# Abrasive waterjet intensifier model for machine diagnostics

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Waterjet/abrasive waterjet (AWJ) cutting machines are used for several industrial applications thanks to the great flexibility of the technology, which is suitable for cutting a wide range of materials [1]. This kind of machine tools includes an Ultra High Pressure (UHP) pump to generate the necessary pressure energy that is then converted into kinetic energy by the orifice into the cutting head. Different components, either belonging to the UHP pump or the cutting head, are subject to different kinds of faults and performance degradation, due to the challenging pressure conditions and the aggressiveness of abrasive particles.

The reliability of AWJ cutting machines is therefore a topic of major concern in industry. A fast detection of a faulty state and the automatic identification of the root cause for observed symptoms are expected to provide several benefits, including the reduction of unexpected machine stops, a quick leakage recovery, the minimization of wastes, the enhancement of maintenance operations, etc.

There are several studies in the literature devoted to AWJ process monitoring [2-4], mainly related to the determination and possible improvement of the cut quality. Nevertheless, very few authors investigated the development of automated tools for in-process monitoring and diagnosis of machine tool health conditions [5-7]. One of major challenge consists of characterizing the AWJ plant behavior under both healthy and faulty conditions, in order to train fault classifiers. Real data under faulty states are always difficult and expensive to collect, which makes purely data-driven diagnostic methods poorly attractive for a practical use. Model-based methods are expected to yield more effective diagnostics capabilities, thanks to the possibility of simulating the plant behavior under different operating conditions. This paper investigates the dynamics of an AWJ plant with multiple phased single-acting plungers, and it represents a first attempt to design an object-oriented dynamic model for such a kind of system. The model may be tuned to generate simulated signal patterns under different health conditions in order to train multi-fault diagnosis tools. The proposed model generates simulated water pressure and plunger displacement patterns, which can be used to characterize the AWJ working cycle. The injections of degraded states and faulty conditions into the model allows one to characterize the pattern deviations from the natural state, and hence to develop novel model-based fault detection and classification toolkits. The dynamic model is validated with respect to real-industrial data, acquired in reference cutting scenarios. Those data includes signals under healthy states and in the presence of faults affecting either the UHP pump components (cracked cylinders) or the cutting head components (broken orifices).

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