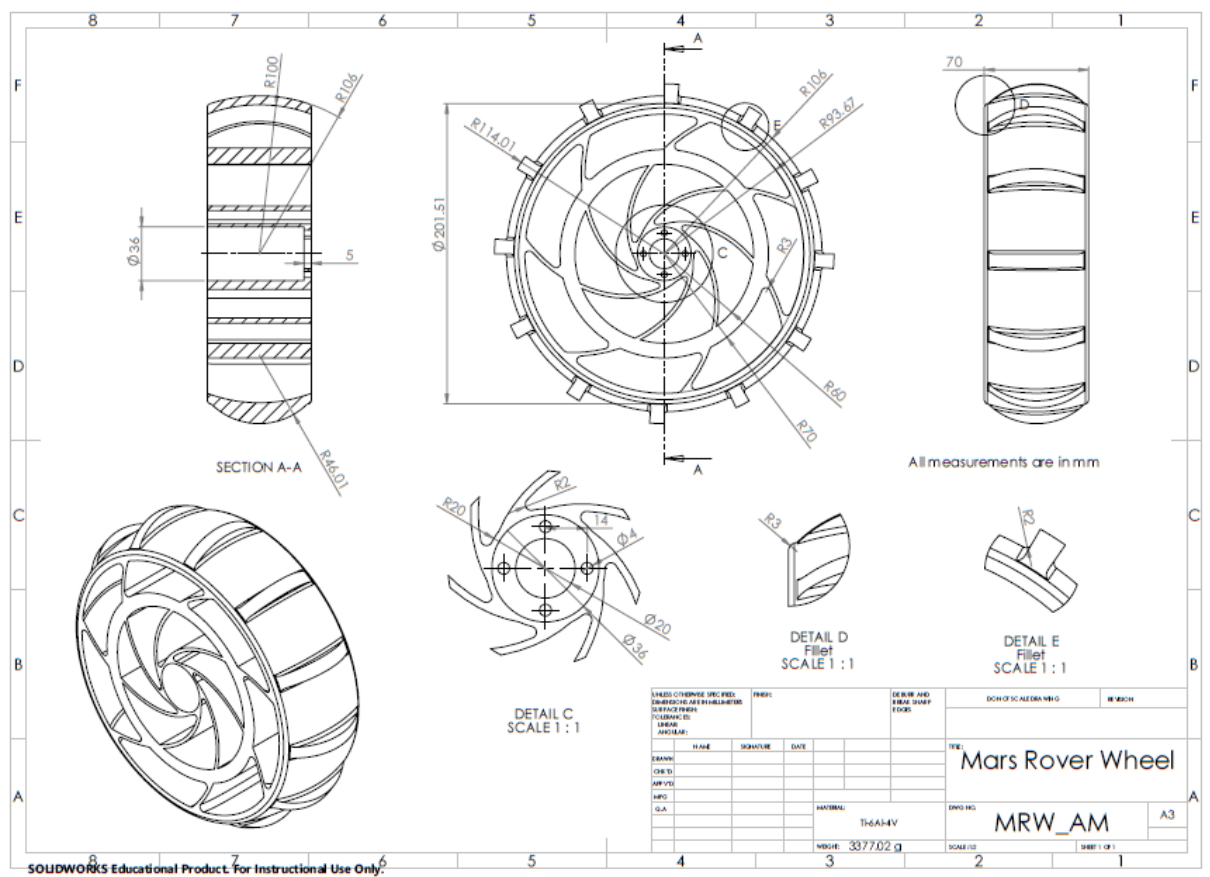








CAD and CAE display

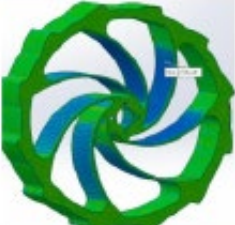



Design of Mars Rover Wheel for A.M.



Setup

Geometry	Fixtures	Loading	
			Force: 850 N Temperature: -67 °C
			Force: 850 N Temperature: -67 °C

Results

Stress Profile	Values
	
	
	<p>Max stress: 272.8 MPa</p> <p>Min FOS: 1</p> <p>Max stress: 266.4 MPa</p> <p>Min FOS: 1</p>

Manufacturing Specification

Volume of the part: 761.42 cm³
 Build height: 73.00 mm
 Distance from part to build plate: 3mm

Support needed: 5.49 cm³
 Build time: 129h 06m 13s

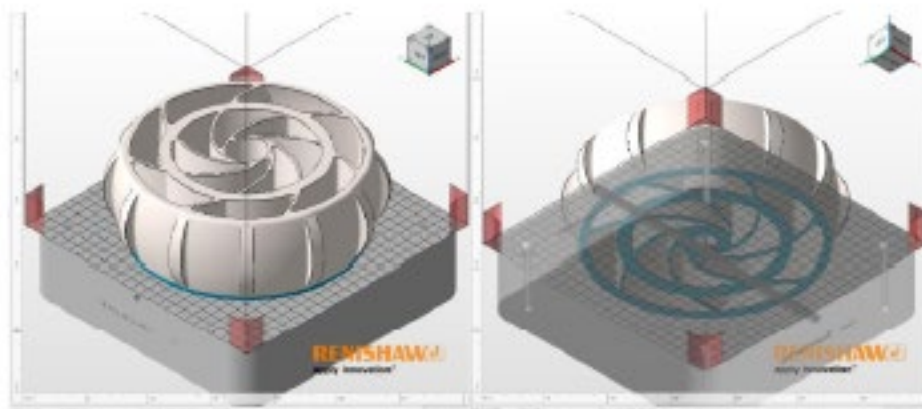


Figure 4 Final design printing orientation in Renishaw

Design of a Thermochemical Battery for Domestic Heating



Design for an efficient thermochemical batteries for domestic heating

Ano C. | Groot-Wassink C. | Marino T. | Niranjan N. | Rex-Ogbu K.

Supervised by Dr Eifion Jewell



The Design

Vesta is a design for personal heating device for domestic heating. Using thermochemical processes that reacts with the humidity from ambient air to produce heat energy. The design also includes a failsafe system, preventing the users from overcharging the batteries. Overuse of batteries may result in dissolution of the substance known as calcium chloride which damages the battery. Vesta would be operating on electricity via plug-in and air is taken in via pump. It has a very small power usage of only 20W.

Component List

Number	Component	Quantity
1	Lid	1
2	Battery Case	1
3	Heating Frame	1
4	Pump	1
5	Arduino	1
6	Power Supply	1
7	Power Switch	1
8	LED Light	1
9	Wheels	4
10	Thermal Resistor	2
11	Cable Ties	1
12	M5 Screws (12 mm)	5
13	M5 Screws (5 mm)	25
14	M4.5 Screws (5 mm)	5
15	M4.5 Nuts	5
16	M5 Nuts	10



Thermal properties of CaCl₂

Enthalpy of a solution involves two processes, lattice energy (energy) given in TATA steel and enthalpy of hydration (LH) (dissociation). Enthalpy of hydration is where heat energy is released from reaction.

$$\text{CaCl}_2 + x\text{H}_2\text{O} \rightarrow \text{CaCl}_2 \cdot x\text{H}_2\text{O}$$

The hygroscopic nature of salt, water is absorbed from the air, and the salt increases its hydration state releasing energy. The calcium chloride is held in a composition of formic acid with a 2:1 ratio. There are three states in which calcium chloride undergoes dihydrate, pentahydrate and hexahydrate. Each releasing energy this is the basic principle of the vesta battery.

Function of Design

Step 1 - Loading

Step 2 - Salt duration

Step 3 - Unloading

Step 4 - Recharge

Health & Safety, Environmental and Legal

The design includes features suitable for domestic environment such as, 100% and child-lock. Even though the thermochemical itself is safe to handle, the over contact with CaCl₂ can be minimised by using the transport case. BS standard should be applied to ensure continuous improvement, employees' safety and to not only create a sustainable product but also be a carbon neutral business by 2030 in accordance with the UK laws.

Detail of the Design

FMEA & Environmental Simulation

Test 4

1) Air industry 2) Global industry

FEA & Optimization of Final design

Materials selection

Manufacturing strategy

Initial Calculations

Special for battery

Cell mass: 0.1 kg
Cell volume: 0.1 m³
Cell flow: 0.1 m³/s
Dimension of cell case: 0.1 x 0.1 x 0.1 m

Business

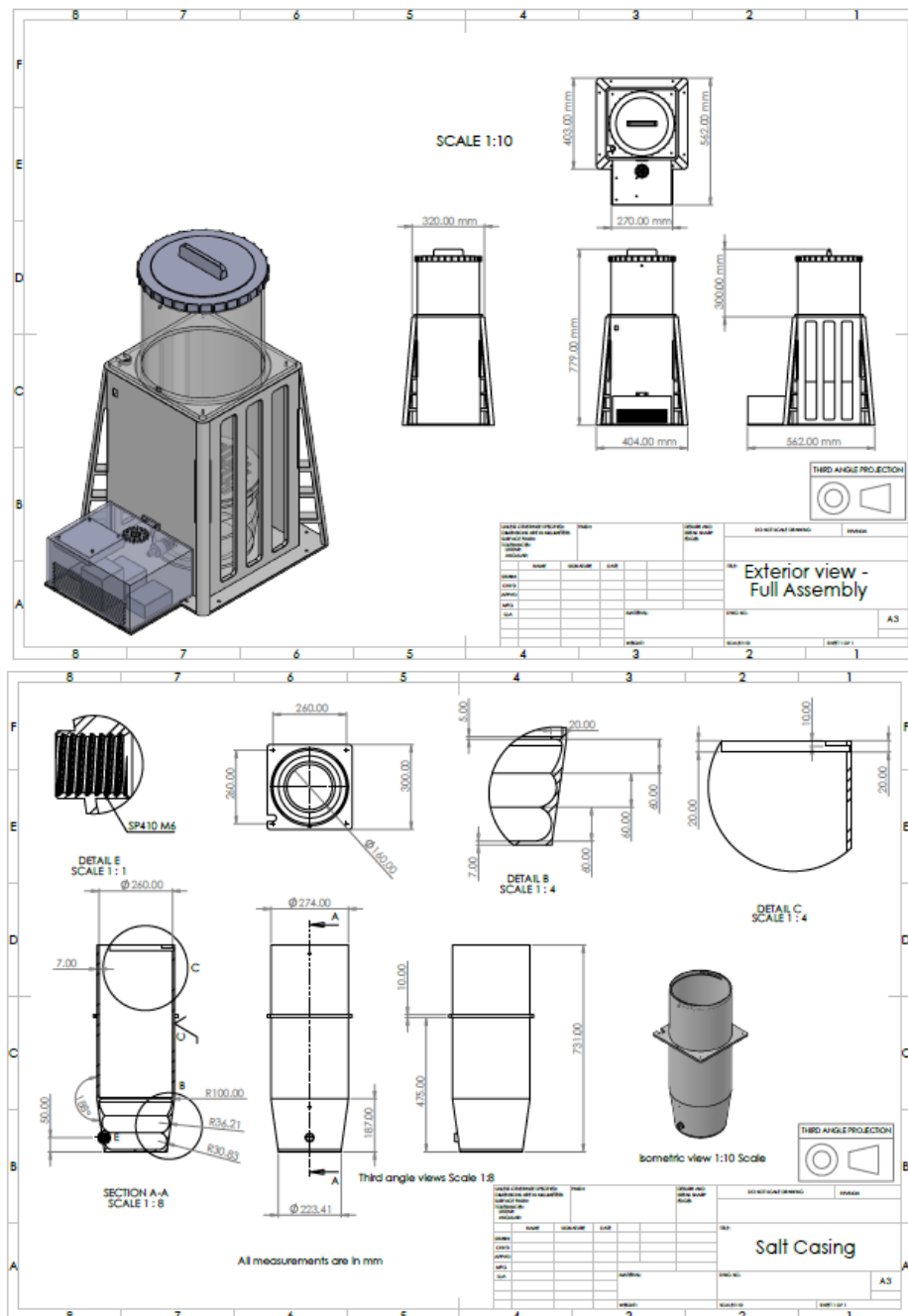
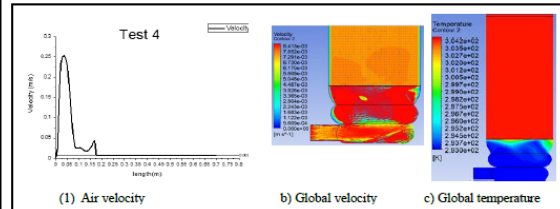
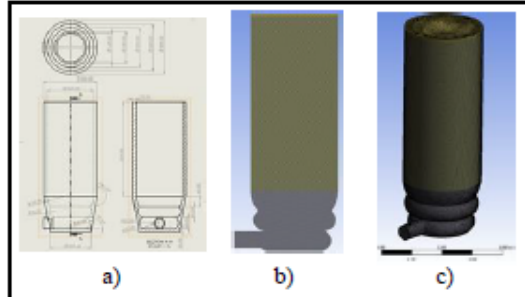
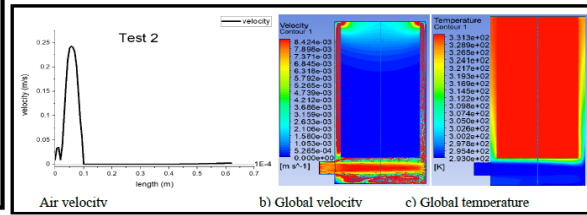
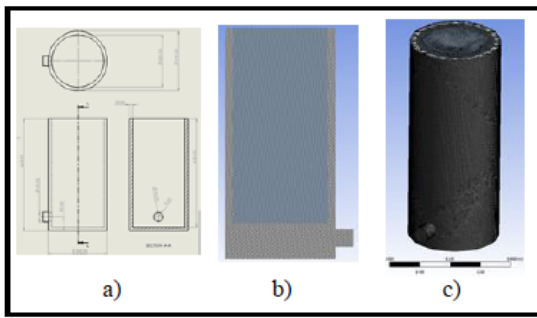
The Vesta device will be implemented on key campus and when fully implemented would only take £20,000 to run comparing this to key campus which is currently spending over £1 million for power usage is a significant difference. This is not accounting for the rise in electrical and gas prices meaning this is a viable business opportunity. The business plan proposed to split into 6 sections. The business will essentially work as a subscription service of £60,000 where Swansea University will be saving at least a third in costs.

Funding and R&D	Pilot and prototype	Assembly	Full Operation	Financial consideration			
Funding acquired from TATA steel and the Welsh government under The Future Generations Commissioner for Wales and TATA steel roadmap to make industry greener. The funding required will be £10,000. Research & Development will be done to ensure the device meets UNCA standards and certification for domestic use.	Once the main prototype device receives a UNCA certification, a pilot stage will be enacted only using one block of the battery which is roughly around 200 units. Over six months, the vesta device will be operated. If results are accurate to the theoretical model, an order of 2000 units will be placed for full implementation for the key campus.	The assembly of the device will use contracted workers and electricians in a production line to produce 2000 units per batch. Over 2000 units to combat any defects or errors in production 1000 units will be left in storage. Production line image can be found in QR.	The operational business plan will be enacted once assembly and the vesta devices are fully incorporated into key campus student accommodation. The base plan will involve various collection points scattered around the university where students will take their finished Vesta batteries at TATA steel. The collection point - enclosed space somewhere like a large transport container filled with trolleys on wheels that contain the depleted batteries and a locked-in trolley containing full batteries. A residence card is needed to enter the space and collect a battery. The final of 10 units will be used on Regular pick-up days on Monday, Wednesday, and Friday, will deliver fresh salt cases and pick up old ones at various collection points.	Year 1	Year 2	Year 3	
				Overall Budget	£1,000,000.00	2	8
				Total revenue	£700,000.00	£350,000.00	£420,000.00
				Net profit	£400,000.00	£400,000.00	£400,000.00
				Revenue	£700,000.00	£350,000.00	£420,000.00

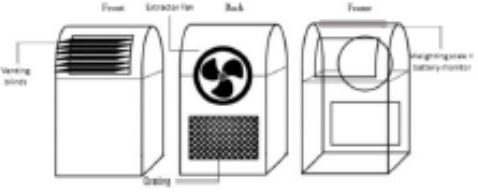
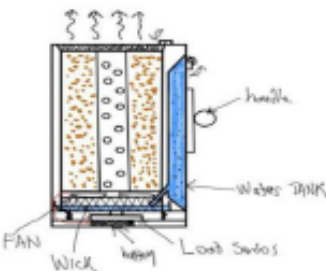
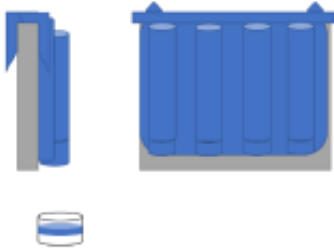
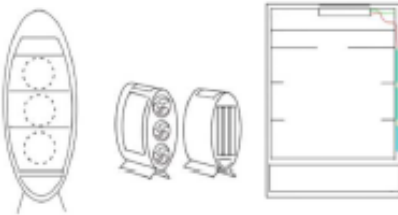
Future Developments

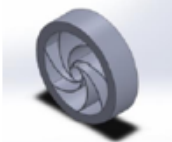


Vesta as a product will be facing a lot of limitations from users especially at the start of the campaign. This is because thermochemical batteries are relatively new and would require more input from consumers (e.g., collection, refill, covering) compared to an already established heating system, such as gas central heating. Moreover, as more inputs are required, the design is not very accessible for people with disability as the fully assembled design is taller than a standard wheelchair's height. On top of that, the weight of the SIM (Salt in matrix) and transport case combined is relatively high which also hinders the design accessibility further. Below are some future considerations:

- Dust Filter: Filtering of the inlet to prevent dust build-up with in the air pump to ensure optimal lifetime and performance of Vesta.
- Mobile Applications: With an app, the user should have more on-demand information of the battery and allow the user to interact with Vesta at any time. This includes notification, and other control features.
- Design Modification: The current sizing and weight has proven to be a burden for consumer from the initial market survey. In the future more light weight and compact design may prove favourable.
- Prototype Testing: With more real-world data, more accurate battery lifetime prediction would be more accurate, hence, more efficient and reduce the unnecessary refills.

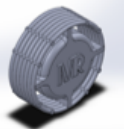

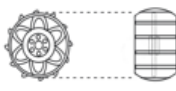


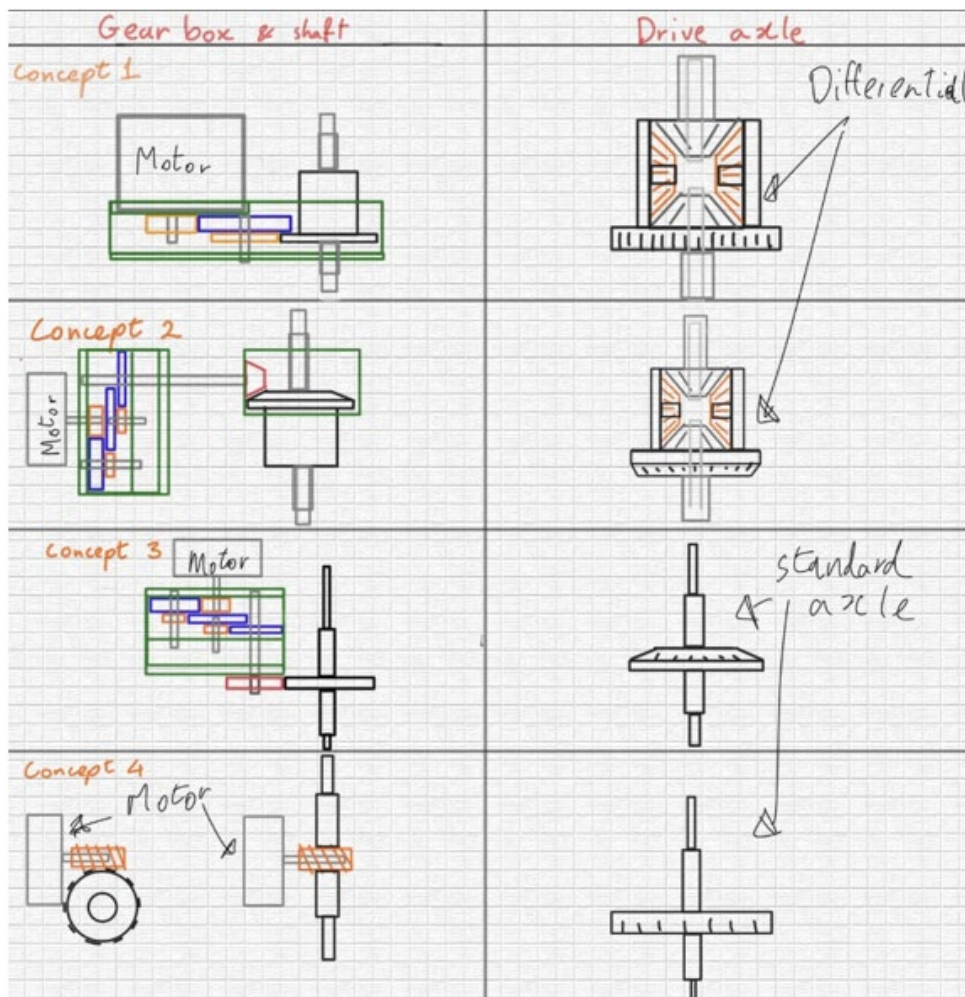
Sketches and concepts during pre-design

Concept Design	Features
 <p>Design 1.</p>	<ul style="list-style-type: none"> Inspired by household dehumidifier with benefits of room heating. Blind to allow air to circulate with in the room Fan system to extract air through back grating when not in use
 <p>Design 2.</p>	<ul style="list-style-type: none"> Detachable water tank flows to tray and wick delivers humid air through fan to the CaCl_2 for discharge. Load sensor to see Δm to see weight difference correlating to battery life. Detachable lid to remove salt for change of battery.
 <p>Design 3.</p>	<ul style="list-style-type: none"> Each cylinder weight will be 5-15kg and 0.58m in length. When salt conversion occurs, it can last up to 3 and 7 days. With 4 to 5 of the cylinders with airtight seals the batteries can last up to a few weeks.
 <p>Design 4.</p>	<ul style="list-style-type: none"> Allows moisture to be dispersed during airflow by passively soaking a cloth, which runs between the fans and the salt. Amount of moisture is controlled by adjusting the gap size where the cloth absorbs the fluid. Moisture or salt collected in the waste compartment is measured to monitor how much salt is being used.

Design Selection		Con					
		Design 1, Chalisa		Design 2, Nish		Design 3, Lars	
							
Selection Criteria	Weighting	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Weight	20%	8.20	1.64	6.75	1.35	6.80	1.36
Machining complexity	15%	6.80	1.02	8.00	1.20	6.40	0.96
Manufacturing difficulty	15%	6.20	0.93	6.75	1.01	7.20	1.08
Printing orientation	10%	8.20	0.82	7.50	0.75	7.40	0.74
Rim support	10%	7.00	0.70	7.00	0.70	7.00	0.70
Tyre design	10%	6.80	0.68	6.00	0.60	5.00	0.50
Shaft connection	5%	5.80	0.29	7.00	0.35	5.40	0.27
Durability	5%	7.20	0.36	6.00	0.30	5.80	0.29
Aesthetics	5%	7.20	0.36	4.75	0.24	6.40	0.32
Costing	5%	8.20	0.41	7.75	0.39	6.80	0.34
		1 Total	7.21	Total	6.89	Total	6.56

cept

Design 4, Adebayo		Design 5, Samuel		Design 6, Tullio			
							
Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score		
5.60	1.12	6.20	1.24	7.80	1.56	Rating	(1-10)
6.00	0.90	6.20	0.93	7.00	1.05	1	unacceptable
6.60	0.99	7.20	1.08	6.20	0.93	5	acceptable
7.20	0.72	6.80	0.68	7.60	0.76	10	more than acceptable
7.80	0.78	7.40	0.74	7.40	0.74		
6.60	0.66	7.20	0.72	7.20	0.72		
5.80	0.29	7.40	0.37	7.00	0.35		
6.80	0.34	7.00	0.35	6.80	0.34		
7.80	0.39	7.00	0.35	8.20	0.41		
5.80	0.29	6.00	0.30	6.80	0.34		
Total	6.48	Total	6.76	Total	7.20		



Drivetrain Design		
	<ol style="list-style-type: none"> 1 Motor 2 Bearings 3 Screws 4 Gear box 5 Drive axle 	<p>The space available for the drivetrain was restricted to 54x95 mm to meet overall size requirement. To install a worm in the design two bevel gears, 1:1 ratio, have been used.</p>
Component Design		
	<ol style="list-style-type: none"> 1 Worm gear 2 Bevel gear 1 3 Bevel gear 2 4 Driven gear 5 Worm gear shaft 	<p>It is best for the driven gear to be a helical gear as it betters the connection to the worm gear. The worm gear can provide give a ratio of 20, which is suitable for a motor of 3000rpm/v.</p>
	<ol style="list-style-type: none"> 1 Drive axle 2 Driven gear pin 3 Wheel support 	<p>The drive axle has a pin to keep a tight connection between the rear gear and the shaft. The wheel shaft can be hexagonal for a secure connection to the wheel.</p>
	<ol style="list-style-type: none"> 1 Motor holder 2 Worm Shaft support 3 Casing support 4 Drive axle support 	<p>The Drivetrain support must hold the shaft for the worm and bevel gears, as well as the drive axle for the rear gear. It also provides a gear box and must connect to the chassis.</p>