OBJECTIVES: Thrombosis and thromboembolism are among the leading causes for mortality in patients who depend on artificial organs. In order to be able to predict platelet behavior, it is necessary to consider both the flow conditions inside the device and the thrombogenic properties of the blood-contacting surfaces. Mathematical modeling of thrombotic reactions is established and validated in test cases. The aim of this study is to experimentally evaluate and computationally simulate platelet activities under the influence of well-defined shear rates for cylindrical gap flow, laminar flow in a rectangular chamber, and stagnation point flow. The application of this model is directed towards the design of left ventricular assist devices, hemodialysis, and gas exchange devices.

MATERIALS AND METHODS: A mathematical model of platelet activation, adhesion, and aggregation has been implemented into a finite element CFD code. The approach is based on the advective and diffusive transport equations for resting platelets, activated platelets, and platelet released agonists. Reactive and collision efficiency terms describe the interactions between them. Experiments with citrated whole blood are performed in a rectangular flow chamber as well as in a Taylor-Couette system for laminar and for Taylor vortex flow. The activation and drop of single platelets, adhesion, and aggregation are measured.

RESULTS: The thrombosis model was applied to different three-dimensional test cases of clinical significance. The numerical simulation results based on physiologically relevant values for the model parameters were successfully validated against experimental data. Regions and flow conditions with a high potential for thrombus growth could be identified.

CONCLUSIONS: The numerical method shows good agreement with measured platelet reactions and adhesion for different test devices. The model can be used for the analysis and prediction of thrombus growth in artificial organs.