



Design and Optimisation of Washing System for Demoulding Supports

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Geberit Production Oy

Abstract:

This thesis project was carried out at Geberit Production Oy in Tammissaari and focuses on the design and partial implementation of a new enclosed washing system for demoulding supports in SACMI ALS casting cells. The existing open washing method caused uncontrolled water splashes within the robot cell, posing safety, hygiene, and equipment risks. The goal was to improve containment, cleanliness, and integration with the automated environment.

The project followed a practical engineering process: from analysing the current setup, conceptualising design improvements, selecting components, to building the physical structure in the workshop. The design incorporates an aluminium profile frame, sheet metal panels, an inclined drain pan, and a brush seal to allow robot arm movement without splash leakage. SolidWorks and the Item Engineering tool were used to generate the technical documentation and order files. The construction was partially completed during the project timeline, with the frame and main components assembled in the workshop. Due to factory scheduling, final integration into the SACMI cell and functional testing will take place during summer maintenance. However, component-level testing and assembly evaluations were conducted and documented. The thesis concludes that the enclosed design and chosen components meet the functional requirements and allow future improvements. The project also demonstrated the importance of effective communication with suppliers and structured documentation. Once fully installed, the system is expected to improve overall functionality, including water control, cleanliness, operational efficiency, workplace safety and sustainability at Geberit Production Oy.

Keywords: Geberit Production Oy, Enclosed Washing System, SACMI Casting Cell, Demoulding Support, Water Containment, Robotic Automation, Design

Lärdomsprov

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Design och Optimering av Tvättsystem för Avformningsstöd
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Sammandrag:

Detta examensarbete genomfördes vid Geberit Production Oy i Ekenäs och omfattar design och delvis uppbyggnad av ett nytt inneslutet tvättsystem för avformningsstöd i SACMI ALS gjutceller. Den tidigare öppna tvättmetoden orsakade okontrollerade vattenstänk i robotcellen, vilket innebar risker för både säkerhet, renhet och teknisk utrustning. Målet var att förbättra vattenkontroll, renhet och anpassningen till den automatiserade miljön.

Arbetet följde en praktisk ingenjörprocess: från analys av det nuvarande systemet, utveckling av designlösningar, val och beställning av komponenter, till uppbyggnad av konstruktionen i verkstaden. Designen består av en ram i aluminiumprofiler, plåtpaneler, en dräneringskonstruktion samt en borsttätning som möjliggör robotens rörelse utan att vatten läcker ut. SolidWorks och Item Engineeringtool användes för att skapa ritningar och beställningsfiler. Under projektets gång byggdes större delen av konstruktionen upp i verkstaden. På grund av fabriken tidtabell sker den slutliga installationen och funktionella testningen först under sommarens fabriksstopp och underhållsperiod. Däremot genomfördes tester på komponentnivå samt montering som dokumenterats. Slutsatsen är att den inneslutna designen och valda komponenterna uppfyller de tekniska kraven och möjliggör framtida förbättringar. Projektet visade även vikten av tydlig kommunikation med leverantörer och noggrann dokumentation. När systemet är fullt installerat förväntas det förbättra helhetsfunktionen, inklusive vattenkontroll, renhet, driftseffektivitet, arbetssäkerhet och hållbarhet vid Geberit Production Oy.

Nyckelord: Geberit Production Oy, Inneslutet tvättsystem, SACMI-Gjutcell,

Avformningsstöd, Vattenhantering, Robotautomation, Design

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1 Introduction

1.1 Background and Motivation

Geberit Production Oy is a leading manufacturer of ceramic sanitary ware, with high-volume production primarily focused on washbasins and wall-hung toilets. Established in 1969, the factory in Tammisaari, Finland, is globally recognised for its highly automated production lines and innovative technological solutions. In line with their commitment to continuous improvement and efficiency, Geberit installed two advanced robotic casting cells delivered by SACMI in 2024, integrating KUKA industrial robots. These cells handle demoulding supports, which are used for extracting delicate ceramic pieces from casting moulds, which must undergo washing and drying after each casting cycle (Geberit Production Oy, 2025).

The existing washing setup within the SACMI casting cells, however, does not fully meet the containment requirements of this automated process, particularly regarding water and residual slip material, prompting the need for a redesigned solution.

1.2 Problem Statement

The main issue addressed by this thesis is the uncontrolled water dispersion and inadequate containment of the current washing system within the SACMI casting cells. Water splashes create pools on the production floor, increasing the risk of slipping and posing potential damage threats to robotic equipment and electronic components. Although the cleaning functionality is sufficient, the existing open-system approach has significant limitations regarding water control and containment. Additionally, there are secondary concerns about residual slip material accumulating in specific areas of demoulding supports (Geberit Production Oy, 2025).



Figure 1. Water dispersion during existing washing cycle.



Figure 2. Washing area after operation with current open setup. The floor remains wet with visible puddles.

1.3 Objectives

The primary goals for this thesis, as explicitly outlined by Geberit Production Oy, are as follows:

1. The washing process should not take more robot time than it currently does.

2. The floor must be completely dry after washing, meaning all water should be collected and directed to a floor drain.
3. The equipment should be easy to service.
4. The support must be clean from slip and dry.
5. No water should be allowed to splash onto the robot wrist, as it does today.

(Geberit Production Oy, 2025).

1.4 Scope and Limitations

This thesis focuses on the design, development, and initial assembly of a modular washing chamber intended for integration into one SACMI ALS casting cell at Geberit Production Oy. The goal is to create a functional and replicable prototype that improves water containment and supports the automated cleaning of demoulding supports. Design considerations include enclosure layout, drainage, sealing solutions, and structural integration using aluminium framing and stainless steel panels.

Limitations of the project include the exclusion of detailed testing of washing efficiency and drying performance, as final installation and commissioning are scheduled after the thesis. Likewise, redesign of nozzle configurations and cleaning tool parameters falls outside the scope. These aspects, including possible simulations or flow optimisation, are recommended for future development once the base design has been fully implemented and tested.

1.5 Structure of Thesis

The thesis follows the project from background research to implementation. It begins with a literature review covering the SACMI ALS casting system, industrial washing technologies, materials for wet environments, sealing solutions, and modular aluminium framing systems. The methodology section describes the practical approach, analysis of the current system and tools used. This is followed by the design and development of the washing system, the assembly process in the workshop, and observations from testing. The work concludes with a discussion, conclusions and reflections based on the project outcome.

This thesis complies with the guidelines provided by Arcada University of Applied Sciences and aligns closely with the specifications detailed by Geberit Production Oy.

2 Literature Review

2.1 Automated Casting Systems (SACMI ALS)

SACMI is an Italian industrial group founded in 1919. It is known for its advanced ceramics, packaging, food processing, and automation technologies. Within the ceramics sector, SACMI has developed various automated casting systems tailored for sanitaryware production. The ALS high-pressure casting system, part of SACMI's Robotic Casting range, is specifically designed for the automated production of washbasins, pedestals, water tanks, lids, shelves and accessories. It uses vertically arranged moulds inside robust frames, each with an independent slip infeed, controlled entirely by a centralised PLC (Programmable Logic Controller) (SACMI, 2025).

Automated high-pressure slip casting uses liquid ceramic slurry (slip) injected under pressure into porous moulds. SACMI's ALS casting cell performs this by injecting a water-based ceramic suspension into closed resin moulds. These moulds absorb water from the slip through capillary action, causing clay particles to consolidate into a solid layer.

Slip injection occurs under hydraulic pressure up to approximately 15 bar. After the mould fills, excess slip is drained, and the two halves open automatically. Each mould is individually clamped with forces of up to 1200 kN and aligned vertically within a rigid frame. The system ensures consistent wall thickness and surface finish across products by synchronising injection, clamping and demoulding in a repeatable cycle (SACMI, 2024).

The ALS system is designed for high output and minimal manual handling. Depending on machine size, each unit can host between 4 to 16 moulds. With fast cycle times ranging from 22 to 33 minutes and quick mould changeovers, the system offers excellent productivity. SACMI emphasises that its ALS cells ensure repeatability and what it refers to as "total quality" – meaning consistent production results, minimal defects, and reduced variation between moulded parts (SACMI, 2024).

The ALS cell at Geberit is equipped with two robots: a 6-axis KUKA KR 210 R3100-2F with a reach of 3100 mm and a 210 kg payload (KUKA Deutschland GmbH, 2022). Gaiotto Automation (Gaiotto, 2025) provides dedicated grippers and handling tools that separate the

moulds and remove the green body following a programmed path. The entire operation from casting to demoulding is controlled by a centralised PLC, ensuring precise and repeatable operation throughout the cycle.



Figure 3. Gaiotto Automation robot gripper for handling demoulding supports in the SACMI ALS cell.

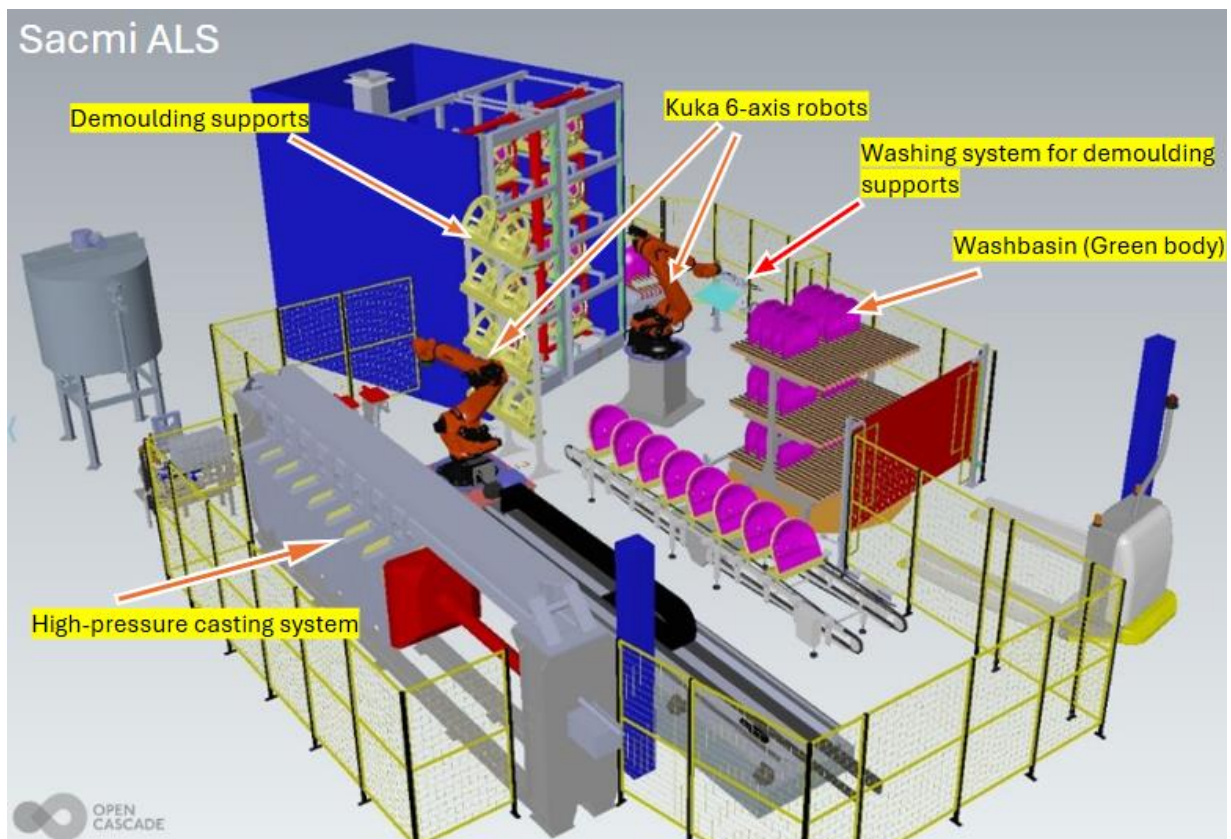


Figure 4. 3D overview of the entire robotic ALS casting cell used in production at Geberit (Geberit Production Oy, 2025).

2.2 Demoulding Supports and Cleaning Requirements

In automated casting cells, the demoulding support refers to the device or tooling that holds and supports the ceramic piece as it is removed from the mould. This support is critical because freshly cast sanitaryware is still wet (“green”) and relatively weak, so it must be handled gently and kept in shape during transfer. Demoulding supports are typically manufactured from high-density polymer or resin-based composite materials, often cast into complex forms that conform to the shape of the ceramic piece. In some applications, stainless steel or aluminium frames may be used where higher mechanical strength is required. To prevent the soft clay body from being marred, the support surface may be coated with non-stick materials or lined with a soft, protective layer (Geberit Production Oy, 2025).

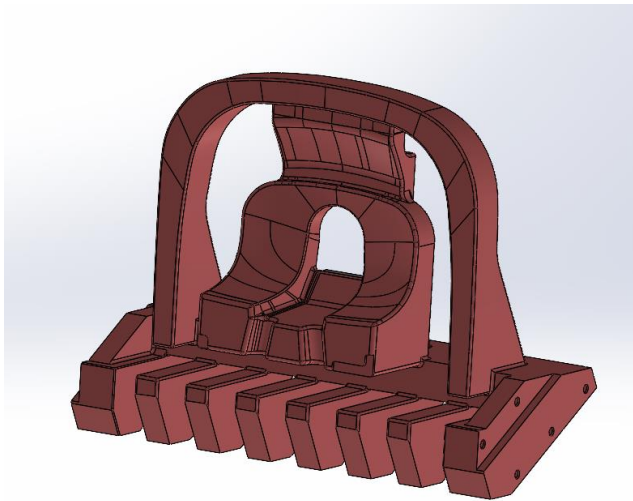


Figure 5. 3D model of demoulding support used in the ALS casting cell at the factory.

Despite these precautions, residues of casting slip and mould release agents can accumulate on the support surfaces through repeated cycles. If not regularly cleaned, these residues can cause defects or interfere with the tight tolerances between the support and the product, leading to improper seating of the cast piece.

SACMI highlights that proper maintenance and cleaning of both the resin moulds and the demoulding supports are essential to extend their service life and to minimise stress or deformation on the products during extraction (SACMI, 2018). In other words, keeping demoulding tools clean preserves equipment and ensures consistent product quality by preventing unwanted friction or misalignment.

2.3 Industrial Washing and Water Contamination

2.3.1 Common Washing Methods

Water-based cleaning systems are commonly used in the manufacturing of sanitary ceramics for cleaning slip residue from equipment, tools, and supports after demoulding. Aqueous cleaning systems are considered safer and environmentally preferable to cleaning with solvents or manual cleaning. Water-cleaning systems often use heated water, along with alkaline or detergent-based solutions, to dissolve and rinse residual slip, oils or grease. Water cleaning also includes mechanical action sprayed agitation or brushing to improve cleaning performance (Jenfab, 2025).

These washers are available in various configurations: basic dip tanks, manual cabinets and automated conveyor systems. Manual wash tanks are simple, economical and suitable for less demanding cleaning tasks. Spray-wash cabinets, however, use powerful, heated jets to quickly remove heavy residues without damaging sensitive parts. Aqueous ultrasonic cleaners utilise cavitation in a warm water bath to clean more intricate surfaces, achieving deeper cleaning (Graymills, 2024).

Continuous inline washers, including conveyor or drum systems, are used for high-throughput operations. These often include filtering systems to maintain consistent cleaning performance (Alliance Manufacturing, 2024).

While solvent-based washers are suitable for special applications where water-based cleaning is unsuitable, they were not relevant to this project. The current design focuses on aqueous methods, especially spray-wash cabinets, as this technology aligns closely with the cleaning process already used for demoulding supports at Geberit. The new design reuses parts of the existing spray system, optimising nozzle orientation and positioning for better cleaning coverage while supporting circular economy principles.

2.3.2 Challenges with Water Containment

One key challenge in aqueous parts washing is managing wastewater. Each wash cycle produces rinse water that may contain suspended solids and chemical residues, all of which

must be managed properly. Without adequate containment, leaks or overspray can affect floors and equipment.

According to FM Global (2022), an insurance and risk management organisation, their loss-prevention guidelines (available via the FM Approvals database) recommend that aqueous cleaning areas be treated as if handling hazardous liquids. This means sealed floor basins, secondary containment (e.g., bunds or spill trays), and sumps to prevent spread and facilitate proper drainage. Additionally, local wastewater regulations require that cleaning solutions be filtered or directed to a treatment system before discharge (Jenfab, 2025).

For this thesis, it is important to note that the washer itself does not include internal filtration or separation. Instead, the washer drains directly into the general floor drain system within the SACMI ALS casting cell. This system is connected to Geberit's internal water treatment facility, which handles the required filtration and environmental safety measures (Geberit Production Oy, 2025).

2.3.3 Established Industry Solutions

Standard industry washers use several strategies to address containment and fluid management. Most aqueous systems recirculate the wash fluid through filters and mesh screens to remove particulates. Oil skimmers and separation units may also be included, especially in systems dealing with greased parts (Jenfab, 2025). While this is less relevant for ceramic applications, such features demonstrate the variety of engineering controls available.

Automated machines often include multiple rinse stages with progressively cleaner water to remove all traces of detergent. Wash basins are typically made of corrosion-resistant stainless steel and equipped with sensors or overflow weirs to prevent flooding (Alliance Manufacturing, 2024).

While this thesis does not include a complete treatment stage, the new washing chamber is designed to direct all wash and rinse water towards a sloped floor with dedicated drainage. This aligns with best practices for water containment, as recommended by FM Global, to prevent puddling and the uncontrolled spread of water on industrial floors (FM Global, 2022).

2.4 Drying of Components

After washing, effective drying is critical to prevent corrosion, water spots, or slippage in handling. In this thesis, cleaned components pass under a series of EXAIR® WindJet® Flat-Fan nozzles (EXAIR, 2025) that deliver high-velocity air in a wide, fan-shaped pattern across each component surface. This impingement drying method is widely used in industry for its energy efficiency and speed (Park & Park, 2022).

The flat airflow produced by WindJet nozzles creates a uniform drying effect. Compared to heat tunnels or infrared dryers, this solution is compact, cost-effective, and suitable for rapid line operation. Literature indicates that air-knife designs, can significantly improve drying efficiency compared to traditional setups (Park & Park, 2022). If further optimisation is required, nozzle positioning and spacing can be easily adjusted in the current system.

Overall, the washing and drying solutions adopted in this thesis align with established industrial practices. The design prioritises cleanability, environmental control and safe operation, while remaining adaptable for future refinements.

2.5 Sealing Solutions in Industrial Environments

2.5.1 Brush Seal for Dynamic Interfaces

In industrial process equipment, effective sealing plays a vital role in controlling liquid splashes, protecting sensitive components and maintaining hygiene. Open gaps can allow water or contaminants to escape, potentially damaging a nearby robot or violating cleanliness standards. For this reason, the sealing solution in this thesis must contain splashes while allowing vertical movement of the robot arm.

Brush seals offer a suitable solution to these challenges. Widely used in high-performance machinery, they have been shown to reduce fluid leakage by up to 80% compared to traditional labyrinth seals. Their compliant bristle construction can accommodate significant dynamic movement without compromising the sealing effect, unlike rigid gaskets (Kwon & Ahn, 2024). In practice, this means a brush seal can form around the robot arm during movement, while still preventing splashes from escaping the enclosure.

The operating principle of brush seals involves a dense array of synthetic bristles forming a flexible barrier. The tightly packed brush conforms to surfaces and fills small gaps, minimising potential leakage paths. Each bristle bends individually to maintain contact across uneven or shifting surfaces, creating an effective seal. Brush seals are used in both wet and dry environments, such as turbines and compressors, where they retain working fluids while allowing thermal expansion and shaft movement (Souissi et al., 2025). Their structure acts as a porous but restrictive barrier, trapping fluids while allowing only minimal leakage. Because bristles return to shape after deflection, the seal remains effective over many movement cycles.

For this thesis, a Raitatuote Stribo PRO H8/120 strip brush was selected, after comparing different commercial products. It consists of an H-profile aluminium holder with densely packed polypropylene bristles, which are water-resistant, durable and chemically inert (Raitatuote, 2025). The aluminium base ensures rigid mounting, while the bristles adapt to movement. Angled mounting is standard in industrial sealing, allowing smooth deflection along the direction of motion and minimising wear (Souissi et al., 2025).

Compared to rubber lip seals or static gaskets, brush seals offer several advantages. Rubber lips may provide tight sealing at first, but often degrade under repetitive use or introduce friction that resists robotic motion. Static gaskets, while effective for fixed joints, cannot accommodate movement and would either require excessive clearance or risk mechanical failure.

Brush seals, by contrast, create a low-friction interface. Each bristle bends independently, reducing resistance and avoiding deformation. The fibres do not shed particles and are easily rinsed clean, making them suitable for use in wet and hygienic conditions. Once the robot arm passes through, the bristles spring back, re-establishing the seal. This self-adjusting behaviour allows long operational lifespans with minimal wear or sealing loss.

Although the cited studies focus on different (smaller) brush seals used in rotating machinery, the core principle remains relevant. This thesis utilises a larger polypropylene strip brush, designed for splash containment rather than pressure sealing. However, it still relies on the same basic mechanism, where dense bristles flex with motion and then return to their original shape to maintain the seal.

2.5.2 Joint Sealing Methods

As a sealing solution for the joints between sheet metal panels in the washing chamber, Sikaflex®-221 is one example of a suitable product. This one-component polyurethane sealant adheres well to metals and plastics, forming an elastic and watertight seal once cured (Sika Group, 2025). Its flexibility (Shore A hardness of ~40) allows it to accommodate vibration and thermal movement without cracking. These properties make Sikaflex-221 a strong candidate for sealing seams and screw penetrations within the washing chamber, where leak prevention are critical. It is also resistant to moisture, ageing and microbial growth, and is certified for incidental food and potable water contact, which supports its use in hygienically demanding environments (Sika Group, 2025).

Alternatively, the panels could be welded together in selected areas of the structure, such as at corners or where vertical panels meet the sloped drain pan. This approach would permanently eliminate gaps, reducing the need for flexible sealants and potentially improving long-term leak resistance. However, welding has not been planned in this thesis, as avoiding it allows for easier disassembly or modification in case design changes are needed later.

2.6 Material Selection for Corrosive Environments (AISI 304 Stainless Steel)

Wet and corrosive environments, such as the washing chamber in this project, demand special materials to prevent rust and degradation. In constant humidity, ordinary carbon steel would corrode rapidly, compromising both structural integrity and cleanliness. Stainless steels, which contain chromium alloying elements, offer far superior corrosion resistance compared to plain carbon steels (Outokumpu, 2022).

AISI 304, also known as EN 1.4301, is an austenitic chromium-nickel stainless steel widely used in industry for its excellent combination of properties. Often referred to as “18/8” due to its nominal composition of approximately 18% chromium and 8% nickel, it forms a thin, self-healing oxide layer that protects against rust (Outokumpu, 2022). As a result, it offers good corrosion resistance, sufficient mechanical strength for structural parts, and excellent manufacturing characteristics. It can be formed and welded without losing performance. These attributes make AISI 304 an “all-purpose” material for environments requiring resistance to moisture.

AISI 304 is commonly used in food-processing equipment, kitchen appliances, and sanitary installations because it resists corrosion and is easy to clean (Outokumpu, 2022). For example, 304 is commonly used in industrial sinks, brewing tanks and dairy equipment where a non-corroding surface is essential. Stainless steel surfaces are also available in polished or brushed finishes to enhance cleanability.

By using 304 stainless steel for the washing chamber, the design ensures that all wetted surfaces remain rust-free, do not leach contaminants, and can be readily sanitised, an important factor for maintaining a clean process environment.

Alternative materials were considered but deemed less optimal for long-term performance. Galvanised steel (carbon steel with a zinc coating) offers initial corrosion protection and a lower cost, but it is vulnerable in wet, abrasive settings. If the protective zinc layer is scratched or wears through, the underlying steel will quickly rust. Even minor coating damages or cut edges can leave galvanised parts “exposed and vulnerable” to corrosion (Metal Supermarkets, 2020). In contrast, AISI 304 is corrosion-resistant throughout its thickness, and even if its surface is scratched, the chromium in the alloy reforms the oxide layer that guards against rust (Outokumpu, 2022).

2.7 Modular Aluminium Framing Systems (Item Profiles)

One key element of this thesis is the frame of the washing chamber, which is constructed using modular aluminium profiles from Item GmbH. Item (styled in lowercase) is a German company founded in 1976 that introduced aluminium extrusion framing systems for industrial applications. It offers a building kit system with over 4,500 compatible components for constructing machine frames, equipment and enclosures (item Industrietechnik GmbH, 2025a).

The fundamental idea behind Item’s system was “screws instead of welds, aluminium instead of steel,” introduced by its founders in 1980. In practice, this means using standardised extruded aluminium profiles and bolt-on connectors to build structures, rather than welding steel. This yields several advantages, including lower weight, enhanced structural stability, rapid assembly and design flexibility (item Industrietechnik GmbH, 2023).

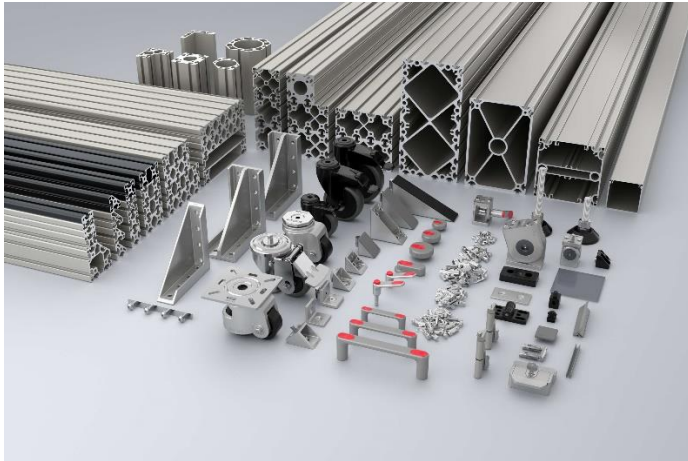


Figure 6. Profile technology. (item Industrietechnik GmbH, 2025a)

Modular aluminium profiles have become a common alternative to traditional steel frames, enabling quick construction of rigid structures without welding. For example, Vladimír et al. (2015) note that anodized aluminium profile systems allow quick and accurate assembly without any welding (avoiding warping or distortion), using a variety of connectors to build or reconfigure structures rapidly. Because the aluminium is anodized, the finished frame requires no painting and will not rust over time.

The Item product range is organised into profile lines distinguished by size. The washing chamber frame in this thesis utilises Item line 8 profiles, which have a 40 mm modular base dimension. Line 8 is Item's most widely used profile family. These profiles are both lightweight and strong, offering a long service life even under continuous use. The material's low density reduces the overall weight of the frame without sacrificing rigidity (item Industrietechnik GmbH, 2023).

To facilitate design and assembly, Item provides an online CAD planning platform called the Item Engineeringtool. This free, browser-based 3D design software lets engineers virtually build assemblies with Item profiles and hardware. It features rule-based design functions and an intuitive interface for selecting and positioning profiles, connectors, and accessories. Once a frame design is completed, the tool can automatically generate all required documentation, including a bill of materials, project drawings and step-by-step assembly instructions (item Industrietechnik GmbH, 2025a).

3 Methodology

3.1 Project Context

The project was carried out at Geberit Production Oy in Tammisaari, Finland, a leading manufacturer of ceramic sanitary products. The factory operates highly automated production lines, including two SACMI robot cells for washbasin casting, installed in 2024. These robot cells handle the casting, demoulding and post-processing of ceramic washbasins in a continuous production cycle.

Within the SACMI cells, 32 demoulding supports are used to handle the delicate ceramic pieces immediately after casting. These supports measure approximately $700 \times 500 \times 500$ mm and require cleaning and drying after each production cycle to ensure operational reliability and cleanliness. The existing washing solution inside the robot cell failed to deliver sufficient cleaning and drying results, resulting in water splashing onto the robot's wrist and leaving wet areas on the floor, creating both safety and operational issues (Geberit Production Oy, 2025).

The washing chamber designed in this thesis is positioned in a corner of the SACMI robot cell, directly adjacent to the robot's final unloading point for the washbasin. After the robot has unloaded the ceramic piece from the support, it immediately lifts the support into the washing chamber without releasing its grip. The robot arm holds the support inside the stationary washing chamber, moving it vertically during the washing and drying phases. Once the washing and drying cycle is completed, the robot arm removes the cleaned support from the chamber and transfers it to the storage rack for reuse. This approach allows the washing chamber to remain fixed while utilising the robot's movement to achieve effective cleaning and drying, without requiring additional robotic time for handling.

The design needed to address several constraints, including limited space within the robot cell, water containment, accessibility for maintenance, integration with existing robot programming and ensuring that no water splashes onto the robot wrist. Collaboration with Geberit's technical team, including automation, robotics and maintenance specialists, was a key part of the development process, alongside iterative design work using engineering tools such as SolidWorks and the ITEM Engineering Tool.

3.1.1 Budget and Procurement

During the execution of the project, an internal investment budget of 6000 euros was opened by Geberit Production Oy. This budget was allocated for the purchase of materials and necessary parts required for the construction and assembly of the washing chamber.

3.2 Current Washing System Analysis

The current washing system installed in the SACMI robot cell at Geberit Production Oy consists of a fixed open spraying setup with two horizontal aluminium pipes positioned parallel to each other. One pipe delivers water through five evenly spaced nozzles, while the other pipe supplies compressed air through twelve yellow flat fan air nozzles mounted along the length of the pipe. Both pipes are connected via hoses to valve assemblies located at the base.



Figure 7. Current washing system.

The washing process is entirely open, with no enclosure or protective walls apart from one of the cells having a flexible plastic curtain hanging to the floor level to minimise water flowing outside the cell. During operation, the robot holds the demoulding support in front of the spray station, moving it vertically to allow full coverage of the surface by the water nozzles and compressed air. The washing phase is programmed for approximately 12 seconds, followed by a 20-second drying phase, totalling 30 seconds per cycle.



Figure 8. Demoulding support in front of the washing system during the wash cycle.

A significant challenge with the current system is the uncontrolled water dispersion. The open design allows water to splash onto the floor, robot arm and nearby equipment, resulting in visible puddles and wet surfaces after each washing cycle. This creates safety risks due to slippery conditions and increases the risk of moisture affecting sensitive electronic components on the robot. Additionally, discussions with Geberit technical staff, have identified occasional issues with residual slip material remaining in certain gaps on the demoulding supports after washing, as well as suboptimal drying performance, causing supports to drip when placed on the storage rack for drying and reuse.



Figure 9. Residual water and contamination on the floor due to splashing from the current open washing system.

No formal measurements of water spillage or cleaning efficiency have been documented. However, visual observations show that the floor remains wet and stained, with accumulated slip residue visible after multiple cycles. The cleaning process fulfils its basic purpose but lacks effective water containment and reliable drying, motivating the development of a fully enclosed washing chamber in this thesis project.

3.3 Design Approach, Tools and Communications

The design process for the washing chamber was carried out using several engineering tools and a combination of iterative design steps, practical considerations, and discussions with Geberit's technical team. The primary CAD software used was SolidWorks, where the initial 3D modelling and assembly design were created (Dassault Systèmes, 2024). Additionally, the Item Engineering Tool was used to configure the aluminium profile framework and to generate detailed part lists and fastening solutions required for procurement and quotation purposes. For viewing and measuring reference models from the SACMI casting cell, CAD Assistant software was used to handle a large 1 GB STP file provided by the supplier (Open Cascade, 2025).

The design process began with preliminary discussions with the thesis supervisor to clarify the project's requirements and constraints. Early brainstorming sessions included considerations of structural materials, enclosure types, and accessibility for maintenance. Initial concept sketches were drawn by hand to estimate dimensions and layout, which were then translated into a SolidWorks model. The aluminium profile system from Item was imported into SolidWorks to build the structural framework, followed by the addition of sheet metal panels, a sloped drain pan, and the integration of a brush sealing solution for the area where the robot arm enters the chamber.

During the design process, attention was given to spatial constraints inside the SACMI cell, ensuring that the chamber would fit without interfering with the robot's movement. An offset was included around the robot's path to allow tolerance for minor positioning deviations while maintaining water containment with the brush seals. Drainage was designed to direct water towards the floor drain, without requiring complex drain piping. Material selections, including stainless steel (AISI 304) for the panels and aluminium Item profiles for the structure, followed

both Geberit's internal standards and logical choices for corrosion resistance and hygiene in a wet environment.

Service accessibility was an important design consideration. A side door was incorporated to enable maintenance personnel to access the interior of the chamber. This feature was refined after a mid-process design review meeting, where feedback from Geberit confirmed the need for easy service access.

Throughout the project, communication with suppliers played a key role. Contact with Item Profiili Oy representatives provided technical guidance on integrating their standard door components with Plexiglas panels for watertightness. A complete design package, including part lists and assembly details generated in the Item Engineering Tool, was submitted to Item Profiili Oy for quotation. Similarly, contact with Rasmet Steel allowed for the fabrication of custom sheet metal components, including the sloped drain pan (Rasmet Steel Oy Ab, 2025). Technical drawings in DWG format were sent to the supplier, specifying plasma cutting, bending and welding requirements for manufacturing.

No physical prototypes were constructed during the design phase. Given the straightforward geometry and reliance on standard components, digital modelling was deemed sufficient for validation prior to installation.

An essential part of the design was the integration of a brush strip sealing solution at the robot arm's vertical moving path. This solution was selected to minimise water splashing from the chamber, both onto the robot arm and outside the washing area. The chosen brush strip was a large-profile type with approximately 120 mm brush length from Raitatuote (2025), providing sufficient coverage for the robot's arm dimensions. Initially, the brushes were designed to face each other in a parallel orientation; however, during the design process, they were angled inward by 30 degrees to better follow the robot arm's movement, improve sealing performance and reduce friction and bending stress on the bristles. The angled design also offers flexibility, allowing the brushes to be adjusted or replaced with a straight configuration if needed in future maintenance or operational adjustments. The design approach also considered future proofing the structure, ensuring that additional washing or drying equipment could be integrated later if necessary.

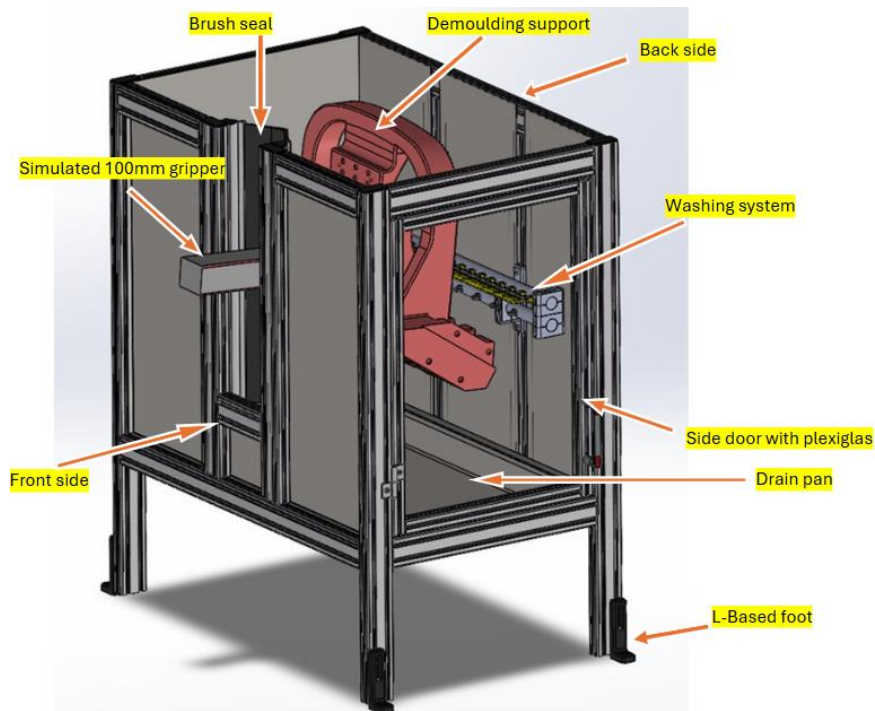


Figure 10. SolidWorks 3D model of the washing chamber design showing the aluminium profile frame, sheet metal panels, side access door, brush sealing system around the robot entry point, and the wash system implemented.

3.3.1 Use of AI Tools

Arcada aims to be at the forefront of new technologies and innovative solutions, actively encouraging both staff and students to make responsible use of AI-supported tools as part of their development and learning processes. In line with this goal, the use of AI tools in this thesis has followed the core principles of honesty and transparency, human–AI–human workflow, data protection and ethical reflection (Arcada, 2025).

Artificial intelligence tools are rapidly evolving and offer significant benefits when used responsibly. During the writing process, ChatGPT (OpenAI, 2025) was utilised as a support tool to generate ideas, help reformulate some sections and assist with clarity and structure. The tool was not used to write any parts of the report independently or to introduce content that was not based on the author’s own design work or research. Instead, it functioned as a support for improving expression and logic, aligned with the recommendations in Arene’s traffic light model, where AI may support planning, ideation and language review, but not act as a substitute for original academic work (Arene, 2023).

Additionally, Grammarly was also utilised for some grammar checking and enhancing sentence flow (Grammarly, 2025). Its use was limited to proofreading and refining text that had already

been written, helping ensure linguistic correctness and readability. All changes were reviewed and validated manually. These tools provided valuable support in maintaining clarity and accuracy throughout the writing.

Throughout the thesis process, the author of the thesis took full responsibility for the content and maintained strict adherence to Arcada's ethical requirements regarding academic integrity and the use of AI.

3.4 Validation and Testing Plan

Due to the project schedule and production constraints, the washing chamber could not be installed in the SACMI casting cell before the completion of this thesis. The installation will take place during the factory's summer shutdown period in the end of July, which means that full validation and in-process testing will be conducted only after this date. As such, this chapter outlines a proposed testing plan rather than a completed evaluation.

The final performance validation will be carried out during production cycles, once the chamber is installed in the cell. Key evaluation criteria will include water containment during washing and drying, robot arm compatibility with the chamber's entry and movement path, drying efficiency and the general ease of service and maintenance. Particular attention will be given to ensuring that no water splashes outside the chamber or affects nearby equipment, and that demoulding supports are removed from the chamber without residual moisture.

Direct observations, photographic documentation and feedback from operators and maintenance staff will serve as the primary validation tools. The maintainability aspects, including the side door and modular panelling, will also be reviewed for practical access during cleaning and service routines. Although these evaluations will take place after the formal end of this thesis project, the chamber has been designed with these future tests in mind. The construction allows for future modifications and the integration of additional equipment, if necessary, without requiring structural redesign. This built-in adaptability supports the continuous improvement of the cleaning process. In the meantime, prior to cell installation, the frame and internal components will be assembled in the workshop. While no process tests will be performed at this stage, the pre-assembly provides an opportunity to verify the physical fit, mechanical fastening and access layout as part of the preparation phase.

4 Results and Design Implementation

4.1 Design Goals and Key Requirements

The design of the washing chamber was guided by a set of technical and practical requirements, based on discussions with Geberit and the physical constraints of the SACMI robot cell. The main goals and key requirements were:

- Fit within the limited space inside the robot cell without interfering with other equipment or the robot's movement path.
- Ensure sufficient height to prevent water from splashing upwards and escaping the chamber.
- Contain all water inside the chamber and direct it toward the floor drain.
- Allow the robot to lift the demoulding support into the chamber without releasing its grip, and to move the support vertically inside the chamber.
- Keep the washing and drying process within the existing cycle time, not exceeding approximately 32 seconds.
- Use corrosion-resistant materials suitable for a wet production environment, including aluminium profiles and stainless steel (AISI 304) panels.
- Include a side access door for maintenance without dismantling the structure.
- Implement a sealing solution around the robot arm entry point to minimise water splashing.
- Allow for future addition of washing or drying equipment without requiring major structural modifications.

4.2 Frame Construction

The structural frame of the washing chamber was designed using modular aluminium profiles from Item's MB Building Kit System, specifically from the profile 8 series. Based on early discussions with Geberit and the mechanical requirements of the application, the 80x40 mm profile (Figure 11) was selected as the main structural element. This profile offered sufficient rigidity while remaining compact, making it suitable for the confined space within the SACMI casting cell.

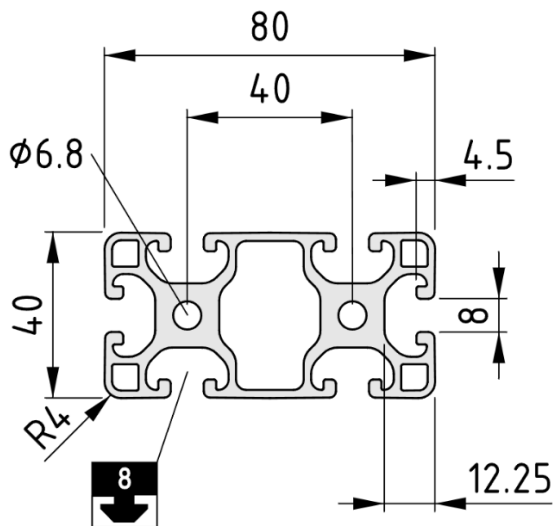


Figure 11. Technical drawing of Item 80x40 mm profile (item Industrietechnik GmbH, 2025a)

Figure 12. Profile example (item Industrietechnik GmbH, 2025a)

The design work began by importing a standard Item 3D model of the 80x40 profile and recreating its sketch geometry in SolidWorks (Figure 13). This approach made it easier to test different design ideas by simply adjusting extrusion lengths within SolidWorks and saving them as new parts, without needing to import new parts for every iteration.

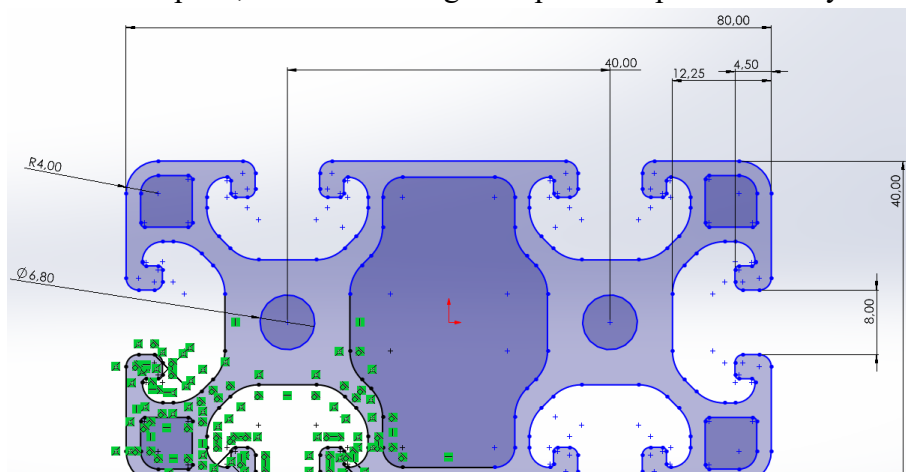


Figure 13. Sketch-based version of the profile created in SolidWorks for parametric modelling.

The basic frame was dimensioned to approximately 1400 mm in height, 1200 mm in length, and 800 mm in width, according to the available cell space and the size of the demoulding support. Additional 80x80 mm profiles were used in the lower section of the frame, providing a 40 mm interior mounting surface that allowed for the secure integration of the sloped drain pan (Figure 14). These larger profiles added both strength and mounting flexibility for drainage components.

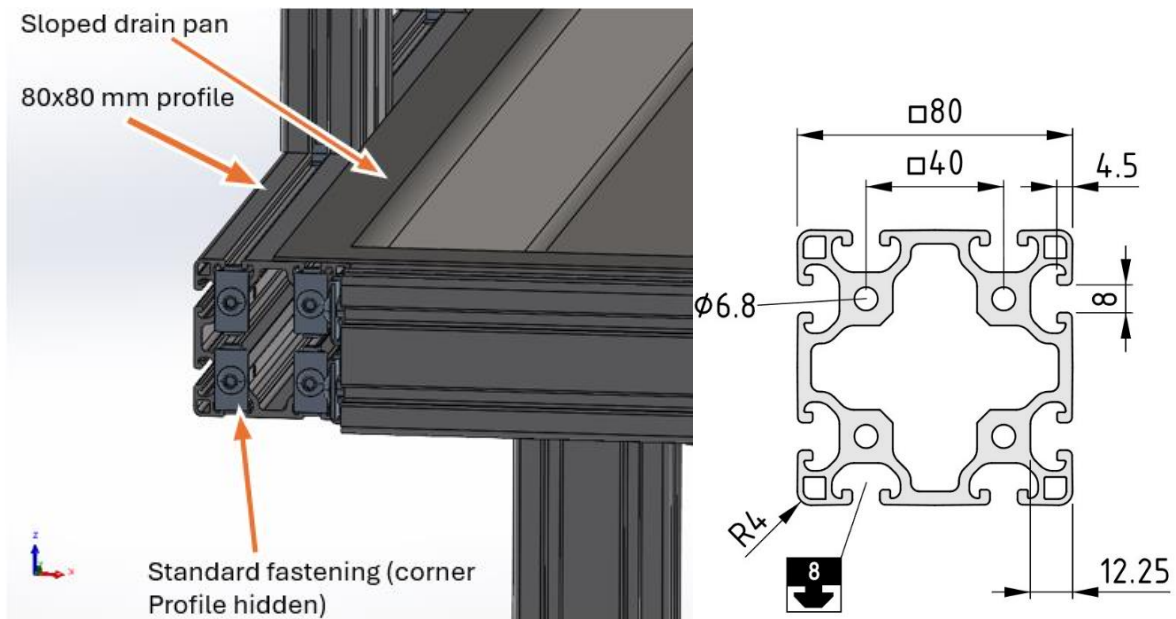


Figure 14. Connection detail of the sloped drain pan mounted on 80x80 mm profiles, shown with reference XYZ axes and opened (corner) profile cut for clarity.

Figure 15. 80x80 profile drawing (item Industrietechnik GmbH, 2025a).

A dedicated opening was created on the front side (the side facing the robot working area) for the robot arm to enter the chamber while still holding the demoulding support. Although the gripper itself measures around 100 mm in width, the opening was made 200 mm wide to provide tolerance for possible misalignment and to reduce stress on the brush seal solution. This also allowed for the use of two Stribo pro brush strips (further explained and visualised in Chapter 4.4), each approximately 120 mm long, installed at a 30° inward angle for better contact. The angled profile pieces used for this were Item R40/80 – 30° profiles (Figure 16), which are typically intended for corner framing, but were repurposed here effectively.

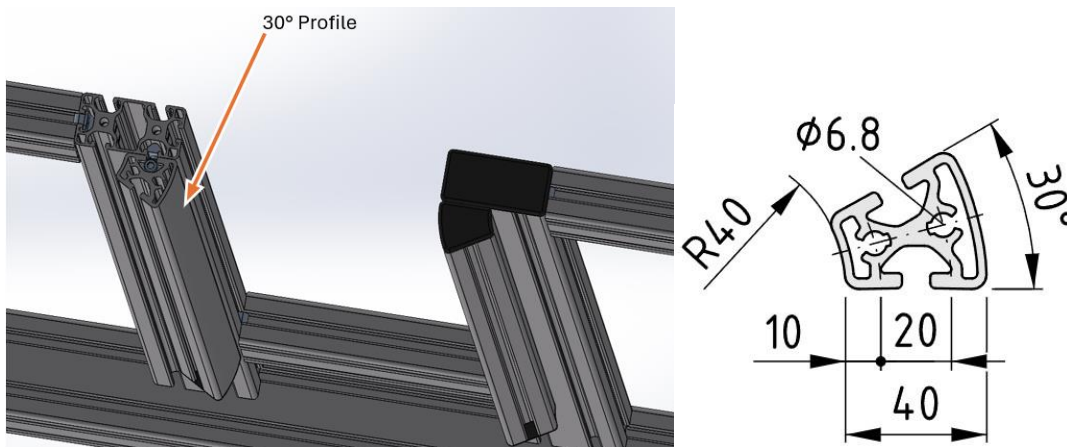


Figure 16. Use of angled profile pieces to support the future installation of the 30° brush seal configuration (brush strips not shown here).

Figure 17. R40/80–30° profile drawing (item Industrietechnik GmbH, 2025a).

An important design decision was to place all sheet metal panels on the inside of the frame, meaning they are mounted against the internal faces of the aluminium profiles rather than covering the outer surfaces. This layout kept the exterior aluminium surfaces exposed for accessibility and reduced the risk of water entering the T-slot grooves. To address the challenge of mounting the washing and drying pipes in this enclosed layout, two vertical 120x40 mm profiles were placed at the back of the chamber. These profiles created a 40 mm gap between the internal panels, forming a channel where components could be height-adjusted or extended later (Figure 18).

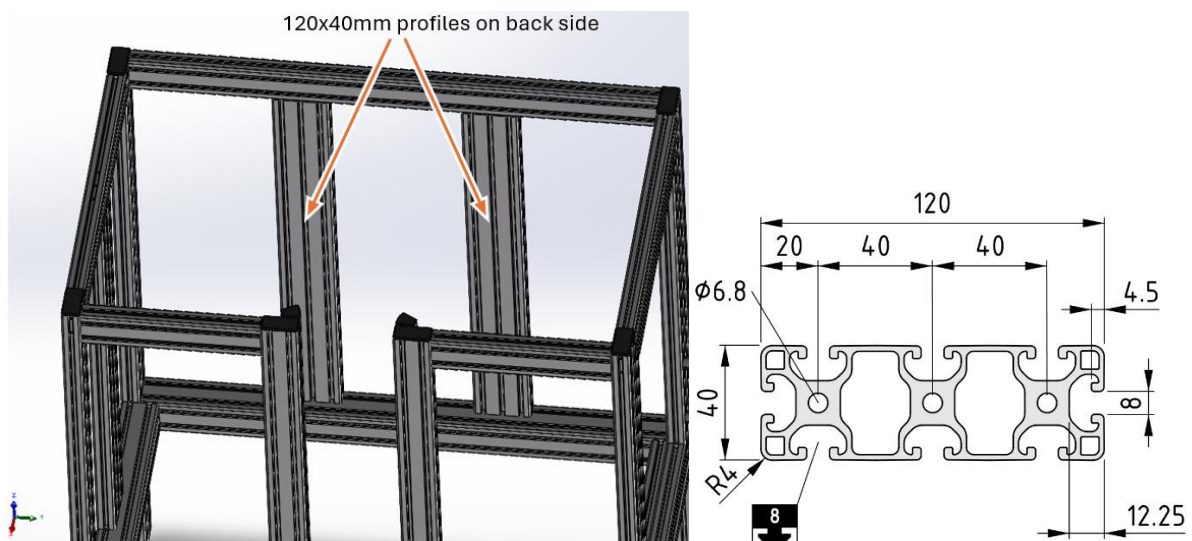


Figure 18. Vertical 120x40 mm profiles with integrated 40 mm channel for mounting wash/dry equipment.

Figure 19. 120x40 profile drawing (item Industrietechnik GmbH, 2025a).

For a stable installation, particularly considering the slight unevenness of the floor in the cell, standard Item height-adjustable aluminium feet (L-Based Foot) were added to all four corners of the frame (Figure 20). This allowed for precise levelling of the structure. According to Item specifications, the foot can withstand a maximum force of 3000 N (approximately 306 kg) and a bending moment of up to 100 Nm (Figure 21).

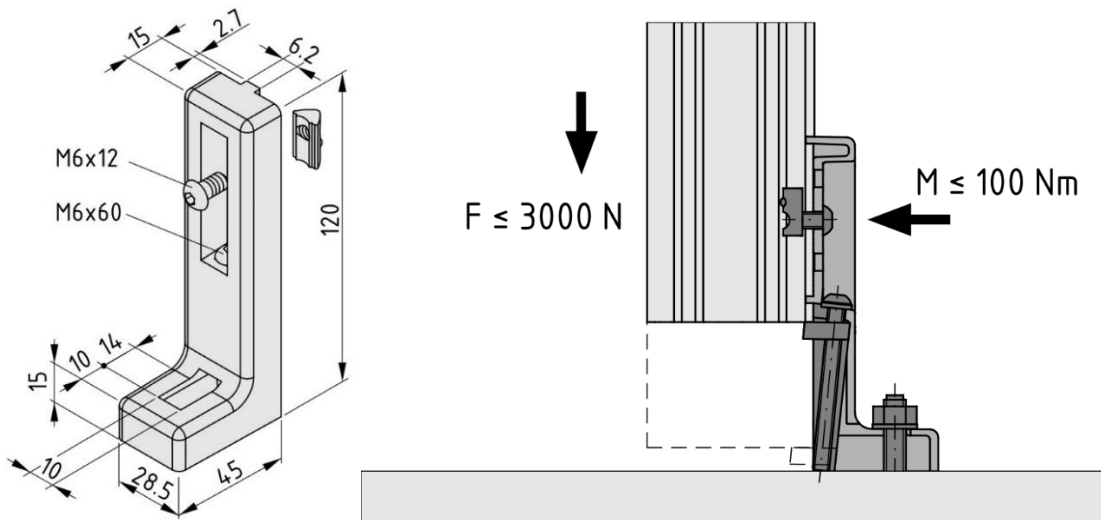


Figure 20. Height-adjustable foot for fine levelling of the frame on uneven floors (item Industrietechnik GmbH, 2025a).

Figure 21. Load limits for the L-Based Foot ($F \leq 3000\text{ N}$, $M \leq 100\text{ Nm}$).

To summarise the frame design, all profiles were arranged to provide a rigid yet adaptable structure that supports water containment, maintenance access and future system expansion. The complete frame, as designed in SolidWorks using all Item components, is shown in Figure 22. According to the Item Engineering Tool, the total weight of the constructed frame, including all Item components, is approximately 74.36 kg, suitable for workshop assembly.



Figure 22. SolidWorks model of complete washing chamber frame using Item aluminium profiles.

4.2.1 Load Capacity Verification

To verify the structural capacity of the aluminium profiles used in the frame, a load simulation was performed using the Item Load Calculator, which provided the section properties, calculated the expected deflection and bending stress, and confirmed their compliance with the material limits (item Industrietechnik GmbH, 2025b). The analysis focused on the 80×80 mm profile, which is utilised in the lower frame to support the sloped drain pan. While the actual structure includes additional vertical and horizontal supports, this simulation used a conservative scenario to assess the profile's standalone performance under load.

A distributed load of 2000 N (approximately 200 kg) was applied across a 1120 mm span, corresponding to the longest continuous horizontal profile in the design. The profile was assumed to be fixed at both ends. According to the Item Load Calculator output, the resulting total deflection was approximately 0.08 mm, and the corresponding bending stress was 5.57 N/mm², which is significantly below the material yield limit of 195 N/mm² specified for EN AW-6063 T66 aluminium profiles (item Industrietechnik GmbH, 2025b).

These calculations are reproduced below for clarity:

Deflection calculation from Item Industrietechnik GmbH (2025b).

Weight force:

$$F_g = m \cdot l \cdot g = 5.33 \frac{kg}{m} \cdot 1120 \text{ mm} \cdot 9.81 \frac{m}{s^2} \approx 58.56 \text{ N}$$

Deflection due to own weight:

$$d_g = \frac{F_g \cdot l^3}{384 \cdot E \cdot I \cdot 10^4} = \frac{58.56 \text{ N} \cdot (1120 \text{ mm})^3}{384 \cdot 70,000 \frac{N}{mm^2} \cdot 134.06 \text{ cm}^4 \cdot 10^4} = \approx 0 \text{ mm}$$

Deflection due to the acting force:

$$d_g = \frac{F_g \cdot l^3}{384 \cdot E \cdot I \cdot 10^4} = \frac{2000 \text{ N} \cdot (1120 \text{ mm})^3}{384 \cdot 70,000 \frac{N}{mm^2} \cdot 134.06 \text{ cm}^4 \cdot 10^4} = \approx 0.08 \text{ mm}$$

Total deflection:

$$d = d_g + d_F \approx 0 + 0.08 \text{ mm}$$
$$d \approx 0.08 \text{ mm}$$

Bending Stress calculation:

$$\sigma = \frac{F \cdot l}{12 \cdot W} = \frac{2000 \text{ N} \cdot 1120 \text{ mm}}{12 \cdot 33.51 \text{ cm}^3} \approx 5.57 \text{ N/mm}^2$$

Although the simulation does not reflect the exact boundary conditions of the installed structure, it provides a valuable reference point and demonstrates that the profile selection was structurally sufficient even under conservative assumptions. The high safety margin further supports the suitability of the chosen profile dimensions.

4.2.2 Ordering and Documentation (Item)

After completing the structural design in SolidWorks, the entire frame was recreated in the Item Engineering Tool to generate a complete bill of materials and ensure compatibility with Item's standard fastening components. The engineering tool also allowed for the easy addition of accessories, such as caps, cover panels, hinges, feet and door fittings (Figure 23).

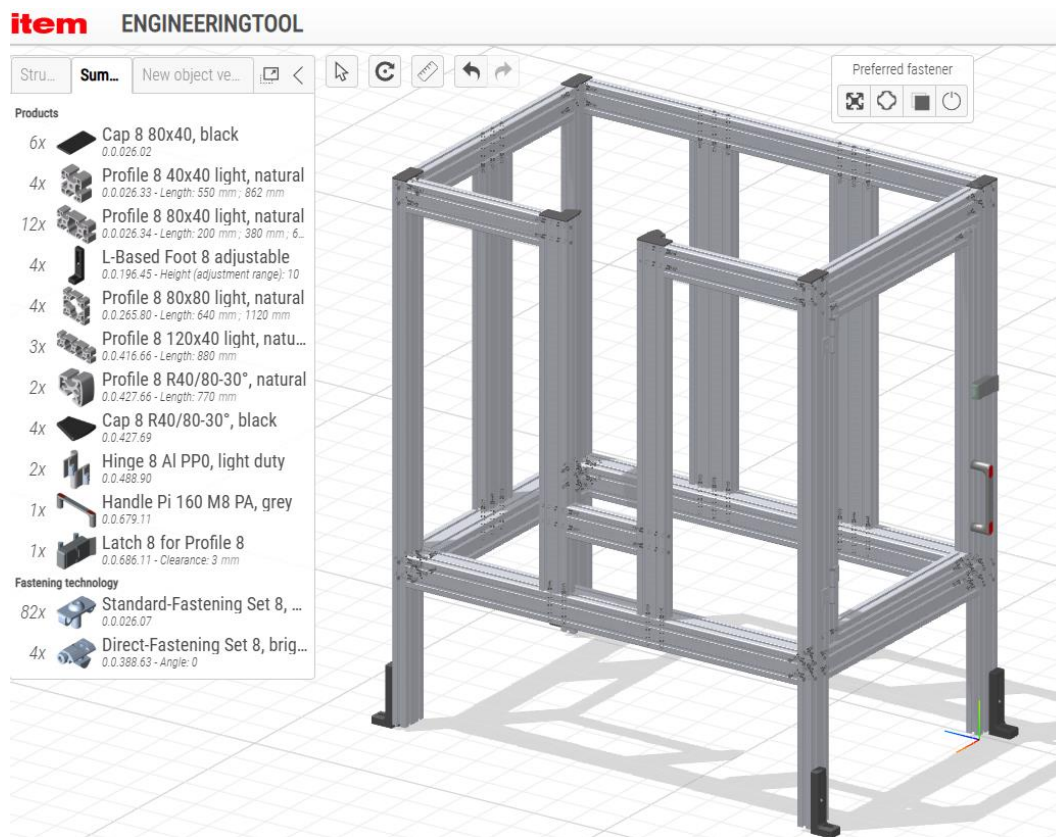


Figure 23. Finalised frame design and component list from Item Engineering Tool (item Industrietechnik GmbH. 2025a.).

The finalised parts list and design documentation were sent to Item Profili Oy for quotation. A reply was received shortly after, confirming the availability and cost of the listed components. The total cost for all required profiles, connectors, accessories, and sealing

elements was €1917.26. The expected delivery time was approximately three weeks. This offer was then forwarded to Geberit for approval before the order was officially placed.

During communication with Item, some optimisations were made to reduce cost, including using standard fastening sets instead of more expensive alternatives. Item also recommended a suitable sealing solution for the service door based on the defined requirements.

4.3 Sheet Metal Components

4.3.1 Sloped Drain Pan Design

The design of the internal sloped drain pan was the first component developed once the structural frame was finalised. Once the basic dimensions of the aluminium frame were established, the geometry of the pan was calculated to fit securely inside it. The aim was to guide water efficiently toward the centre and allow easy drainage through a single opening, while maintaining enough vertical depth for the demoulding support to be lowered without obstruction.

The sloped drain pan was again designed using SolidWorks (Dassault Systèmes, 2024). The first step in SolidWorks was to create a loft between two profiles. The base profile, measuring 70x70 mm, was selected to accommodate a standard Geberit-recommended pipe connection for drainage. The upper profile in the loft measured 996x596 mm, this refers to the intermediate sketch used as the upper boundary of the loft feature. This initial geometry created a shallow inner cone to start the sloping (Figure 24). The next step was to add a boundary feature, extending from the same 996x596 mm sketch up to 1036x636 mm, creating a steeper outer wall (Figure 25). Finally, a top extrusion of 1120x720 mm was added to match the inside dimensions of the supporting frame (Figure 26).

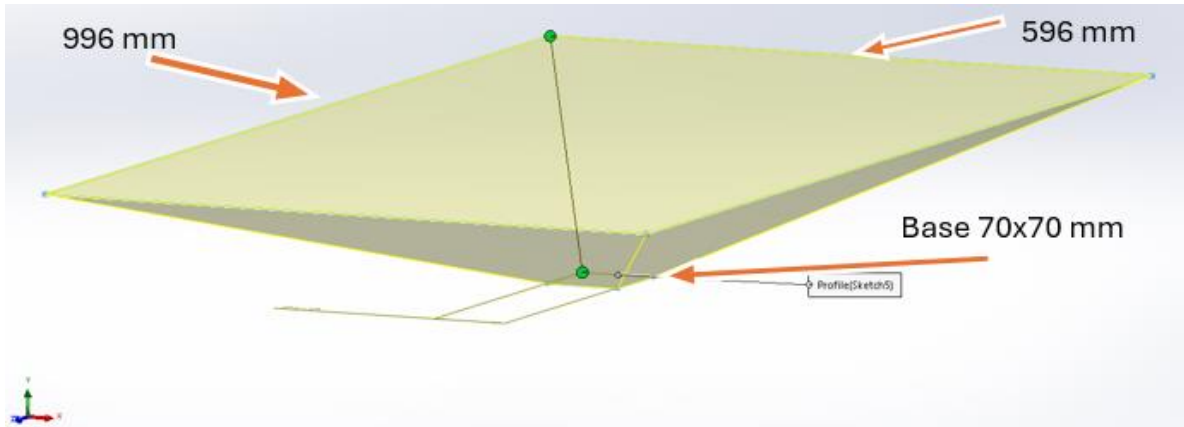


Figure 24. Loft feature from 70x70 mm base to 996x596 mm intermediate profile in SolidWorks.

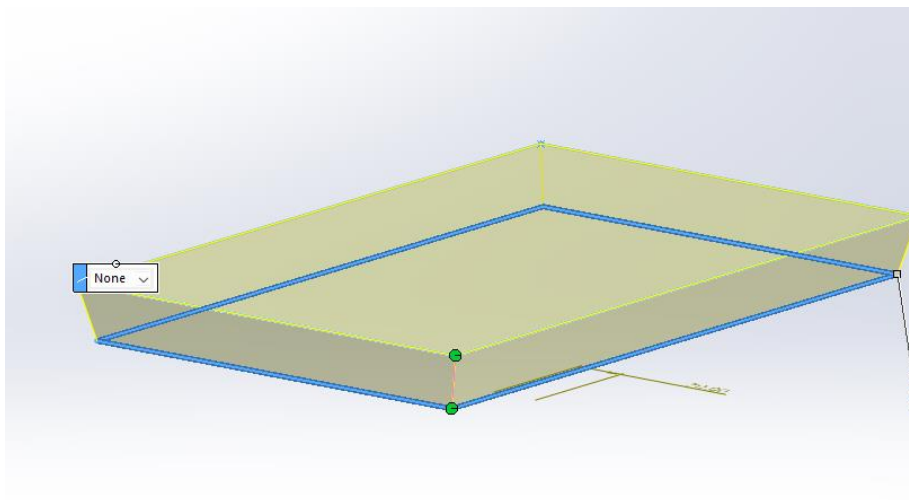


Figure 25. Boundary feature extending outer sloped edge to 1036x636 mm.

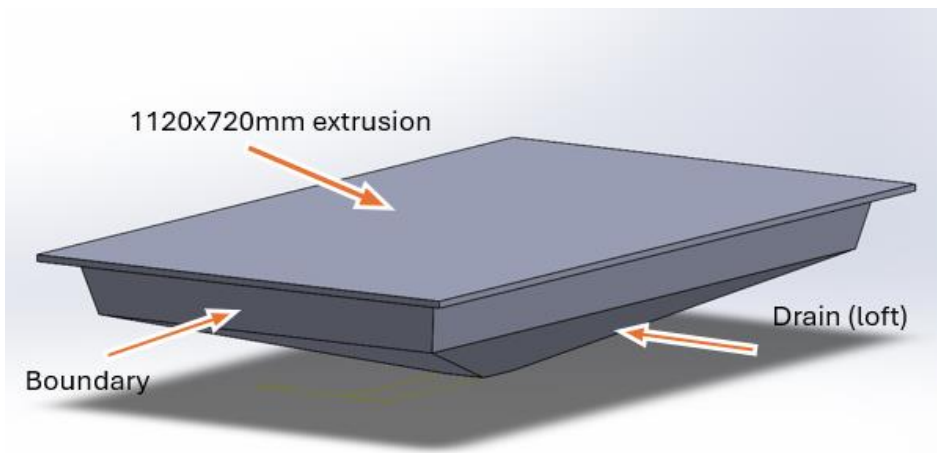


Figure 26. Completed solid geometry with added 1120x720 mm extrusion on top.

The reason for combining a gentle initial loft and a steeper boundary was to provide enough depth to the drain area before the slope begins. Without this step, the entire sloping geometry would begin immediately from the frame edges, which could interfere with the lowering of the

demoulding support or leave too little fall for proper water drainage. By introducing a more recessed centre, the demoulding support can be lowered deeper into the chamber and water is more effectively directed to the centre without pooling.

Once the solid geometry was complete, it was converted to a sheet metal body using the "Convert to Sheet Metal" tool in SolidWorks (Figure 27). Before converting, split lines were applied to the top extrusion corners to define the necessary bends. Rather than using the automatic mode, the manual approach was selected to define individual faces and bend lines for greater control. A material thickness of 2 mm in AISI 304 stainless steel was set for all faces, consistent with the rest of the washing chamber's sheet metal components.

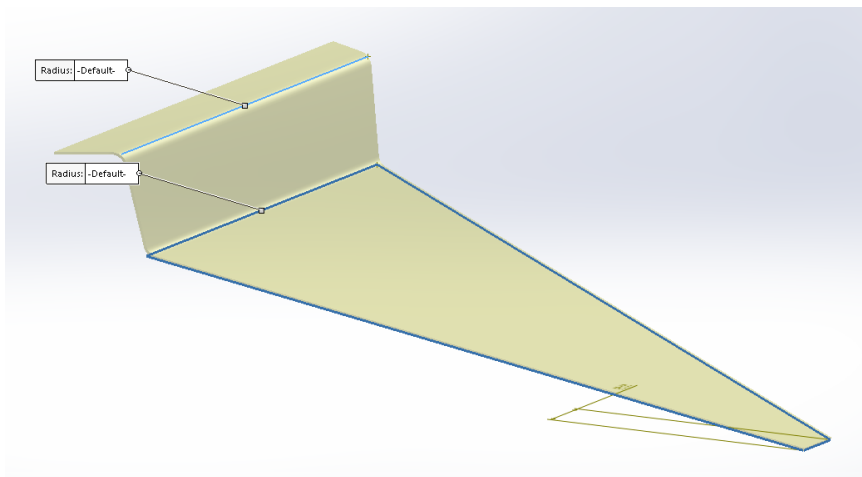


Figure 27. Manual sheet metal conversion showing the bent face.

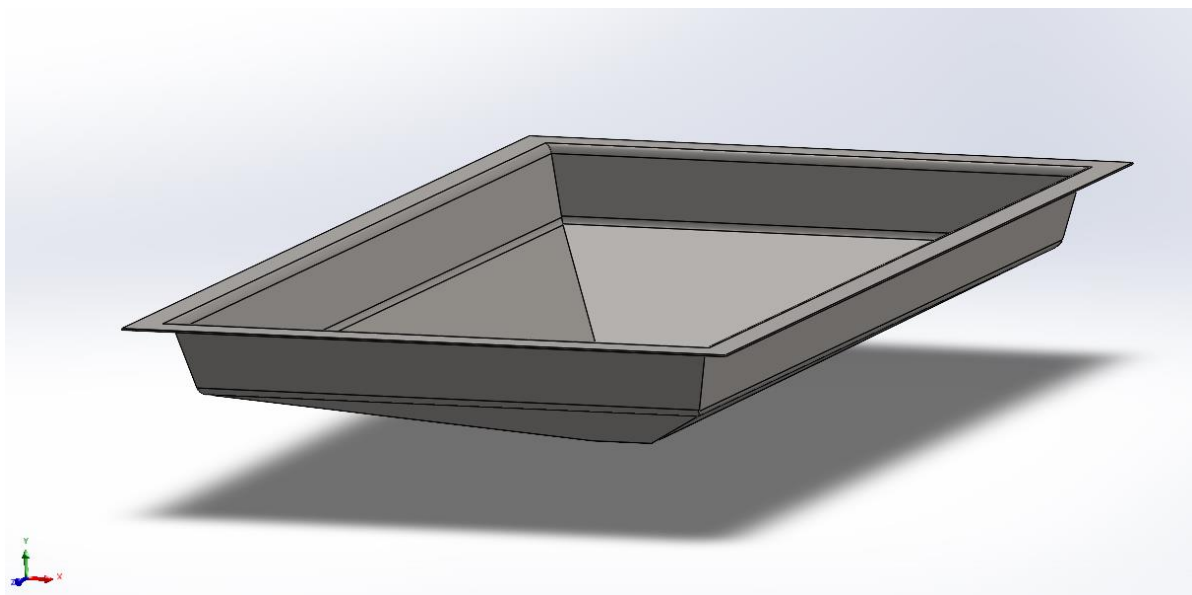


Figure 28. Finalised design of sloped drain pan.

The resulting model could then be flattened to generate manufacturing drawings and unfolded views for laser cutting and bending. Section 4.3.3 describes this process, along with DWG export and production specifications.

After completing the drain pan model, it was inserted into the whole frame assembly in SolidWorks. Using the mate function, key features on the pan were aligned with the supporting profiles to ensure proper alignment and fit (Figure 29). The drain pan will be fastened to the lower aluminium profiles using Item V 8 St M6 T-slot nuts and custom M6 screws with O-ring gaskets (preferably EPDM type of synthetic rubber or silicone) placed under the heads to maintain watertightness around the screw holes. Hole drilling will be done manually in the workshop to ensure perfect alignment with the actual frame. Although this adds some time during assembly, it eliminates the risk of misalignment during pre-fabrication. In future reproductions of the chamber, holes can be pre-cut once all dimensions are confirmed and tested.

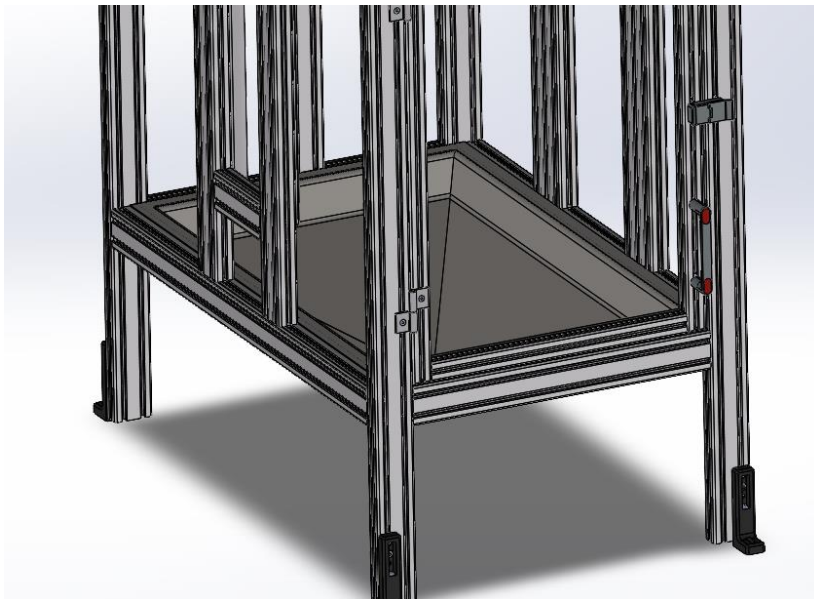


Figure 29. Sloped drain pan positioned inside the frame.

The final drain geometry features a central base of 70 mm x 70 mm and a total height of 212 mm, with drainage slopes of approximately 15.7° along the longer sides and 26.3° along the shorter sides. The boundary walls rise at approximately 76° to create the initial depth before the slope begins. These values were optimised to balance clearance, water flow, and room for piping underneath.

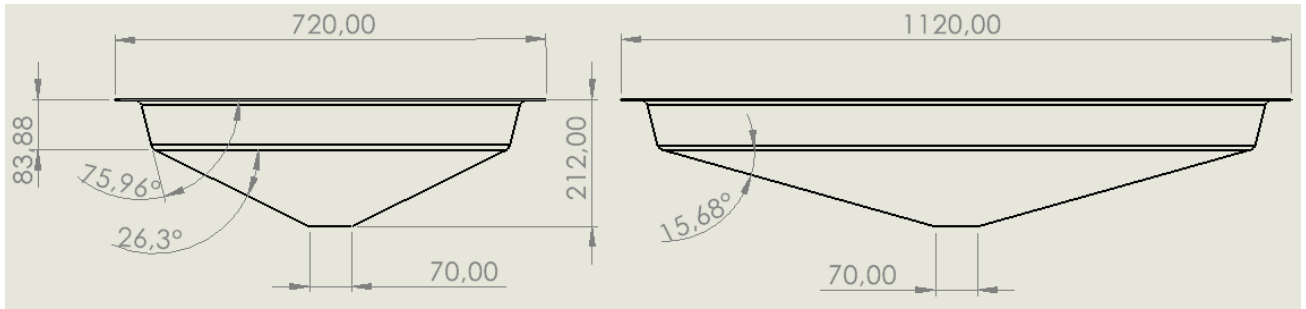


Figure 30. Technical drawing showing drain pan angles and basic dimensions (SolidWorks drawing view).

4.3.2 Sheet Metal Panels

The sheet metal panels forming the side walls of the washing chamber were once again designed using SolidWorks (Dassault Systèmes, 2024). The panels were modelled directly within the assembly to streamline the design process. This allowed dimensions to be sketched in place based on the internal frame geometry, ensuring a precise fit and alignment with the aluminium profile structure.

Each panel was created using a simple sketch and extruded to a thickness of 2 mm. The material selected was stainless steel AISI 304, matching the drain pan. The back side consisted of three vertical panels: two identical outer pieces and one central panel. This layout was chosen to expose the fastening channels of the 120x40 profiles. These channels allow for future installation of an adjustable washing or drying system, enabling height flexibility and modular upgrades. The figure clearly shows the visual gaps aligning with the profile tracks (Figure 31).

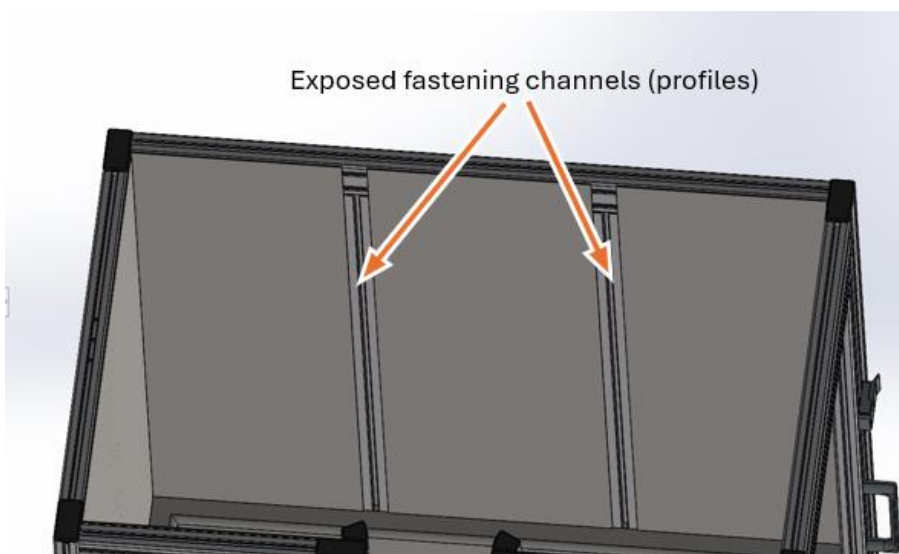


Figure 31. Three-part back wall panel layout allowing access to 120x40 profile tracks.

The side wall was modelled as a single panel covering the entire structure's side. During the frame design, a 120x40 profile was intentionally placed in the middle of the side wall to allow later division of this panel into two if side-mounted washing and drying equipment is installed. Even if not used for mounting, the profile still adds structural rigidity and reduces vibration during operation (Figure 32).

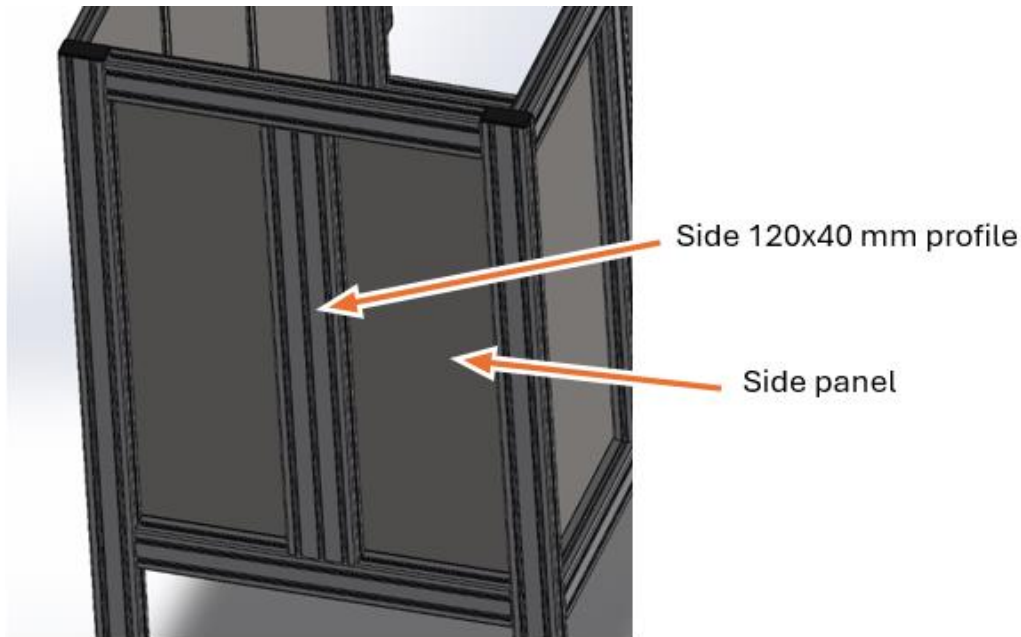


Figure 32. Side panel with profile for optional future washing system mounting.

The front panel differs in shape due to the cutout needed for the robot arm's vertical movement path. The opening also had to accommodate the 30° angled profiles supporting the brush seals, which required additional attention during sketching to avoid interference. The final panel design ensures the necessary clearance while maintaining full edge coverage for water containment (Figure 33).

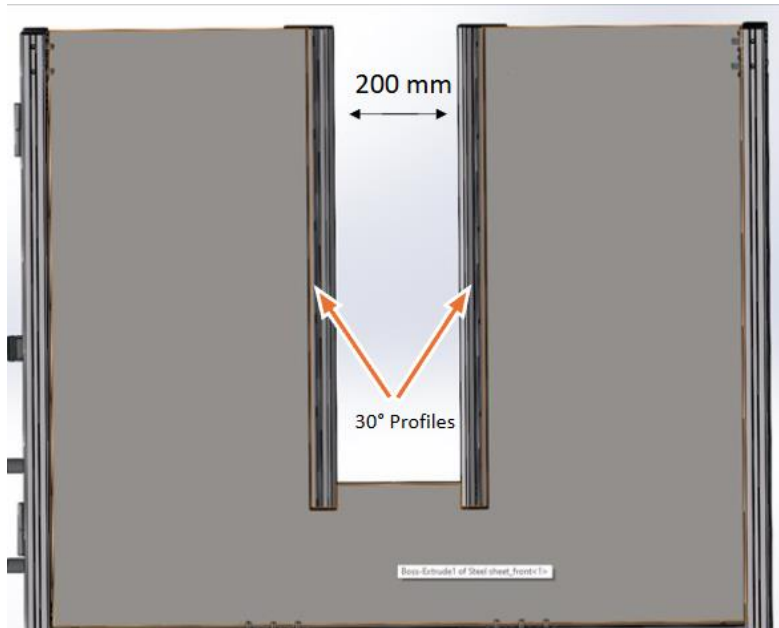


Figure 33. Front panel with opening for robot arm and angled brush seal supports.

Each panel is planned to be mounted using the same method as the sloped drain pan: M6 screws paired with Item T-slot nuts inserted into the profile tracks. Fastening points are intended to be spaced at intervals of approximately 300 mm to ensure sufficient clamping pressure for sealing and mechanical stability.

Figure 34 presents the complete technical drawing with dimensions for all panels, including front, side and back wall components. These are used in the ordering documentation for Rasmet Steel, detailed in the next section. Like the drain pan, holes for fasteners will be drilled manually during the assembly process. This method reduces the risk of misalignment and allows minor adjustments during installation.

4.3.3 Ordering and Documentation (Rasmet Steel)

To manufacture the sheet metal components, the thesis supervisor at Geberit recommended working with Rasmet Steel, a local supplier and production partner frequently used by the factory (Rasmet Steel Oy Ab, 2025). It was explained that Rasmet can deliver fully welded stainless-steel constructions.

Upon reviewing Rasmet Steel's services online, it was confirmed that they utilise CNC plasma cutting, which requires each part to be provided as a separate DXF file. Therefore, each component was exported from SolidWorks (Dassault Systèmes, 2024) as an individual DXF

file for compatibility with their machine tools. In total, seven unique files were produced, with two of them being mirrored or duplicated to complete the whole drain pan geometry. The wall sheet metal panels were compiled into a unified PDF drawing to aid visual clarity during ordering and verification.

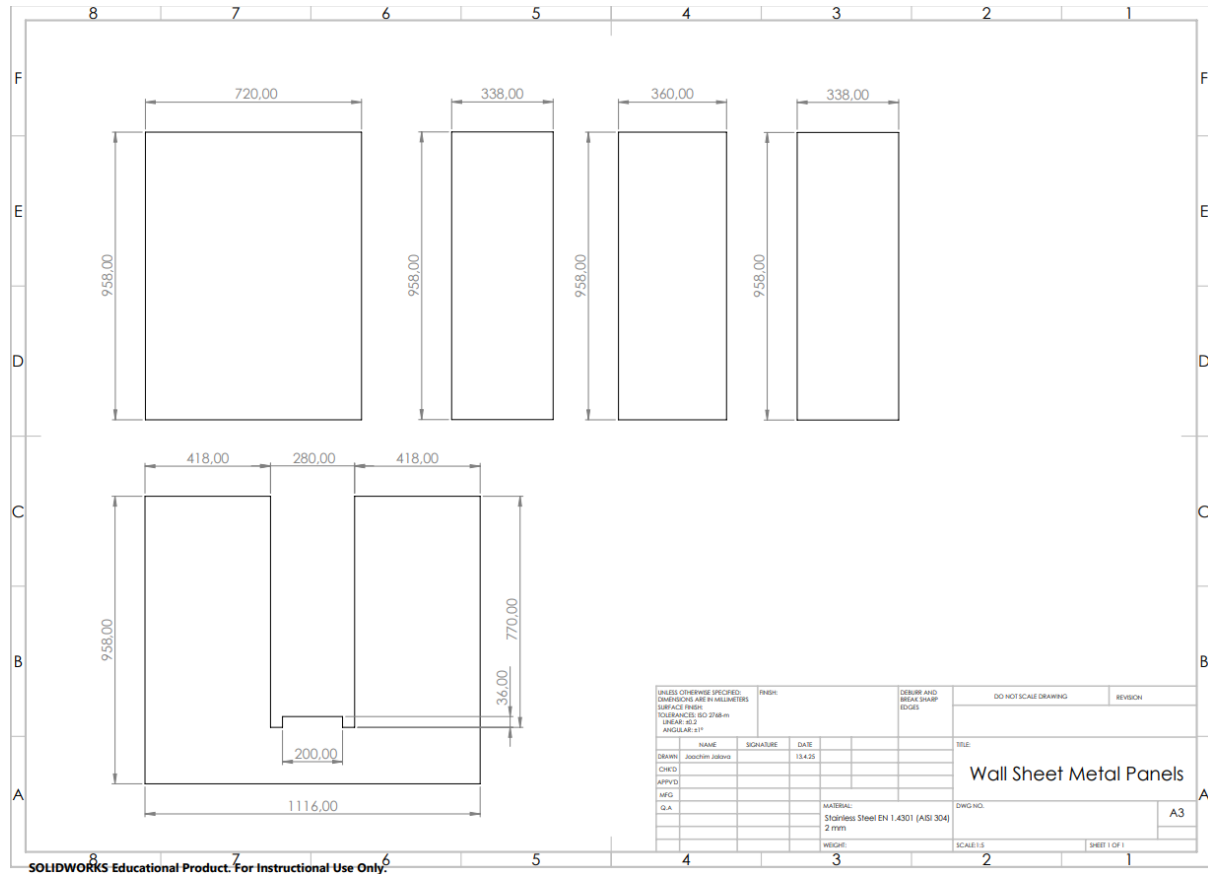


Figure 34. Combined drawing of wall sheet metal panels used for documentation and visual reference.

Flat pattern drawings were created for the sloped drain pan using the sheet metal tools in SolidWorks, including clear bend angles, radii and orientation annotations. These drawings allowed Rasmet to accurately interpret the final form and requirements for the assembly (Figure 35). The goal was to have the entire drain pan manufactured and delivered as a fully welded stainless steel unit.

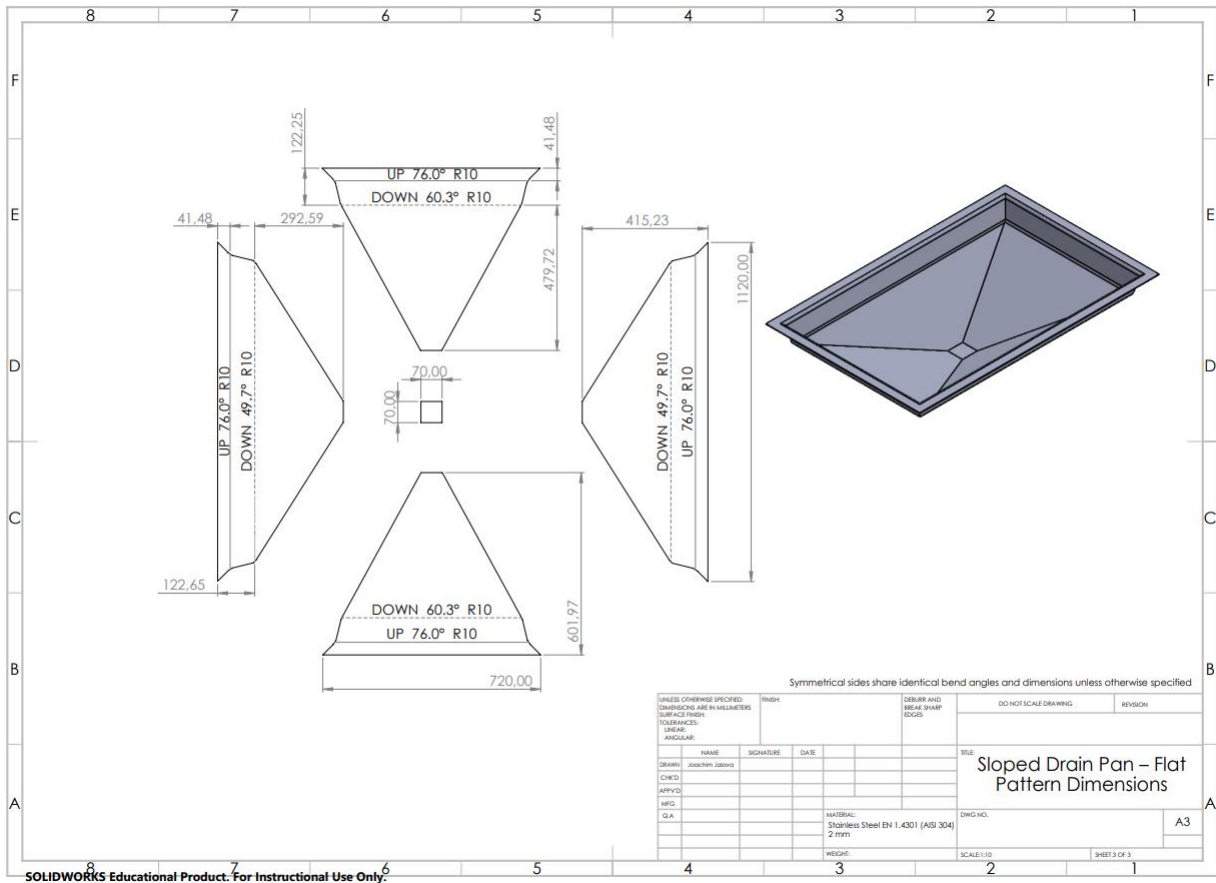


Figure 35. Flat pattern drawings of the sloped drain pan, with bend angles and dimensions.

When all documents were finalised, an email was sent to Rasmet Steel explaining the project and specifying the chosen material (AISI 304 stainless steel, 2 mm thickness). A ZIP archive containing the DXF files and the PDF drawings was included. A follow-up phone call was made to ensure that the files had been received and to confirm they were compatible with Rasmet's process. No issues were reported.

Rasmet Steel provided a written reply via email, including both price and estimated delivery time. The quoted cost was €1850 excluding VAT for the complete drain pan and five wall panels, with an approximate lead time of three weeks. This quote was then forwarded to Geberit for internal approval.

Due to a minor communication misunderstanding, the actual order was placed slightly later than initially intended. However, the components were still delivered in time to allow for analysis and documentation within the project scope. Rasmet accepted the order and scheduled it for manufacturing accordingly.

The communication and file exchange process otherwise proceeded smoothly, with no additional clarification or resubmission needed. The drawing content was sufficient to meet the requirements for both cutting and fabrication.

4.4 Sealing System using Brush Strips (Stribo Pro)

4.4.1 Functional Concept and Design Integration

One of the key design challenges was to effectively seal the vertical opening in the washing chamber through which the robot arm moves while holding the demoulding support. The solution had to provide sufficient sealing performance to contain splashing and dripping water while allowing the robot to enter and exit the chamber smoothly.

Brush seals were identified as the most suitable solution. Unlike rubber gaskets or static flaps, brushes allow for a flexible passage of components with varying shapes and motion paths, such as a robot gripper. The bristles deform gently around the arm, maintaining a relatively consistent seal without creating excessive friction or wear.

After comparing different commercial products, the Stribo Pro H8/120 model from Raitatuote was selected due to its 120 mm bristle length and compatibility with the chamber geometry (Raitatuote, 2025). The idea was to use two brush strips mounted facing each other across a 200 mm wide opening. To verify the concept, a simple geometric projection was calculated: each brush angled inward at 30° would reach approximately 104 mm along the horizontal axis, resulting in an estimated 8 mm overlap.

The brush profile was modelled in SolidWorks using the manufacturer's specification drawing as reference (Figure 36). The brush strip was extruded to a length of 770 mm, which slightly exceeds the full height of the opening, ensuring that water is guided into the drain pan below. Based on Stribo's H8/120 dimensions, a custom sketch model of the aluminium profile was integrated into the complete assembly (Figure 37).

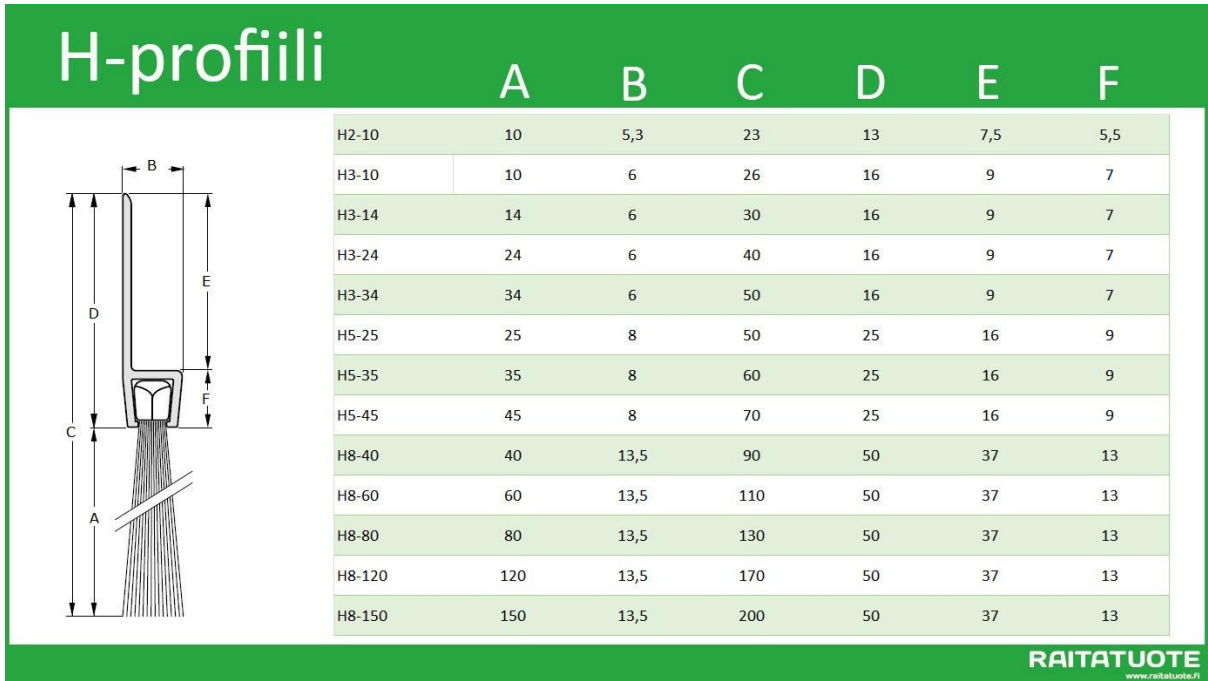


Figure 36. Product dimensions for Stribo Pro H8/120 from Raitatuote (2025).

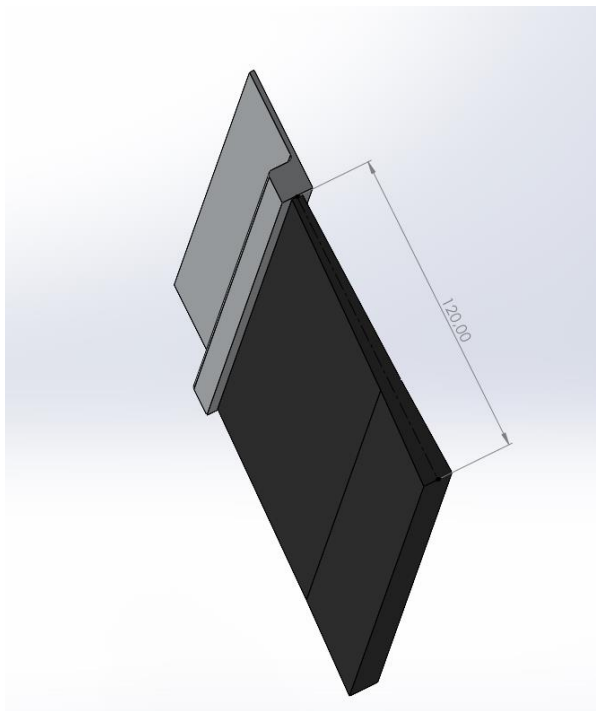


Figure 37. Brush seal modelled in SolidWorks using Raitatuote’s product dimensions.

The initial concept was to mount the two brush strips directly opposite to each other, without using any angled Item profiles, and instead fastening them straight onto the vertical frame elements (Figure 38).

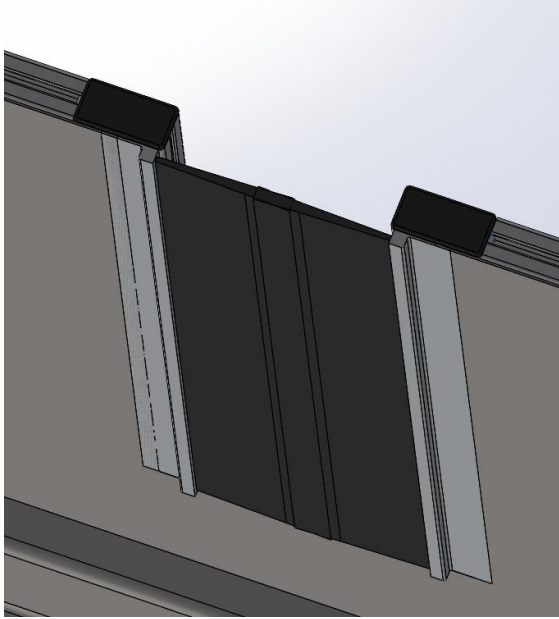


Figure 38. Initial straight mounting concept without angled profiles.

This setup would have required slightly shorter bristles to ensure proper sealing, and the direct contact risked increased friction and wear. As the design progressed, an idea emerged to mount the brushes at an angle to guide water better and reduce resistance. One of the concept approaches tested involved mounting the brushes at a 45° angle using Item's 80×80–45° profile, which was identified during a review of their available profile options (Item Industrietechnik GmbH, 2024). A concept model of this solution was built and evaluated (Figure 39).

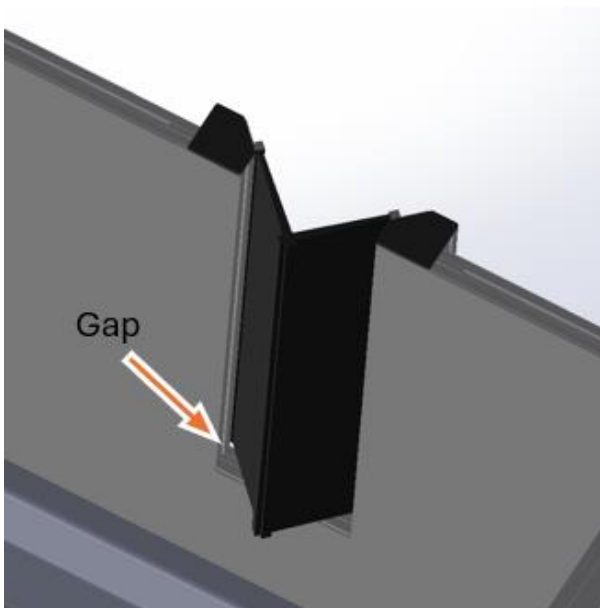


Figure 39. Design concept using 45° Item profile (80x80-45°) showing gap near base.

However, it was found that this setup left an open gap near the bottom end of the brushes, increasing the risk of water leakage from the washing chamber. As a result, the idea was revised once more to use a pair of 30° Item profiles instead. This proved to be the most suitable solution, as it allowed the bristles to overlap naturally while offering improved flexibility and sealing performance. A final assembly model was created, illustrating the complete brush concept along with the demoulding support and robot arm for visual verification (Figure 40).

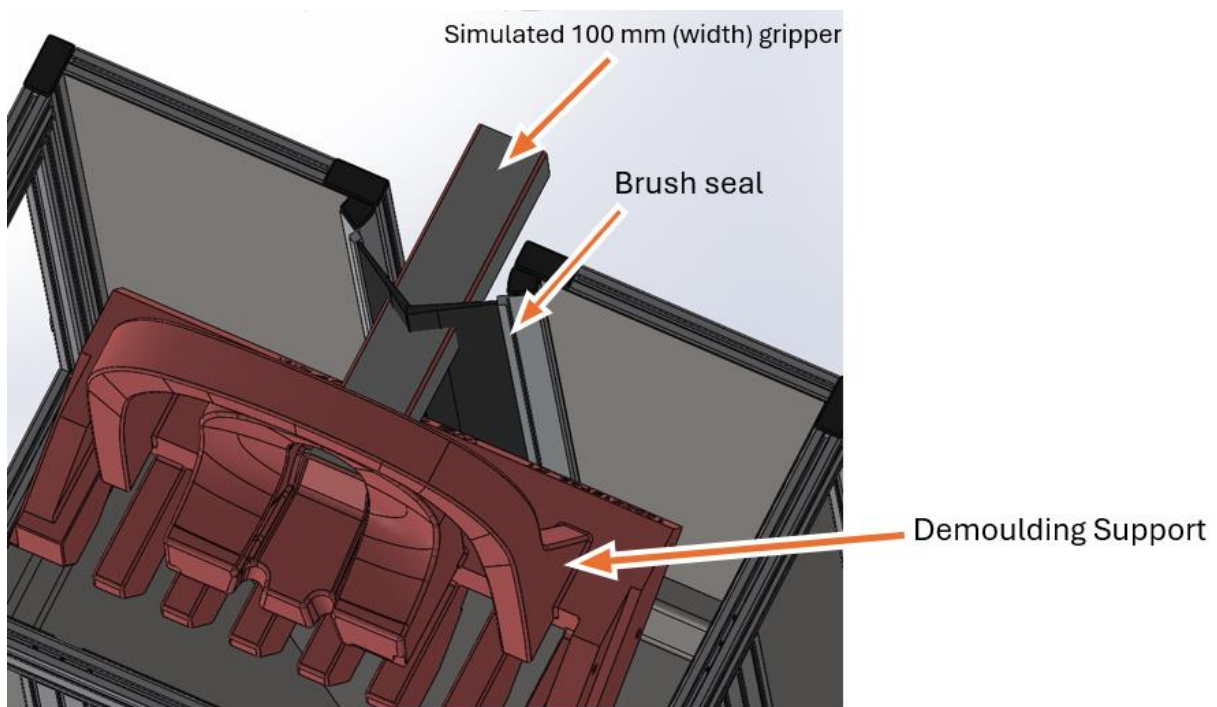


Figure 40. Final implementation with 30° Item profiles, showing demoulding support gripper integration.

The brushes were extended approximately 40 mm below the lower edge of the opening. This ensured that water running along the bristles would be directed into the sloped drain pan, rather than escaping from the chamber through the bottom gap. The final solution fulfilled two functional design goals: to create an adaptive sealing system that accommodates the motion of the robot arm, and to control and guide water efficiently into the drainage area.

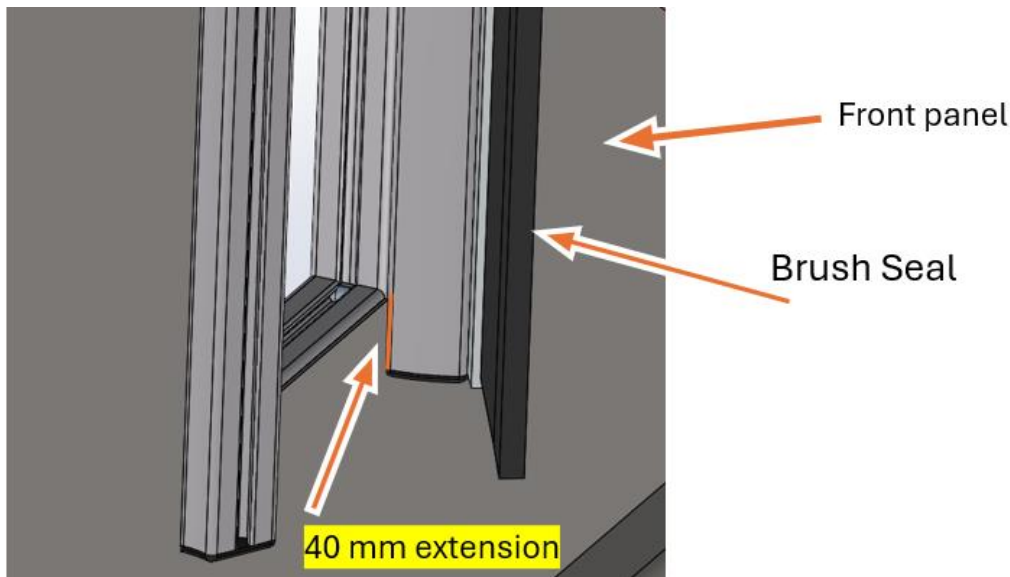


Figure 41. Detail showing 40mm extension for better guidance of water splashing.

4.4.2 Product Selection and Ordering (Raitatuote)

Following the selection and integration of the brush sealing concept into the design, Raitatuote received a supplier inquiry regarding the Stribo Pro H8/120 brush strip. This model was chosen based on its compatibility with the opening dimensions and the required sealing function.

A formal email was sent to Raitatuote’s project sales department, addressed to the company’s designated quotation and sales personnel, requesting a quotation for two brush strips at a final length of 770 mm. The standard product is supplied in 3000 mm lengths (product code: 300817), so clarification was sought regarding the possibility of pre-cut delivery. Additional technical context was provided, explaining the application in an automated washing chamber within a robotic cell and offering an image of the concept.

The response from Raitatuote was received a few days later. It confirmed that the product is only available in full 3-meter lengths, and that pre-cutting was not offered. However, they advised that the profiles can be easily shortened using a hacksaw and recommended smoothing the aluminium edge with a file after cutting. They also suggested compressing the profile ends with pliers to prevent the brush from loosening within the aluminium channel after trimming.

The quoted price was €275.60 per 3-meter strip, with shipping costs of €50 via Schenker or the customer’s freight agreement. Delivery time was stated as 2–3 working days.

This information and quotation were forwarded to Geberit for internal handling. As Raitatuote was not among Geberit’s approved direct suppliers, it was decided that the product would be ordered through Rasmet Steel. This approach allowed centralised procurement and coordination, which was carried out without complications.

4.5 Washing and Drying System Concept

Due to limitations in accessing the original 3D model of the current washing unit, a model was recreated in SolidWorks (Dassault Systèmes, 2024). This model was based on physical measurements of the existing system and serves as a visual representation of its structure, with minor design adjustments for integration.

The recreated concept includes separate pipes for water and air distribution, each with an outer diameter of 35 mm. The original system supports seven water nozzles, although only five are currently used. All seven positions are included in this design, with potential upgrades in nozzle type or pressure settings to reduce ceramic slip buildup.

Three ready-made external component models were incorporated into the design: a VeeJet® stainless steel water nozzle and a WindJet® flat fan air nozzle made of ABS plastic, both downloaded from Spraying Systems Co. (Spraying Systems Co., 2025.), and a 5035-PP pipe clamp from STAUFF (STAUFF, 2025). These components were mounted at standard distances to reflect current alignment.

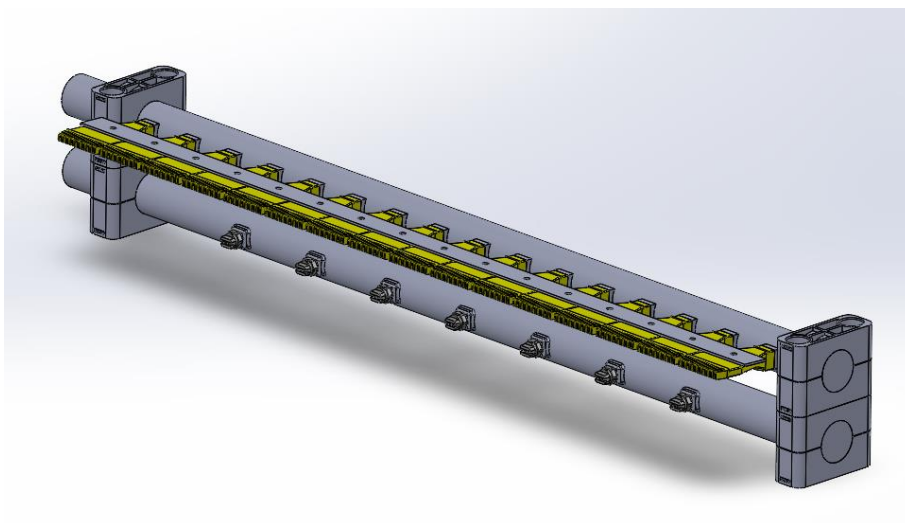


Figure 42. 3D Model of washing and drying system with pipe clamps and nozzles (SolidWorks).

The assembled unit was then integrated into the final washing chamber design. Mounting is achieved using the 5035-PP pipe clamps, which attach the pipe to a steel bracket running along a 120 x 40 mm Item profile. This bracket is fastened using M6 screws with T-slot nuts. The configuration enables vertical adjustability, allowing for fine-tuning of angles to achieve optimal cleaning performance.

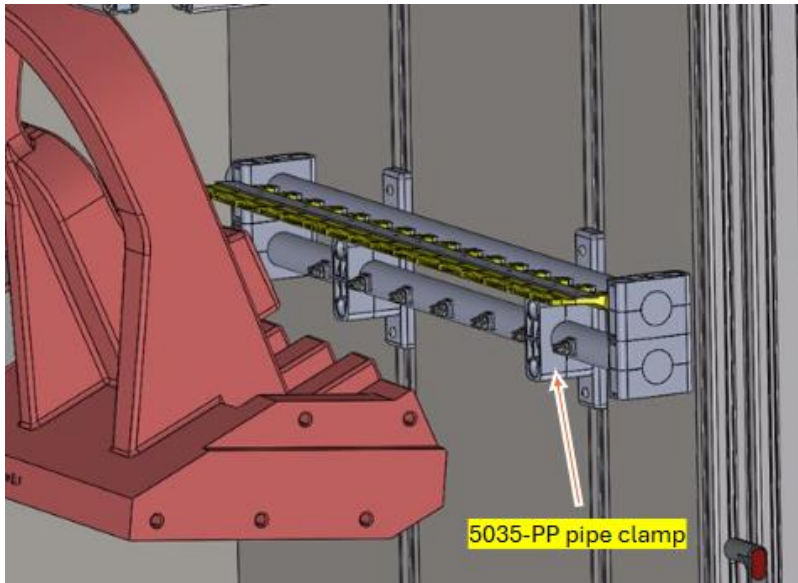


Figure 43. The washing and drying system is inside the assembly.

This solution remains a conceptual adaptation of the existing system, with final implementation and testing planned during the summer maintenance shutdown. Future variants may include similar modules added to the profile if needed. The idea is to connect the water and air pipes via flexible hoses routed through a sealed cable gland or bulkhead fitting in the side panel, linking the internal unit to the valve assembly outside the chamber.

4.6 Assembly in Workshop

4.6.1 Frame Assembly

The aluminium frame was delivered pre-assembled by Item Profili Oy approximately three weeks after the order was confirmed (see Figure 45). Initially, it was assumed that Item would only cut and drill the profiles, and that the final assembly would take place in-house. However, the fully assembled delivery turned out to be both time-saving and precise.

Upon arrival, the frame's overall geometry was verified manually using a tape measure. The main dimensions corresponded well to the original CAD design. The unit felt robust, and no structural corrections were required. However, during the later installation of the front panel, a few profiles had to be temporarily disassembled to allow better access for fitting and alignment. These adjustments were expected and did not affect the overall fit or stability of the construction.

The door came fully mounted, including a pre-installed plexiglass panel and sealing strip. The locking mechanism was tested and confirmed to function smoothly, ensuring that the door closes securely and seals tightly. At this stage, the base feet for the structure has not yet been mounted. They will be installed during the final assembly.



Figure 44. Close-up of the installed sealing strip for the door.



Figure 45. Frame construction delivered pre-assembled by Item Profiili Oy.

4.6.2 Sheet Metal and Drain Pan Assembly

Before proceeding with the final mounting, all sheet metal components and the sloped drain pan were placed in position for dry fitting. The process began with verifying all dimensions against the CAD design using a tape measure and visual inspection. Overall, the components corresponded well with the frame, confirming the accuracy of manufacturing and the dimensional fit.

A minor modification was required on the upper front edge of the drain pan, where the panel meets the door area. The door's lower sealing strip extended approximately 5 mm beyond the frame, which interfered slightly with the drain pan lip. To solve this, a small notch was carefully cut into the stainless steel flange using an angle grinder, ensuring proper clearance without compromising the pan's structural integrity.

Once in position, the drain pan fit well onto the Item profile base and was mechanically stable. The material choice of 2 mm stainless steel proved to be appropriate, offering both rigidity and

low vibration during placement. Although the drain pan could remain in position without additional fastening, it will be secured using screws and sealing washers at the final stage to ensure long-term watertight performance. The central drain hole has not yet been drilled, as further planning is required for connection to the factory's wastewater system.

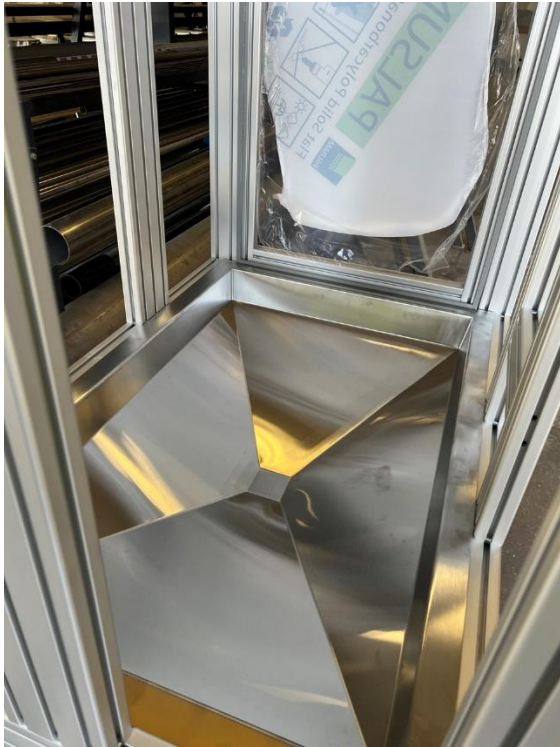


Figure 46. Sloped drain pan in assembly.

The wall panels were checked next. To insert the front panel, the 30-degree inclined aluminium profile supports had to be temporarily removed. Once cleared, the front, side and rear panels were all placed and aligned. At this stage, the panels were held in position using tape to visually inspect the fitting, confirm tolerances and plan further installation steps. No unexpected gaps or misalignments were observed meaning all joints can be sealed later using either flexible sealant or optional welding if necessary.

This mock-up assembly confirmed that both structural layout and clearances were as designed, allowing final mounting to proceed as planned.



Figure 47. Final dry fitting of components.



Figure 48. Interior view of the washing chamber during dry fitting, showing the installed sheet metal panels, drain pan, and brush seal system.

4.6.3 Brush Seal Assembly and Functional Test

The sealing brush (Raitatuote Stribo PRO H8/120) was delivered within a few days of ordering. It arrived in the standard 3-meter length and was manually cut down to two 770 mm sections using a hacksaw, as recommended by the manufacturer. To secure the bristles in place and

prevent slippage, both ends of the aluminium profile were crimped with pliers according to Raitatuote's installation guidance.

For an initial function test, the two brush strips were temporarily taped to the 30-degree angled frame profiles to simulate their final orientation. A stack of scrap wood, approximately 100 mm wide, was used to represent the robot arm during motion (Figure 49). As the block was pushed vertically through the centre, the bristles flexed smoothly around its sides, forming a tight seal on both flanks.

A slight gap was observed at the top when the wooden block was pushed downward through the bristles and then stopped in a mid-position. This occurred as the upper bristles bent downward during movement. However, since the robot arm will remain in motion throughout the washing cycle, this temporary deformation is not expected to compromise splash containment.

The brush strips fit precisely against the angled profiles, with good surface contact. Final mounting will be performed by drilling four holes in each aluminium brush profile and fastening them with four M8 screws and T-slot nuts into the corresponding 30° Item profile. Sealing will be used to minimise any potential leakage around the mounting points. Overall, the brush arrived in good condition and integrates well with the constructed frame. The material is rigid enough to resist deformation over time, yet flexible enough to conform to the movement of the robot arm.

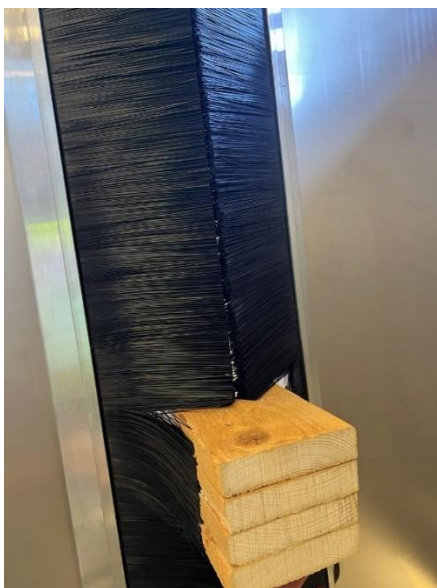


Figure 49. Functional sealing test using simulated 100 mm robot arm geometry.

5 Discussion

Throughout this thesis project, some practical and communicative challenges occurred. During the design process, minor adjustments were frequently required to refine specific aspects of the washing chamber and sealing solution. One difficulty involved handling the large STP file representing the entire SACMI ALS casting cell. Extracting relevant components, such as the previous washing system and the Gaiotto Automation robot arm, proved problematic due to the file size and complexity. As a result, this constrained the ability to visualise certain parts of the new design within the complete production context.

Additionally, minor communication errors arose during the ordering process with Rasmet Steel, leading to delayed order and delivery. This highlighted the importance of clear and consistent communication with suppliers through direct phone conversations, confirmation emails, and regular follow-ups. Ensuring good communication early in the ordering phase was identified as crucial for minimising potential delays.

Collaboration with Geberit was consistently productive throughout the project. Assistance and support was available whenever needed, greatly facilitating the design phase. However, more active and regular engagement during the design stage could potentially have further improved the process and outcomes.

The brush seals were suitable for preventing water splashes towards the robot arm and outside the washing chamber. The modular design allows for simple replacement or further improvement if future analyses or tests suggest alternative sealing methods. Interaction with Item for the modular aluminium framing also proceeded smoothly, reaffirming the importance of providing detailed and precise documentation and CAD drawings in advance to facilitate accurate and efficient quoting.

Certain components were deliberately not ordered as part of the thesis, primarily because they were available from Geberit's internal storage or local suppliers. Items such as specific screws and minor accessory parts, as well as drain connections and pipes, were expected to be sourced conveniently from readily accessible suppliers, ensuring flexibility and efficiency during the assembly phase.

Although simulation methods such as spray dispersion analysis or flow modelling were not included in the scope of this thesis, they could represent a relevant next step in further optimising the system, particularly once final nozzle types and spray angles have been selected and installed. With more time, such analysis could enhance understanding of internal splash behaviour and support future design iterations.

The final practical tests of the newly designed system are scheduled to occur after the thesis is completed. While this limits concrete testing results at this stage, it allows additional time for detailed analysis and potential adjustments before final integration into the production environment.

5.1 Cost Summary and Budget Status

A dedicated investment budget of €6000 was opened for the project by Geberit Production Oy, covering the purchase of major components and materials for the project.

The total cost of parts ordered at the time of writing amounted to approximately €4042.86, with the breakdown as follows:

- ITEM aluminium profile system: €1917.26
- Rasmat sheet metal and drain pan components: €1850.00
- Raitatuote brush seals: €275.60 + 50€ shipping.

Additional minor components, such as sealing materials, pipe fittings, screws, and additional nozzles remain to be procured. These are expected to add a few hundred euros to the total, depending on final installation requirements. Overall, the project is expected to stay within the allocated budget.

6 Conclusion

The project provided valuable experience in managing a practical engineering design task from the initial concept and design to the final preparation for assembly and installation. Throughout the process, the importance of clear communication and continuous verification, especially regarding critical aspects such as order confirmations and supplier interactions, became evident.

From a technical standpoint, substantial improvements in CAD modelling and documentation skills were achieved. The approach of designing individual components separately within SolidWorks, followed by assembling them into complete units and generating detailed technical drawings, proved effective. This methodology enabled clear communication with suppliers and provided robust documentation, streamlining the ordering process.

For Geberit, the project resulted in a new and improved washing and drying system specifically designed for the demoulding supports utilised in their automated casting cells. The solution addresses previously encountered issues, such as excessive water splashing, thus enhancing both the cleanliness and safety of the working environment. In addition to its practical and safety-related benefits, the new washing system also contributes to improved environmental performance. Minimising uncontrolled splashing, enabling more targeted cleaning, and reducing the amount of water needed per cycle helps to lower daily water waste and consumption. This renders the solution not only more efficient but also more sustainable in the long term. Furthermore, the design remains adaptable for future modifications or enhancements based on further practical evaluation. The final installation and operational testing of the system, planned during the summer maintenance shutdown, will confirm the practical viability of the design. This approach ensures careful and detailed validation, guaranteeing that the final implementation meets all performance expectations.

Overall, the project illustrates the effective combination of theoretical engineering methods and practical considerations, providing Geberit Production Oy with a tangible and adaptable solution, while also offering significant professional development in engineering design and project management.

7 Swedish extended abstract (Sammandrag)

1 Introduktion

1.1 Bakgrund och Motivation

Geberit Production Oy är en ledande tillverkare av keramiska sanitetsprodukter, med fokus på storskalig produktion av tvättställ och vägghängda toaletter. Fabriken i Ekenäs, som grundades 1969, är internationellt känd för sina automatiserade produktionslinjer och tekniska innovationer. År 2024 installerades två avancerade gjutceller från SACMI (Italien), utrustade med KUKA-robotar för hantering av avformningsstöd, som används för att ta ut ömtåliga keramiska delar från gjutformarna. Dessa stöd måste tvättas och torkas efter varje cykel (Geberit Production Oy, 2025). Det befintliga tvättsystemet uppfyller dock inte kraven för denna automatiserade process, vilket leder till behovet av ett nytt omdesignat tvättsystem.

1.2 Problembeskrivning

Det största problemet med det befintliga tvättsystemet för avformningsstöden är att det är helt öppet och därmed inte förhindrar spridning av vatten i robotcellen. Vatten stänker ut på golvet och på robotarmen, vilket leder till att det bildas pölar, ökad halkrisk och skada på robotens komponenter. Även om rengöringen i sig fungerar, saknas effektiv kontroll av vattenflödet (se figur 1–2).

Utöver detta finns sekundära problem med att rester av keramikmassa som samlas på avformningsstöden efter flera cykler, särskilt i vissa specifika områden som noterats vid upprepade tillfällen. Dessa beläggningar kräver förbättrade rengöringslösningar för att inte påverka kommande gjutningar negativt. (Geberit Production Oy, 2025)

1.3 Mål

De huvudsakliga målen för detta examensarbete, enligt specifikation från Geberit Production Oy, är följande:

1. Tvättprocessen får inte ta längre tid än den nuvarande – robotens cykeltid ska inte påverkas.
2. Golvet ska vara helt torrt efter varje cykel, vilket innebär att allt vatten måste samlas upp och ledas till golvbrunnen.

3. Tvättutrustningen ska vara lätt att underhålla.
4. Avformningsstöden ska vara rena från slip rester och helt torra efter tvätt.
5. Inget vatten får stänka mot robotarmen, som det gör i nuläget.

(Geberit Production Oy, 2025)

1.4 Omfattning och Begränsningar

Arbetet fokuserar på själva konstruktionen och uppbyggnaden av en modulär tvättkammare för en SACMI ALS-cell. Det innebär bland annat val av material (aluminiumram, rostfri plåt), utformning av dränering och tätningar samt delmontering i verkstad. Det ingår inte detaljerade flödessimuleringar, optimering av munstycken eller fullskaliga rengöringstester i cell. Slutlig montering och test i robotcellen genomförs under sommarens planerade underhållsstopp.

2 Litteraturoversikt

2.1 Automatiserade gjutsystem (SACMI ALS).

SACMI är en italiensk industrikoncern känd för automatiserade lösningar inom keramik, förpackning och processindustri. Inom sanitetskeramik har de utvecklat avancerade gjutsystem. Deras ALS-system är avsett för högtrycksgjutning av sanitetsprodukter. Vid gjutning injiceras vattenbaserad keramisk massa under tryck (upp till ca. 15 bar) in i porösa hartsgjutformar. Formarna pressas med en kraft på upp till 1200 kN för att säkerställa konsekvent formning. ALS-cellen är högproduktiv och kräver minimal manuell hantering; varje cell har beroende på storlek 4–16 formar med cykeltider på endast 22–33 minuter. SACMI betonar att ALS-systemen ger hög total kvalitet genom repeterbara och konsekventa cykler. Geberits cell är utrustad med två sexaxliga KUKA-robotar och Gaiotto-verktyg som separerar formar och avformar godset med centralt styrsystem (PLC) (se Figur 3-4). Systemets automatik säkerställer att injektion, pressning och avformning sker i en konsekvent cykel.

2.2 Avformningsstöd och rengöringskrav

Ett avformningsstöd är en stödjande konstruktion som håller och stabiliserar den fortfarande mjuka keramiken under avformningsprocessen. Stöden är kritiska eftersom det så kallade gröna godset (d.v.s. den formade men ännu inte brända keramiken), är skört och måste hanteras varsamt. De tillverkas oftast av gjutna polymer- eller hartskompositer, formade för att passa

produktens geometri (se Figur 5). I vissa fall används stål- eller aluminiumramar för extra styrka. Ytorna kan förses med non-stick-beläggningar eller mjuka ytskikt för att minimera risken att skada godset. Trots dessa försiktighetsåtgärder kan rester av massa och släppmedel samlas på stöden efter flera cykler. Om rengöring försummas kan det leda till ytdefekter eller försämrad passning mellan stödet och godset. SACMI menar att skötsel och rengöring av både formar och avformningsstöd är avgörande för att förlänga utrustningens livslängd och bibehålla produktkvaliteten (SACMI, 2018). Alla kontaktytor bör rengöras regelbundet och spillvatten hanteras på korrekt sätt.

2.3 Industriell rengöring och vattenhantering

Inom industrin sker rengöring av komponenter vanligtvis med olika vattenbaserade metoder. Exempel på dessa är doppkar, tvättkabiner och ultraljudsrengörare. Uppvämt vatten med alkalier eller rengöringsmedel används för att avlägsna oljor och smuts (Jenfab, 2025). En vanlig tvättkabin använder kraftiga, uppvärmda vattenstrålar för att tvätta bort beläggningar utan att skada känsliga detaljer. Ultraljudsbad använder kavitation i ett uppvärmt bad för noggrann rengöring (Graymills, 2024). För hög kapacitet används kontinuerliga tvättsystem med transportband eller roterande trumma, ofta med integrerade filtersystem (Alliance Manufacturing, 2024).

Lösningsmedelsbaserade tvättar används ibland vid specialbehov men är inte relevanta för detta projekt. Här används befintlig teknik från vattenbaserade tvättsystem med sprutmunstycken och optimerade munstycksplaceringar. Den nya designen bygger på tvättkabinprincipen och återanvänder delar av det befintliga systemet, med förbättrad placering av munstycken för effektiv rengöring och användning av resurser.

2.3.1 Utmaningar vid vattenhantering

En central utmaning vid vattenbaserad tvätt är hanteringen av spillvatten, som efter varje cykel kan innehålla fasta partiklar och kemikalierester. Utan tillräcklig inneslutning finns risk för läckage och stänk som kan påverka golv och närliggande utrustning. Enligt FM Globals riktlinjer bör rengöringszoner betraktas som hanteringsområden för farliga vätskor, vilket kräver tätade golvytor, golvbrunnar och sekundära uppsamlingslösningar för att förhindra spridning (FM Global, 2022). I detta projekt saknar tvättkammaren intern filtrering eller separationssystem. I stället leds spillvattnet direkt till den befintliga golvbrunnen i SACMI

ALS-gjutcellen, som är ansluten till Geberits interna vattenreningsanläggning. Denna hanterar all nödvändig filtrering och uppfyller miljökraven för säker hantering av processvatten (Geberit Production Oy, 2025).

2.4 Torkning av komponenter

Efter tvätt krävs snabb och effektiv torkning för att förhindra korrosionsbildning, vattenrester och risker vid fortsatt hantering. I detta projekt används EXAIR WindJet-munstycken, en form av så kallade luftknivar, som blåser en bred, högtrycksluftstråle med hög hastighet över stödet. Denna teknik möjliggör energisnål och jämn torkning och är vanlig i industrin (Park & Park, 2022).

2.5 Borst- och fogtätning

För rörliga gränssnitt, särskilt vid robotarmens inträde i tvättkammaren, valdes borsttätningar, som är vanliga i industrimaskiner för att minska vätskeläckage vid dynamisk rörelse. Dessa består av täta, följsamma syntetborstar som kan minska läckage med upp till cirka 80% jämfört med traditionella labyrinttätningar (Kwon & Ahn, 2024). Även om studierna i arbetet handlar om mindre tätningar i roterande utrustning, är funktionsprincipen densamma, borsttätningen anpassar sig efter rörelse och återgår till sin form. I detta projekt används större borsttätningar (från Raitatuote) för att täta runt robotarmen och hindra stänk.

För fasta skarvar mellan plåtar användes elastiska lim- eller tätningsmassor som tål fukt, exempelvis Sikaflex®-221 (enkomponents PU), som fäster mot både metall och plast och bildar en vattentät, elastisk fog. Produkten har låg hårdhet (~Shore A 40), klarar vibrationer, temperaturväxlingar och är godkänd för indirekt livsmedelskontakt (Sika Group, 2025). Svetsning undveks för att bevara demonterbarhet vid framtida ändringar.

2.6 Materialval och Ramkonstruktion

Materialvalen anpassades för att klara en fuktig industrimiljö. Alla delar som utsätts för vatten, såsom dräneringsplåten och interna plåtpaneler, tillverkas i rostfritt stål av typ AISI 304. Vanliga kolstål skulle snabbt korrodera vid konstant fuktpåverkan och försämra både hållfasthet och hygien. AISI 304 ("18/8") innehåller cirka 18 % krom och 8 % nickel, vilket bildar en skyddande passivfilm av kromoxid som motverkar rost. Materialet har hög

korrosionsbeständighet, god formbarhet och bibehåller hållfastheten utan ytbehandling och valdes för att säkerställa lång livslängd (Outokumpu, 2022).

Själva tvättkammarens bärande ram är uppbyggd av anodiserade aluminiumprofiler från Item-systemet. Konstruktionen följer principen ”skruv istället för svets” – en moduluppbyggnad med standardiserade extruderade profiler som enkelt skruvas ihop istället för att svetsas (item Industrietechnik GmbH, 2025a). Detta ger låg vikt, god strukturell stabilitet och snabb montering. I detta projekt användes Line 8-profiler (basmått 40 x 40 mm) för att uppnå en stark men flexibel ram som enkelt kan justeras eller byggas om vid behov. Ramens geometri och infästningar verifierades med konstruktionsberäkningar.

3 Metod

3.1 Projektets utgångspunkt

Examensarbetet genomfördes vid Geberits fabrik i Ekenäs, där två nya SACMI-ALS gjutceller hanterar automatiserad tillverkning av tvättställ. I processen används 32 avformningsstöd som måste tvättas och torkas efter varje cykel. Den befintliga tvättlösningen i robotcellen orsakade problem med stänk, fukt på golvet och nedsatt rengöring. Projektets mål var därför att konstruera en ny stationär tvättkammare som integreras i cellen utan att kräva extra robottid. Geberit avsatte en investeringsbudget på 6000 € för projektet. Av detta användes cirka 4043 € vid tidpunkten för rapporten till profilstommar, plåtkomponenter och borsttätningar. Övriga smådetaljer (skruvar, tätningsmaterial, rördelar, extra munstycken) anskaffas utifrån behov under monteringen.

3.2 Analys av befintligt tvättsystem

Det befintliga tvättsystemet består av en fast, öppen spoluppställning med två horisontellt monterade aluminiumrör placerade parallellt. Det ena röret levererar vatten genom fem jämnt fördelade munstycken, medan det andra tillför tryckluft via tolv (gula) fläktsmunstycken monterade längs röret (se Figur 7).

Robotarmen håller stödet stilla framför munstyckena och rör det vertikalt upp och ner för att säkerställa full täckning. Tvättfasen är programmerad till 12 sekunders vattenspolning och 20

sekunders lufttorkning, totalt 32 sekunder per cykel. Bristen på inneslutning leder till onödigt vattenstänk utanför det avsedda området, med våta golv som följd (se Figur 8).

3.3 Designansats

Den nya tvättkammaren placeras på samma plats som det befintliga tvättsystemet, vid robotens avlastningspunkt. Under varje cykel sänker roboten ned avformningsstödet i kammaren och håller det kvar med gripdonet. Stödet förs därefter vertikalt upp och ned framför vatten- och luftmunstyckena, vilket möjliggör effektiv rengöring utan att stödet behöver släppas (se Figur 8). Denna metod gör att cykeltiden kan bibehållas och att tvättmomentet utnyttjar robotens befintliga rörelser.

Designprocessen genomfördes iterativt med hjälp av SolidWorks (Dassault Systèmes, 2024) och Item Engineeringtool, där varje komponent modellerades separat för att passa Geberits krav. Lösningens mått anpassades efter det begränsade utrymmet i cellen och måtten på avformningsstöden, för att säkerställa att konstruktionen kunde integreras utan att påverka robotens rörelse.

3.4 Validering och testning

Slutlig funktionsprovning kommer att genomföras efter installationen under fabriken underhållsstopp. Fram till dess utfördes tester på komponentnivå och monteringskontroller. Någon fullskalig tvätt test kunde inte göras innan systemet var installerat, men monteringen i verkstaden användes för att verifiera passform och åtkomlighet.

4 Systemdesign och konstruktion

4.1 Designmål och krav

Utformningen av tvättkammaren baserades på tekniska krav från Geberit och begränsningarna i SACMI-gjutcellen. De huvudsakliga målen var att placera tvättkammaren utan att hindra robotens rörelser, säkerställa att inget vatten stänker på golvet eller roboten, hålla tvättcykeln inom nuvarande tid, använda korrosionsbeständiga material, samt underlätta framtida service och modifieringar (Geberit Production Oy, 2025).

4.2 Konstruktion av Ram

Tvättkammarens bärande ram byggdes av anodiserade aluminiumprofiler från Item. Den primära profilen som användes var 80 x 40 mm, men även 80 x 80 mm, 120 x 40 mm och specialprofiler ingick i konstruktionen. Ramens dimensioner och profiltyper modellerades först i SolidWorks och sedan i Item Engineering Tool, där en komplett komponentlista skapades och skickades för offert till Item Profiili Oy (se Figur 23).

4.3 Plåtkonstruktioner

För tvättkammarens invändiga ytor valdes 2mm rostfri plåt (AISI 304) på grund av dess höga korrosionsmotstånd. Den viktigaste komponenten var den lutande dräneringsplåten, designad i SolidWorks för att effektivt leda allt vatten mot ett centralt avlopp (se Figur 28). Plåten tillverkades genom laserutskärning, bockning och svetsning hos Rasmet Steel, tillsammans med övriga väggpaneler. De monteras mot ramens profilskenor med hjälp av T-spårsmutter och skruv med tätning.

4.4 Borsttätning

För tätning kring robotarmens genomföring valdes borsttätningar av typen Stribo PRO H8/120 från Raitatuote. Dessa består av polypropenborst monterade i en aluminiumprofil och installerades i 30 graders vinkel mot varandra (se Figur 40), vilket skapar en tät men följsam öppning som anpassar sig efter robotarmens rörelser och minskar friktionen mot borsten. Lösningen minimerar risken för vattenläckage. Borsttätningen levererades i tre meters längd och kapades till rätt mått på plats enligt ritning. Beställningen gjordes direkt från leverantören efter prisförfrågan via e-post, då standardmått och produktkod redan var kända från deras katalog (Raitatuote, 2025).

4.5 Tvätt- och torksystem

Eftersom originalmodellen var svår att få tag i, återskapades tvätt- och torksystemet i SolidWorks utifrån uppmätta mått. Syftet var att anpassa den befintliga lösningen för montering i den nya tvättkammaren. Vatten- och lufrör monterades parallellt med STAUFF 5035-PP rörklammer. På rören placerades munstycken från Spraying Systems Co., i enlighet med det befintliga systemet. Systemet monteras mot två profilskenor och kan justeras i höjddled, vilket möjliggör finjustering av sprayvinklar för förbättrad tvätteffektivitet (se figur 42–43).

4.6 Verkstadsmontering

Under projektet monterades ramen, plåtkomponenterna och borsttätningen delvis i verkstaden, vilket verifierade passform, täthet och åtkomlighet. Montering gav möjlighet att identifiera och korrigera små avvikelser innan slutlig installation i robotcellen (se Figur 47–48). Fullständig installation och testning planeras under fabriken sommarstopp.

5 Reflektion och slutsatser

Som resultat av examensarbetet har ett nytt system för tvätt och torkning av avformningsstöd tagits fram och som uppfyller de uppställda kraven. Jämfört med den tidigare lösningen möjliggör den nya konstruktionen helt innesluten tvättning, vilket eliminerar vattenstänk och säkerställer att golvet är torrt efter varje cykel. Systemet är inte bara tekniskt och säkerhetsmässigt förbättrat, utan bidrar även till bättre resurseffektivitet. Genom att minska vattenstänk, rikta spolningen mer exakt, återvinna allt vatten och leda det vidare, minskar förbrukningen per cykel och spill i cellen. Detta gör lösningen mer långsiktigt hållbar.

Genom att designa komponenter individuellt och sedan sammanställa dem kunde vi använda standardprofiler och lättmonterade plåtdetaljer, vilket förenklade konstruktion och montering. För att undvika fel och effektivisera arbetsflödet skapades detaljerade ritningar och komponentlistor, vilket gjorde kommunikationen med leverantörer och monteringspersonal smidig. Detta förenklade beställningsprocessen och minskade risken för missförstånd, eftersom alla parter hade tydlig information.

Med hjälp av Geberits automations- och underhållspersonal kunde tekniska begränsningar identifieras och beaktas, vilket gjorde det möjligt att anpassa designen. Det minimerade risken för missförstånd och omarbetningar. Rent tekniskt har arbetet fördjupat kunskaperna i modulär systemdesign, CAD-modellering, materialval och teknisk dokumentation.

När systemet är i drift finns fortsatt utvecklingspotential. Genom detaljerade flödessimuleringar kan vattnets flöde, spolvinklar och täckning analyseras och förbättras. Även en optimering av munstycksconfigurationen kan genomföras för att maximera tvätteffektiviteten och minimera vattenförbrukningen per cykel.

Reflektion kring genomfört arbete

Inledningsvis vill jag tacka Geberit Production Oy och handledare Stefan Hildén för möjligheten att genomföra detta projekt. Jag har personligen fått värdefulla insikter i praktiskt ingenjörarbete. Projektet har lärt mig vikten av noggrann planering, iterativ design och kontinuerlig verifiering av lösningar. Det har även gett mig erfarenhet av samarbete med specialister från olika fält, något som visat sig avgörande för att lyckas. Sammanfattningsvis har detta examensarbete varit en lärorik kombination av teori och praktik. Jag har bidragit med en konkret teknisk lösning för Geberit och samtidigt utvecklats yrkesmässigt genom arbetet med CAD, modulära konstruktioner, dokumentation och kommunikation.

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