HYDRAULIC DIGITAL SOLUTIONS

walvoil

MOTION BY PEOPLE

NEW

Operating Assistance System

Assisted driving Mini/Midi-Excavator for enhanced performances and improved safety

BACKGROUND AND DRIVER NEEDS

Assisted driving systems are widely adopted in the automotive sector to enhance comfort and improve safety.

In contrast, Off-Highway vehicles-such as construction or agricultural machines-have seen limited adoption of such systems, despite the fact that their operators often work in more demanding conditions. These include rough terrain, complex multi-tasking operations, and the need for constant awareness to ensure personal and bystander safety.
As a result, the physical and mental workload on Off-Highway vehicle drivers is significantly higher.

THE SYSTEM FOR MINI/MIDI-EXCAVATOR APPLICATIONS

Walvoil's Operating Assistance System for Mini/Midi-Excavators integrates robotics concepts into the control of hydraulic arms, automating the manual operation of each joint to significantly enhance performance and improve operational safety.

The main goals of the system are:
- automating trajectory tracking to simplify the creation of trenches and slopes with specific inclinations;
- enhancing operational safety by preventing unintended or dangerous boom swing movements during work activities.

SOFTWARE SIMULATION

The functions are designed using the most advanced simulation software.

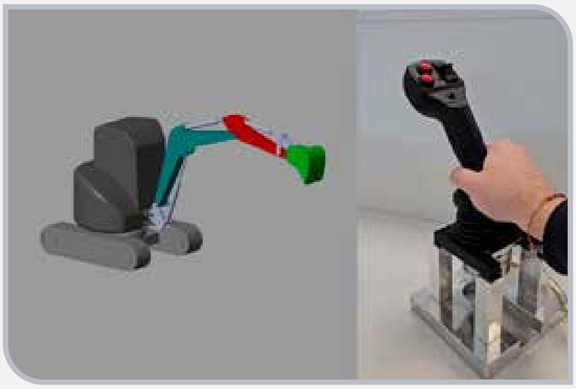
In MATLAB® environment, the hybrid model including CANbus control signals, hydraulic circuit and mechanical components was built. The mechanical system is imported with a specific Simscape Multibody® add-on.
This complete model of the excavator was inserted into a complete Simulink® model with the specific control algorithm.

The advantage of simulation is that it is possible to test numerous control algorithms by varying the main configuration parameters until the optimal ones are identified.

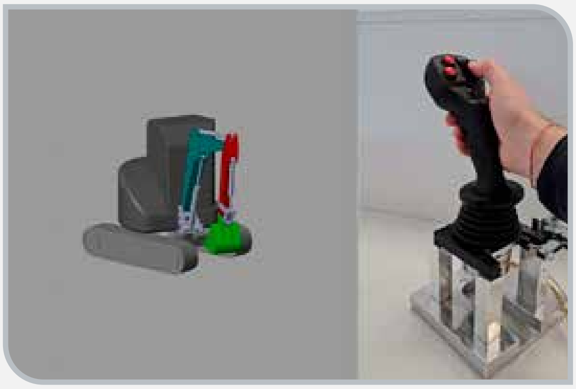
Going into details, a model-based design approach was applied following these development steps:

- the kinematic and the dynamic models of the arm of the excavator have been deeply studied. This step also included the validation of the model using real data acquired from on-field experiments;
- the mathematics of the inverse kinematics have been derived in closed form to allow the implementation in cost effective ECU (electronic control unit), e.g. with limited computation power;
- a robust closed-loop control algorithm, derived from the implementation of trajectory follower in robotic applications, was finally developed and tested.

Boom, arm, bucket movements simulation



Swing movement simulation



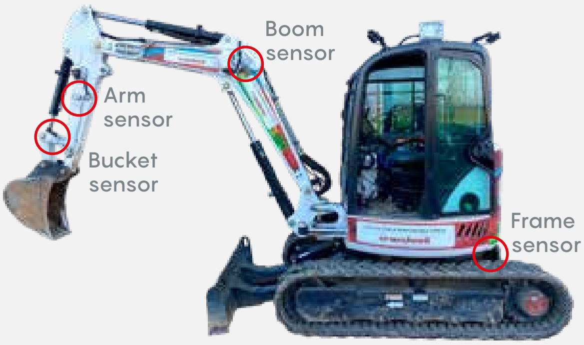
SMART GRADING FUNCTION

The excavator operations require coordinated movement of the swing, boom, arm and bucket to control the position of the End Effector, centre of the bucket tip, to obtain the desired trajectory. This can be achieved through the implementation of an automatic control system for the excavation task, which requires the understanding of the kinematics, the dynamics, and the control of the excavator.

The desired features are obtained equipping the machine with a minimum of onboard sensors to dynamically monitor the geometry of the machine (6 Degree of Freedom Inertial Measurement Unit), without using external equipment or sensors like GPS or Laser.

These features are obtained thanks to the strong integration of the electronics system with the hydraulic one. In order to support the robotization task with maximum precision and stability, the hydraulic circuit is based on the latest developed components technologies: a Load Sensing Flow Sharing Main Control Valve with electro-hydraulic controls is provided together with a Variable Axial Piston Pump with electronic displacement control. A dedicated ECU executes a control strategy that achieves the best and most efficient working conditions; a continuously adjusted pump Pressure Margin allows to emphasize the flow delivery smoothness; additionally, a flow control contribution eliminates pressure instabilities and ripples. Both control strategies cooperate to a solid foundation for the automatic functions.

Sensors position



The function is based on Machine Geometry Detection and it's composed of:

• three single-axis IMU (Inertial Measurement Unit) sensors used to detect the movements of the boom, arm, and bucket;
• one dual-axis IMU sensor used to detect the frame's roll and pitch movements relative to the ground;
• one Hall effect sensor used to detect the cabin swing.

Trajectory definition

The operator defines the desired trajectory with the following parameters:

• starting point, by moving the end effector at the desired position;
• inclination angle and vertical offset level, set via the machine HMI.

The algorithm calculates the trajectory up to the end point, which is determined by the joints reaching their limits.
The geometry of this specific excavator allows the generation of a trajectory with a maximum length of 3000 mm (*118 in*).
The Smart Grading function allows a trajectory accuracy up to ±1.5% for both depth and slope.

VIRTUAL SAFETY WALL

The system includes 2 functions that work in synergy with each other: 360° view and obstacle detection..

Cameras position and 360° view

The system includes four cameras installed on the front and rear corners of the machine, providing a 360° view of its surroundings.

Obstacle detection and Safety Wall

An AI-based visual system can detect human presence and highlights it on the screen with red dots.
The software automatically defines hazardous areas and creates Virtual Walls to prevent dangerous operations.

OPERATING ASSISTANCE SYSTEM FEATURES AND BENEFITS

- The functions are designed using the most advanced simulation software and real data acquired from field experiments.
- The strong integration of the electronic system with the hydraulic one ensures optimal performance, repeatability and durability.
- Thanks to the dedicated IMU sensors and sophisticated control algorithm, the Smart Grading function allows a trajectory precision of up to ±1.5% for both depth and slope.
- Surrounding cameras allow 360° vision.
- AI based system detects human presence and obstacles
- The software creates Safety Virtual Walls to prevent dangerous operation.

time saved

lower costs

increase productivity

increase site safety

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