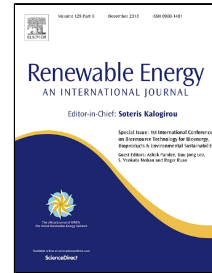


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Wave Tracking Method of Hydraulic Transients in Pipe Systems with Pump Shut-Off under Simultaneous Closing of Spherical Valves

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1 Wave Tracking Method of Hydraulic Transients in Pipe Systems with Pump 2 Shut-Off under Simultaneous Closing of Spherical Valves

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11 **Abstract.** The limited wave propagation speed in water permits the propagation of pressure
12 surges in hydraulic transients to be tracked in the time series. This occurs by tracking the
13 primary (F) and the reflected (f) waves. The *wave tracking method* has been demonstrated to
14 be applicable to highly complex hydraulic systems. The wave propagation induced by passing
15 through a T-junction in the flow complies with the *wave conservation laws* which concern
16 both the wave reflection and the transmission. It has been shown that all computations can be
17 simply implemented in a computation tool like MS Excel. This considerably ensures both the
18 accuracy and the reliability of computations. At a hydraulic system of Pelton turbines,
19 excellent computational results have been achieved. The application to a highly complex
20 hydraulic system with pump shut-off and the simultaneous closing of a spherical valve also
21 showed excellent results, when compared with the field measurements. The key point in the
22 presented computations is to unify the characteristics of the pump and the spherical valve. The
23 entire computation covers the flow rate in the system, the reverse flow through the pump, the
24 pressure response, the deceleration of the rotational speed and the system oscillations.

25
26 **Keywords:** Hydraulic transients; wave tracking method; conservation law; pump; spherical
27 valve; hydraulic characteristics

28 29 1. Introduction

30 Transient flows, for instance, in hydropower stations are encountered at each start and
31 shutdown of fluid machines or by regulating the operating points of the machines like pumps
32 and turbines in the hydraulic system. The worst cases of transient processes, however, are
33 given at load rejection and emergency shutdowns of the machines. Since such hydraulic
34 transients represent highly complex flow dynamics and often lead to rapid pressure rises,
35 cavitation and system instability, the related flow phenomena and pressure rises have, for
36 safety reasons, to be considered already in the early stages of design and constructions. The

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