

Interface Control Design



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1. Scope

This section describes the system-of-interest to which this document describes the interface characteristics.

1.1 Identification

The system-of-interest is the AGCO combine harvester, which is, broadly speaking, comprised of three primary subsystems, as per defined in our ConOps: the combine header, the feederhouse and the processor. As such, we will be specifying two interfaces, one between the combine harvester header and its feederhouse and one between the feederhouse and the processor.

In the next subsystems, the purpose of each of these subsystems is described.

1.1.1 Combine header

The header of the combine harvester operates mainly in 4 states. When the harvester is operating at a field, the first thing to occur is the crop being fed into the header, as seen at point 1. The crop is then cut at the stem, as shown at point 2, before being transported into the collector, which handles and distributes the crop into the combine harvester.

1.1.2 Feederhouse

After the crops have been harvested by the combine header, it is being transported to the feederhouse. In this the crops are being collected, stored and transferred to the processor.

1.1.3 Processor

The last subsystem is the processor. In this, the harvest is being cleaned by mechanical processes, and the harvest is being handled for local storage, remote storage or further processing. It is also in the processor that residue management happens.

2. Referenced documents

In this section, the documents that are being referenced are declared.

Document name	Abbreviation
Concept of Operations	ConOps

3. Interface design

In this section, the design of each of the two interfaces is elaborated.

3.1 header to feederhouse interface

The most common interface between the header and the feederhouse is called a header adapter. The purpose of the interface is to provide a reliable and secure physical and electrical connection between the header and the combine harvester. This allows for the attachment and detachment of the header as needed, and enables the transmission of power, control signals, and data required to operate the header during harvesting.

The Header Adapter Interface is responsible for ensuring that the header is correctly positioned and controlled during harvesting. This includes controlling the height and tilt of the header to optimize crop collection, as well as regulating the speed of the header reel to ensure smooth and consistent crop feeding. The interface must also enable the transmission of data between the header and the combine harvester, providing real-time feedback on the status of the header and ensuring that it is operating safely and efficiently.

In the sub-sections below, different aspects of this interface are described.

3.1.1 Interface participants

The following are the participants involved in the Header Adapter interface:

- **Combine Harvester:** The main system that the header adapter is attached to, responsible for providing power, control signals and communications.
- **Header:** The component that is being attached to the combine harvester via the header adapter.

3.1.2 Interface components

The header adapter typically consists of:

- **Frame:** The frame of the header adapter is usually made of sturdy materials such as steel or aluminum and is designed to support the weight of the header while also providing a secure attachment point for the adapter arms.
- **Adapter arms:** The adapter arms are usually adjustable and connect the header to the feederhouse. They are typically designed to be compatible with a range of header sizes and types, allowing the adapter to be used with different crops and harvesting conditions.
- **Auger or conveyor:** In some header adapter designs, an auger or conveyor may be included to help transfer the harvested crop from the header to the feederhouse. This can help ensure a smooth and consistent flow of material into the combine harvester.
- **Hydraulic or electrical connections:** Some header adapters may include hydraulic or electrical connections to provide power and control signals to the header. This can allow the header to be raised, lowered, or adjusted while in use, improving the efficiency and effectiveness of the harvesting process.
- **Latching mechanism:** The header adapter should include a latching mechanism which ensures secure attachment between the header and the adapter arms. The purpose of this is to help the header from becoming detached during operation which could cause damage to the machine or create a safety hazard.

3.1.3 Interface requirements

The interface has the following requirements:

- **Attachment Mechanism:** The header adapter should have a secure attachment mechanism to connect the header to the combine harvester's feederhouse. The mechanism should be easily attachable and detachable without the need for external tools.
- **Compatibility:** The header adapter should be compatible with different types of headers and combine harvesters. This includes ensuring that the adapter is compatible with the header's width and the feederhouse's attachment points.
- **Height and Tilt Adjustment:** The header adapter should be adjustable in terms of height and tilt to ensure proper alignment with the crop. This is particularly important for crops with varying heights and widths.
- **Electrical and Hydraulic Connections:** The header adapter has multiple electrical and hydraulic connections which enables it's communication and power transfer between the header and the combine harvester. The connections should be easy to install, remove and should be durable enough to withstand frequent use and normal wear and tear.
- **Safety Features:** The header adapter should have safety features to prevent accidents and injuries during operation. These may include guards around moving parts, emergency stop buttons, and warning lights or alarms.
- **Durability and Maintenance:** The header adapter should be able to withstand the wear and tear of daily use. It should also be easy to maintain that has an easy access to parts and components for repair and maintenance.
- **Compatibility with Header Height Control System:** If the combine harvester has a header height control system, the header adapter should be compatible with it. This will ensure that the header is properly positioned for optimal crop feeding.
- **Material Selection:** The header adapter should be made of high-strength materials that can withstand the forces and stresses involved in harvesting. This includes exposure to vibration, shock, and corrosion.
- **Load Capacity:** The header adapter must be able to support the weight of the header, as well as the weight of the crop being harvested. The load capacity should be enough to prevent any bending or severe deformation of the adapter.
- **Structural Design:** The header adapter must be designed in a way to withstand the prolonged harvesting and stresses involved in harvesting. The structure should be optimized for weight reduction while still maintaining strength and durability.
- **Corrosion Resistance:** The header adapter should be designed with corrosion-resistant materials and coatings to prevent rusting and other environmental factors to withstand corrosion and have a sturdy system for harvesting.
- **Maintenance Requirements:** The header adapter should be designed with ease of maintenance in mind. As such, it must allow for easy access to vital components that may need to be repaired or replaced, and the header adapter must also ensure that it can be cleaned and lubricated easily.

3.1.4 Interface input-output parameters

The interface has the following inputs:

Inputs:

- **Electrical power:** The header adapter interface receives electrical power from the combine harvester to power the various components of the header, including the header reel, header height and tilt control, and any additional sensors or control systems.
- **Hydraulic fluid:** The header adapter interface receives hydraulic fluid from the combine harvester to power the hydraulic cylinders used to adjust the height and tilt of the header.
- **Control signals:** The header adapter interface receives control signals from the combine harvester to perform the necessary changes to the adapter for harvesting. The control signal includes signals to adjust the height and speed of the header adapter during harvesting.
- **Data signals:** The header adapter interface gets real-time data from the data signals of the header about the status of the header and its operations during harvesting. This has data such as crops harvested, and crops processed by the header per second for optimizing the harvesting process.

Outputs:

- **Electrical power:** The header adapter interface delivers electrical currents to the header reel, the header height control, the tilt control systems, and the sensors in the different control systems.
- **Hydraulic fluid:** The header adapter interface supplies hydraulic fluid to the hydraulic cylinders used to adjust the height and tilt of the header.
- **Control signals:** The header adapter interface sends control signals to the header to regulate its operation. These signals include commands to adjust the height and the tilt angle of the header, and instructions for controlling the speed of the header reel.
- **Data signals:** The header adapter interface ensures that data signals are delivered to the combine harvester. The purpose is to provide real-time feedback on the status of the header and its operation (header height, tilt and reel speed). The data signals also report crop yield, crop flow, and other key metrics that can be used to optimize the harvesting process.

3.1.5 Interface testing

The testing section of the Header Adapter Interface serves to verify the proper functioning of the interface and ensure that it meets all the technical and functional requirements laid out in the interface control design document. The testing section should be organized into several phases, each focused on a different aspect of the interface's operation.

Phase 1: Component testing

The first phase of testing should involve the individual components of the Header Adapter Interface, including the electrical and hydraulic systems, control systems, and any sensors or feedback mechanisms. Each component should be tested in isolation to ensure that it functions properly and meets the necessary technical specifications.

Phase 2: Integration testing

When the individual components are tested modularly, we need to test the entire system as a single unit to ensure each module works as expected and the process is completed as a whole. The integration testing should include control and feedback mechanism testing to ensure system can communicate with each other effectively and also test the electrical and hydraulic systems to ensure operations for harvesting are done properly

Phase 3: Functional testing

The third phase of testing tests functional requirements. This includes the ability to adjust the height and the tilt angle of the header, control the speed of the header reel, and provide real-time data

feedback to the combine harvester. It is important that the interface is tested under different operating conditions such that it consistently performs reliably.

Phase 4: Performance testing

The final phase focuses on testing performance related requirements. Performance testing should be conducted under realistic conditions to ensure that the interface meets or exceeds all performance specifications.

3.2 feederhouse to processor interface

The feederhouse to processor interface is a critical component of the combine harvester, responsible for moving the crop from the feederhouse to the processor and separating the grain from the chaff. The interface consists of several key components, including the feeder chain, auger, crop flow sensors, and threshing system. The feeder chain and auger work together to move the crop from the feederhouse to the threshing system, while the crop flow sensors monitor the flow of the crop to ensure efficient operation. The threshing system is responsible for separating the grain from the chaff, which is then collected in the combine's grain tank.

3.2.1 Interface components

The interface uses mechanical and electrical components to transfer the crop from the feederhouse to the processor. These components are designed to work together to provide smooth and consistent crop transfer.

- **Feeder Chain:** The feeder chain is a series of metal links that grip and move the crop through the machine. It is responsible for pulling the crop from the feederhouse and transferring it to the threshing system. The feeder chain is typically powered by the combine's engine, and its speed can be adjusted to optimize the crop flow.
- **Auger:** The auger rotates and pushes the crop towards the threshing system. It is responsible for moving the crop from the feeder chain to the threshing system, and it can also help to break up any clumps of crop for better processing. The speed and direction of the auger can be adjusted to optimize crop flow.
- **Crop Flow Sensors:** These sensors are located at various points along the interface between the feederhouse and the processor. They monitor the crop flow through the machine and alert the operator to any potential issues or blockages. The sensors help in adjusting the speed and direction of the feeder chain and auger if needed.
- **Threshing System:** This is the main unit of processing in the combine harvester. It ensures that the grain can be separated from the chaff by two mechanical processes: crushing and separating the crop. The threshing system typically consists of a series of rotating cylinders or rotor bars that crush and separate the crop.

3.2.2 Interface requirements

In this sub-section we declare requirements for the interface in terms of each of the separate components.

3.2.2.1 Feeder Chain

- The feeder chain has to be constructed of materials that can withstand continuous operation (for example steel).
- The feeder chain must support efficient movement of crops from the feederhouse to the processor.

3.2.2.2 Auger

- The auger must be made of sturdy and durable materials such as steel , etc to withstand continuous operation.

- The design of the auger must be made in such a way that its an effective way to move crops from header to feederhouse

3.2.2.3 Crop Flow Sensors

- The crop flow sensors must be located at key points along the interface to accurately monitor the flow of the crop.
- The crop flow sensors must be able to detect blockages or other issues in the flow of the crop and alert the operator.

3.2.2.4 Threshing System

- The threshing system must be designed of materials that can withstand continuous operation (for example steel).
- The threshing system must ensure efficient separation of the grain from the chaff.
- The threshing system must be able to handle a variety of crop types and operation under varying environmental conditions.
- The threshing system must accommodate easy maintenance and repairation to minimize operational downtime.

3.2.3 Interface input-output parameters

The interface between the feederhouse and processor has the following inputs and outputs:

- **Input:** Harvested crop from the feederhouse
- **Output:** Separated grain and chaff from the processor

3.2.4 Interface testing

The interface between the feederhouse and processor will be tested to ensure that it meets the requirements specified in this document. The interface testing will include functional testing, stress testing, and validation testing. The testing will be conducted using simulated harvesting conditions to ensure that the interface functions as intended under realistic conditions.

Phase 1: Functional testing

The focus of this testing phase is to verify that the interface functions as expected in a controlled environment. During functional testing, the develop team will perform various tests to ensure that the feeder chain, auger, crop flow sensors, and threshing system work together as expected. These tests may include simulating various harvesting conditions, such as adjusting the speed of the combine harvester, changing the type of crop being harvested, and adjusting the position of the interface components.

Phase 2: Stress testing

The second testing is focusing on the limits of the interface by subjecting it to extreme conditions. During stress testing, harvesting extremes will be simulated. This may include harvesting in very wet or dry land, or harvesting on slopes. The goal of stress testing is to identify any weaknesses or points of failure in the interface, which can then be addressed before operation.

Phase 3: Validation testing

The final phase is validation testing. This phase ensures that the interface accommodates the requirements specified in the design document. This testing will do harvesting simulations to ensure that the interface functions as intended under realistic conditions. As such, the testing simulation must validate variables such as crop moisture, crop density, and terrain diversity.

Contributions

Date	Contribution	Contributor
2023-12-04	Header to feederhouse interface	Alexander & Shivaram
2023-12-04	Feederhouse to processor interface	Liulihan & Henrik