to increase or decrease the spinning speed in order to find the best tradeoff between spinning performance and reliability

List of attended classes

•	08IXTRV	Project management (15/2/2018, 6.67)
•	02LWHR	Communication (15/2/2018, 6.67)
•	01RISRV	Public speaking (15/2/2018, 6.67)
•	02RHORV	The new Internet Society (13/3/2018, 8)
•	01PJMRV	Etica informatica (14/3/2018, 26.67)
•	01PJMRV	Programmazione scientifica avanzata in matlab (14/3/2018, 26.67)
•	02ITTRV	Generatori e impianti fotovoltaici (11/4/2018, 26.67)
•	01RGBRV	Optimization methods for engineering problems (13/6/2018, 50)
•	02PJWRV	Reti ad alta efficienza energetica (13/7/2018, 66.67)
•	01LCPIU	Experimental modeling: (10/5/2019, 44)

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