Karlsruhe Institute of Technology

Division III – Mechanical and Electrical Engineering

IPEK – Institute of Product Engineering

IPEK-sCiL: Scaled-Components-in-the-Loop

Power Scaling of Prototypes for Testing in Product Development

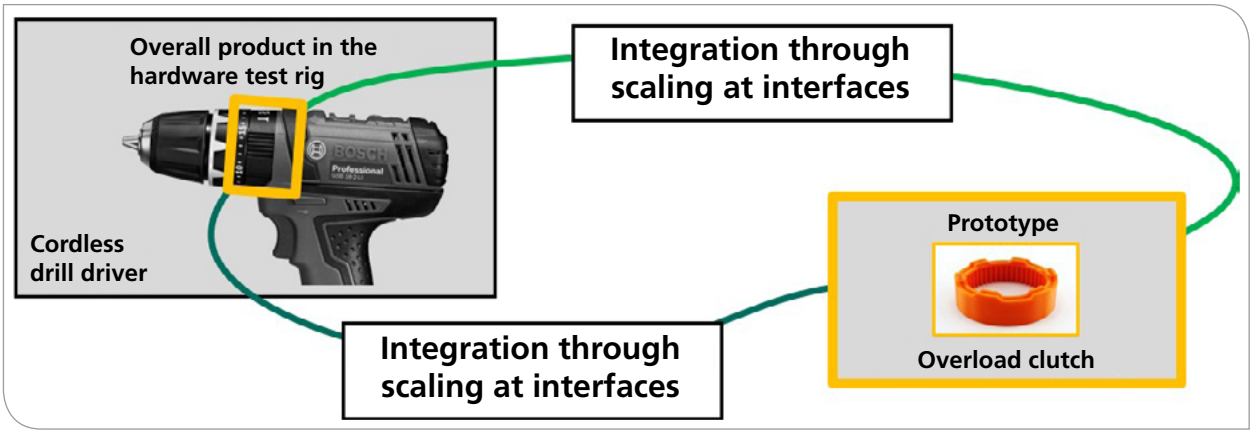
Product development is frequently carried out with product series. In this way, components with their function can be reused in various power classes. Geometry parameters are scaled, while the function remains the same. Testing reveals whether functioning of the component in the overall product is ensured. If additive manufactured mechanical prototypes are to be used in testing, their mechanical loadability often cannot be guaranteed, in particular when they are to be applied in larger systems of the series. With the help of the IPEK-scaled-Components-in-the-Loop approach (briefly: IPEK-sCiL), prototypes can be integrated in a power test rig and operated in a power-scaled manner.

Prototype Integration Approach

When using the IPEK-sCiL approach for integration of prototypes of reduced loadability, the overload clutch of a power tool, for instance, is first removed from the overall system. At the resulting interfaces, the prototype of a new overload clutch is integrated in the overall system via couplings. This integration is of virtual character only. With the help of a scaling model, loads can be adapted according to the loadability of the prototype. Virtual integration thus enables scaling at the interfaces to the required performance level. Interactions with the not yet existing adjacent subsystems and relevant environmental impacts in the overall product can be studied. These interactions are either added by virtual models or reproduced in the test rig using existing components of other series. Adapted power scaling enables testing of additive manufactured prototype components in an early development stage. The IPEK-sCiL approach is also suited for supporting the development of new series. Typically, function fulfilment is difficult to assess when components of different series and power classes are to be combined. Power scaling solves this problem.

Test Environment for the New Development of Power Tools

When applying the IPEK-sCiL approach in a test environment for overload clutches of battery screwdrivers, the overload clutch is removed from the test rig and the prototype is integrated in the overall product via coupling systems. The subsystems are not connected mechanically. Coupling of power flow takes place via the coupling systems at the interfaces. Necessary scaling of the power characteristics is integrated. In the coupling systems, power can be adapted to the loadability of the individual subsystems of the powertrain. Depending on the loadability and performance of the overload clutch to be studied, power can be adapted via scaling models. In addition, subsystems of the powertrain from various series can be combined and tested in spite of different power classes. This



IPEK-sCiL approach to integrating prototypes of reduced loadability through scaling at interfaces

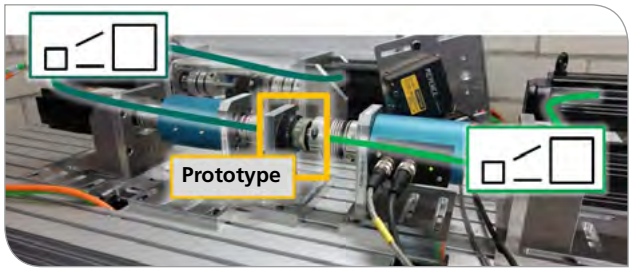
test environment enables studies of the behavior of a battery screwdriver with a changed geometry of the overload clutch. Various clutch types can be tested in the test environment as additive manufactured prototypes. Consequently, their behavior can be assessed at an early stage even before series components are available.

Research Goals

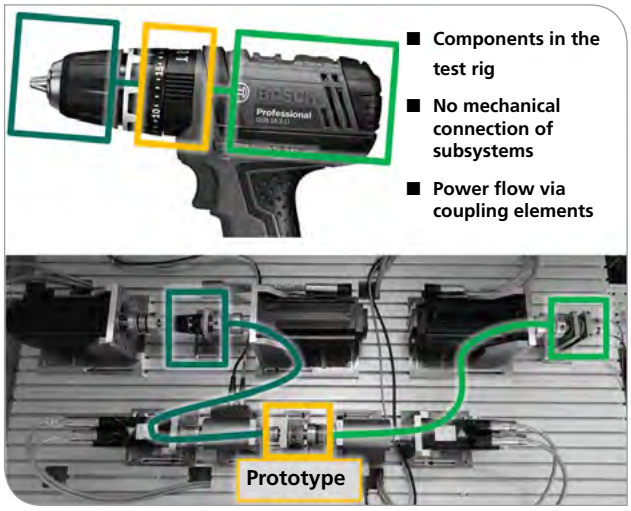
- Development of scaling models for adapting power characteristics to the loadability of mechanical prototypes and subsystems of the powertrain in the hardware test rig.
- Investigation of the influence of design features on the function.

Investigation Options

- Investigation of prototypes.
- Validation of components on various mechanical power levels.
- Integration of components from products of higher power of a series.
- Tests of additive manufactured prototypes.
- Simulation of interactions.
- Tests of subsystems with integration in the virtual or physical subsystems.
- Consideration of difficult-to-model effects and interactions by integration of physical components in the test rig.



Testing of power-scaled prototypes in the IPEK-sCiL



Powertrain of a cordless drill driver in the IPEK-sCiL test rig. A prototype of the overload clutch is integrated. Its load can be adapted with the control computer button of the test rig

Technical Data

Drives and Coupling Systems	
3 high-performance synchronous motors	13 Nm, 4500 min^{-1}
2 power-scaled synchronous motors	1.3 Nm, 6000 min^{-1}
Measurement technology	Combined speed and torque measurement
Measurement and Control System	
Measurement and control system	ADwin Pro-II real-time system with 100 µs cycle time
Simulation environment	MATLAB, Simulink
Test Environment	
Test rig design	Modular
Simulation of interactions	Virtual and physical components
Investigations	Additive prototypes, components in series
Scaling	
Power level	Up to 30 Nm

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