A full second-order theory for coupling numerical and physical wave tanks is presented. The ad hoc unified wave generation approach developed by Zhang et al. [Zhang, H., Schäffer, H.A., Jakobsen, K.P., 2007. Deterministic combination of numerical and physical coastal wave models. Coast. Eng. 54, 171–186] is extended to include the second-order dispersive correction. The new formulation is presented in a unified form that includes both progressive and evanescent modes and covers wavemaker configurations of the piston- and flap-type. The second order paddle stroke correction allows for improved nonlinear wave generation in the physical wave tank based on target numerical solutions. The performance and efficiency of the new model is first evaluated theoretically based on second order Stokes waves. Due to the complexity of the problem, the proposed method has been truncated at 2D and the treatment of regular waves, and the re-reflection control on the wave paddle is also not included. In order to validate the solution methodology further, a series of nonlinear, periodic waves based on stream function theory are generated in a physical wave tank using a piston-type wavemaker. These experiments show that the new second-order coupling theory provides an improvement in the quality of nonlinear wave generation when compared to existing techniques.