Innovative Algorithm for Washing Machine: Unbalance and Inertia Detection

The washing machine is probably the most popular household appliance in the world. At the beginning of the twentieth century the laundry was preferably washed by hand using the nearest river or the municipal wash house (Fig. 1) although, some prototypes of washing machines were already developed to increase the washing efficiency while saving time.

Fig. 1. Municipal wash house.

These prototypes were manually powered (Fig. 2) and did not have a wide diffusion in fact, only after the Second World War, the washing machine spreads in the homes of many customers. At that time, the customer did not worry about acoustic noise, energy and water consumption. Appliance builder were not interested to add special cycles for delicate fabrics or other features in their washing machines because the main advantage, compared to hand wash system, was to save time and avoid a very annoying activity.

Year after year, the consumer has become more demanding, in fact current washing machines can wash a larger amount of laundry, is more efficient in terms of energy and water consumption, is much less noisy and has many additional options (special cycles, delayed start, wi-fi connection etc.) compared to that of the last half century.

Fig. 2. Hand power washing machine.

The washing machine must be as cheap as possible, so none of its components are over-sized and new technologies (such as microcontrollers) were introduced only when their cost was affordable.

In particular, some components, such as bearings, are designed to work correctly within their load limit which depends by the maximum allowed unbalance. In fact, the unbalance mass stresses the bearings with a bending moment proportional to the squared value of the drum speed (Fig. 3). If the unbalance exceeds the max allowed value, the bearings are noisier and their life is dramatically reduced with a negative impact on system reliability.

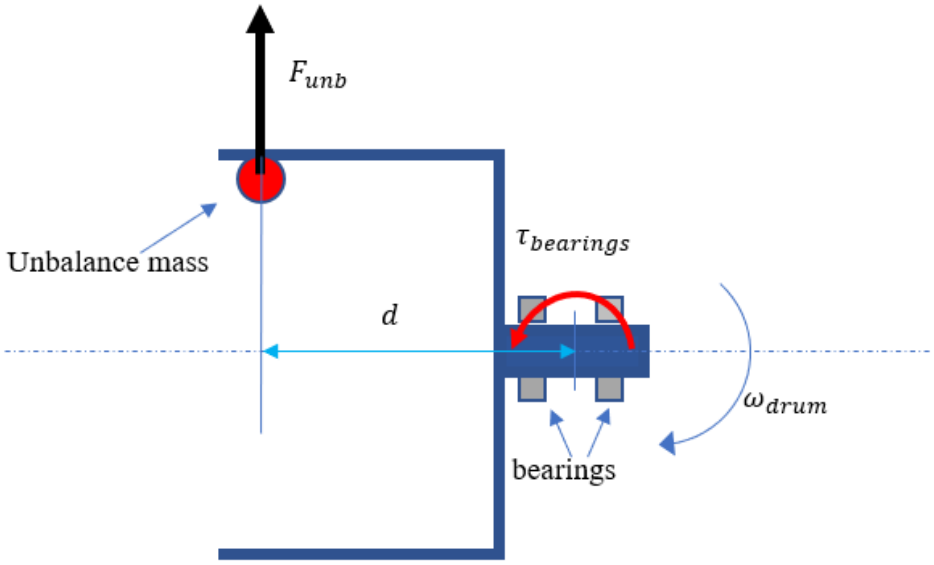

Fig.3. Effect of the unbalance mass on the bearings bending moment.

Therefore, the management of the unbalance plays a fundamental role in correctly setting the spinning parameters and reducing mechanical stress and noise during the spinning phase. In addition, the laundry inertia estimation, at the beginning of the washing cycle, has a key role to set the amount of the water, the amount of the detergent, the water temperature and the tumbling time. This leads to good washing performance without wasting energy and resources. As a consequence, a very precise unbalance and inertia detection is required to avoid mechanical stress and noise (in case of underestimated unbalance or inertia) and to reduce the water and energy consumption.

The laundry unbalance and laundry inertia estimation is performed at relatively low speed (as example between 100 rpm and 600 rpm) and, during this procedure, the washing unit moves inside the cabinet due to the unbalance load. The market trend requires to have very large drum to increase the rated capacity of the washing machine. Therefore, the inertia and unbalance estimation is now more challenging than few years ago. In fact, a larger drum reduces the available space and increases the risk of mechanical interference during the estimation process (Fig. 4).

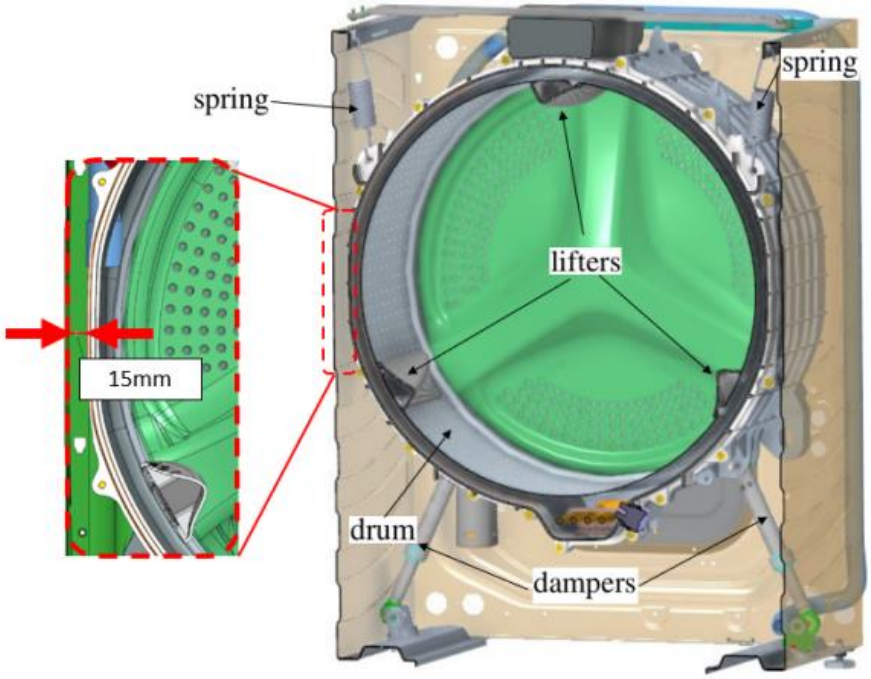

Fig. 4. Washing machine with large drum and reduced available space between drum and cabinet.

The aim of this thesis is to design a simple method to estimate the laundry unbalance and the laundry inertia avoiding the risk of mechanical interference. The suggested idea uses the existing sensorless control scheme of the motor, enhanced by a position tracking observer. The proposed approach has been validated on two commercial horizontal-axis direct drive washing machines using a sensorless motor control scheme and it has been recently published in a journal paper. In addition, the proposed method is currently patent-pending and it will be applied on next generation washing machines from Haier.