Turbines tests in Natural Environment

Description of the Laboratory

In order to be able to make waveform conversion models, a laboratory was formed, which included 1.25 m deep, 1.0 m wide and 10.0 m long pool. The pool was equipped with wave generators, wave conversion model installation equipment, wave parameter measurement and data archiving equipment with two computer programs and a wave suppressor (Fig. 1) [1].

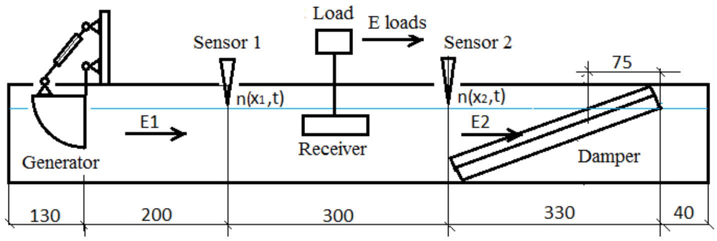

Fig.1. Principal Scheme of laboratory components [1]

In addition, the wave pool is equipped with water supply, drainage and side monitoring equipment and some handheld gauges and a photo / video camera.

Wave Generator

For generating the waves we created a generator, by means of which the wave parameters *T* and *H* can be adjusted (Fig. 2).

Fig.2. Wave generator

The operating modes of the distributor are set with the processor (Fig. 3), thus setting the frequency and distance of the pendulum stroke.

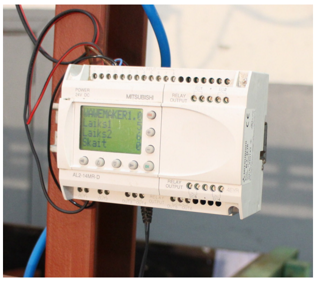

Fig.3. Processor

Wave Parameter Measurement and Data Archiving Equipment

Wave parameter measurement and archiving equipment consists of:

1. Two foam floats that copy water surface fluctuations (Fig. 4);
2. Two laser sensors that detect float oscillations and transmit signals to the processor (Fig. 5);
3. Data analyzer for receiving and processing signals and archived data (Fig. 6);
4. Two computer programs for receiving, processing and archiving data were installed in the data capture / processing processor.

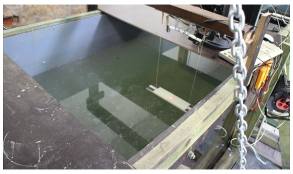

Fig.4. Float

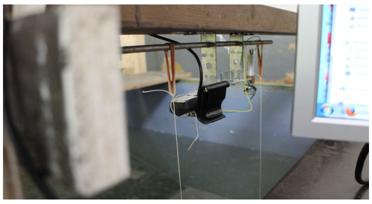

Fig. 5 Laser sensor

Fig. 6 Data analyzer

Computer Programs

Laser Beam Coordinate Image Processing Program

A WEB-camera image processing algorithm was created and a program for determining the coordinates of the measurement laser beam in angular units for recording and recording them in the absolute time of the computer was created. Programming language *Jawa script*. The program text is a formal record of the data processing algorithm. The structure and language of the program is shown in Fig. 7.

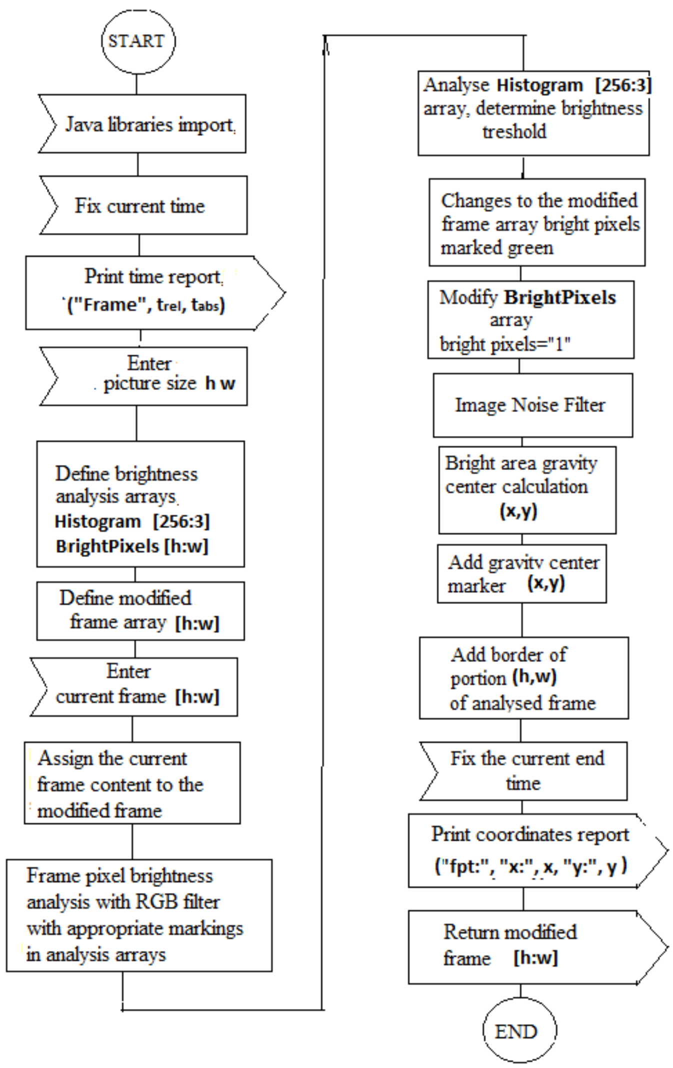

Fig. 7 Description of the structure diagram and language of the laser beam coordinate image processing program

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WEB-camera Image Data Capture Program

WEB-camera image data capture program was created, the text of which describes its algorithm. The description of the structure diagram and language is shown in Fig. 8. With the program the compilers help to convert the text of the program into a working program code or program that collected and processed the measurement data for obtaining intermediate results.

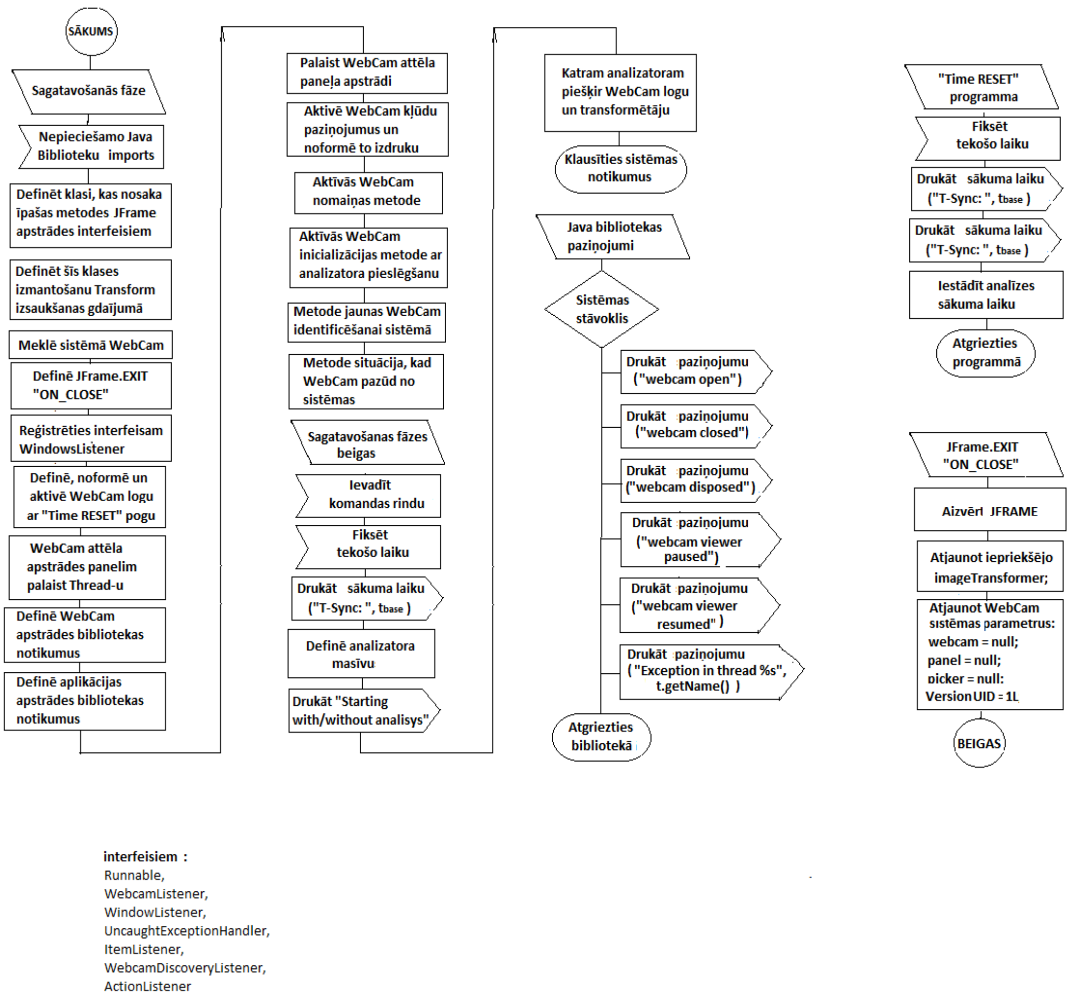

Fig. 8 Description of the structure and language of the WEB-camera image data capture program

Wave Damper

The wave damper was made of a frame with a sieve, which can be adjusted with a hand winch. On a sieve with a thickness of about 10 cm, 2 – 4 cm fractions of dolomite were deposited (Fig. 9).

Fig. 9 Wave damper

Implementation of the Pilot Project

Pilot Project Model Solution

An image of an axial self-regulating blade hydro-kinetic turbine (*APRLHK* turbine) was developed (Fig. 10).

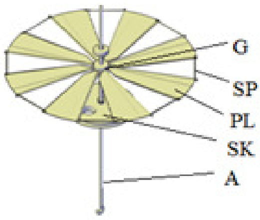

Fig. 10 *APRLHK* turbine construction (*G* - bearing, *SP* - tensioning rubber, *SAB* - self-adjusting blade, *SK* - pulley, *A*-axis)

The vertical rigid axle *A* (Fig. 10) was fitted with bearings and interconnected by a pulley *SK APRLHK* for mechanical loading of turbines and a turbine wheel with *SAB* acting on the wave force.

Choice of the Pilot Project Implementation Method

An experimental method was chosen for the pilot project. Laboratory experiments with a model turbine are used to research turbine in action and clarify its parameters.

So far, there were known hydro-kinetic turbines to operate in variable direction streams with *SAB*, which used a ring to form the outer diameter of the turbine to provide the movements needed to support one hinge group. These types of turbines had disadvantage – the support ring was a significant additional resistance and also increased the turbine mass.

The *APRLHK* turbine with sail type *SAB* was developed in the pilot project. It does not need a ring.

Wave converter models and a laboratory where waves with variable parameters can be created were created to perform the experiment.

Tests

The work describes how the test procedure was followed, what tools were used, how the measurement, calibration, measurement processing, results analysis, how the wave parameter measurement works were performed, the recorded data was recorded and archived. Observations were described. Wave process analysis scheme (Fig. 11) was developed and used [1].

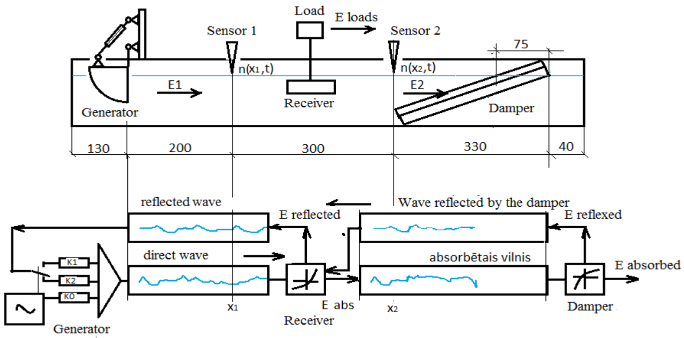

Fig. 11 Wave process analysis scheme [1]

Window interpolation was used for measurement processing. The interpolation window is shifted by one step (i + 1) and the calculations of the polynomial coefficients are repeated until the entire interpolation segment is processed (Fig. 12).

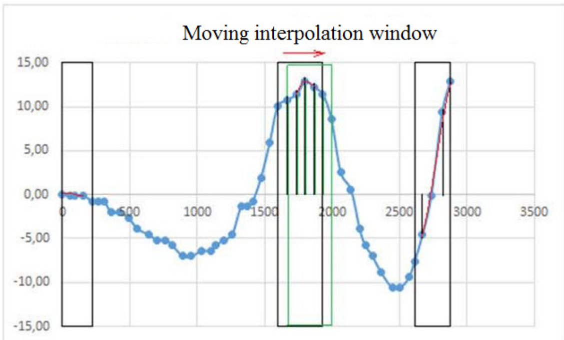

Fig. 12 Interpolation window in interpolation segment

Modelling Results

Various results were obtained from the *APRLHK* turbine testing with different types of *SAB* (Table 1) (Fig. 13).

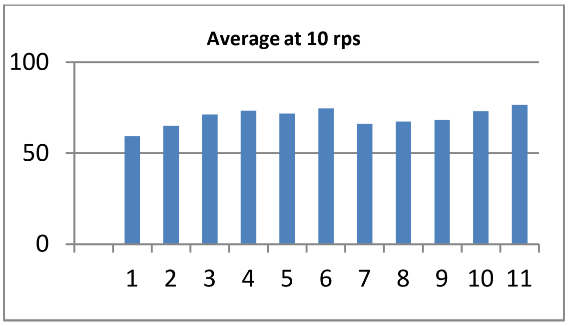

Fig. 13 Test results (s) of the *APRLHK* turbines in which they perform 10 revolutions

On the basis of the entrance data, the most successful *APRLHK* turbine power at various revolutions was calculated (Fig. 14).

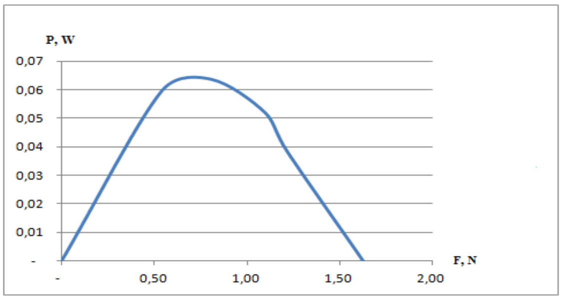

Fig. 14 Turbine power *P* (W) calculation results at different loads

Wave parameters were measured with sensors A and B and the wavelengths and absorbed capacities were calculated from these parameters (Table 1). Turbines with blade profile No B-1 calculations of power and turbine utilization factor (Table 4.1).

Table 1

Turbines with blade profile Nr. B-1 power and utilization factor calculations

ω (rps)	***F*** (N)	***r*** (m)	***v*** (m/s)	***P*** (W)	$P_{(AK)}$ (W)	η_T (%)
-	1.63	0.15	-	-	0.736	-
0.03	1.22	0.15	0.03	0.04	0.736	5.43
0.05	1.10	0.15	0.05	0.05	0.736	6.79
0.08	0.81	0.15	0.08	0.06	0.736	8.15
0.12	0.54	0.15	0.11	0.06	0.736	8.15
0.17	-	0.15	0.16	-	0.736	-

Symbols of the Table 1:

w – Turbine speed (rps),

F – Turbine braking load force (N),

r – Braking load application shoulder (m),

v – Vector velocity (m/s),

P – Braking power (W),

$P_{(AK)}$ – Corrected wave power before loaded turbine (W),

η_T – Turbine utilization rate (%).

Now we can create turbines with blade profile Nr. B-1 turbine utilization factor η_T depending on rpm. (Fig.15).

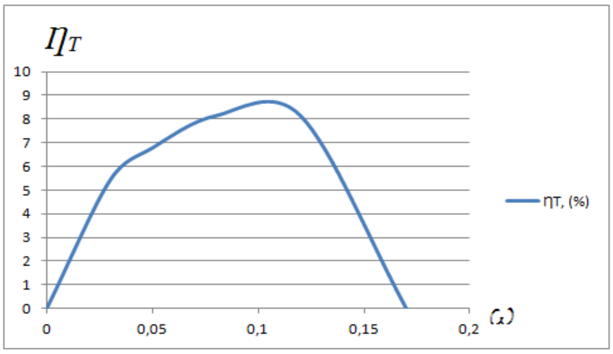

Fig.15. The characteristic curve of the turbine utilization factor η_T, depending on rpm

SOURCES OF INFORMATION

[1] J. Beriņš, J. Beriņš. Measurements of Wave Power in Wave Energy Converters Effectiveness Evolution, Latvijas fizikas un tehnikas žurnāls, 2017, Nr. 4