custom shaped blocks

CUBES

CO_2 – ENVIRONMENTAL STUDY

CUBES PU technology compared to polystyrene casting and panel bonding

1. BASIC CONCEPT

The newly developed CUBES technology is more environmentally friendly than many other alternative PU-production methods. Due to the lower material and electricity consumption during the milling process, the CO_2 impact can be significantly reduced. Just by not using moulds made of expanded polystyrene, a lot of CO_2 can be saved. This report shows the calculation of the CO_2 saved.

2. METHODS AND THEIR CO_2 – EQUIVALENTS

2.1. POLYSTYRENE CASTING

Where does the CUBES process save CO_2 compared to polystyrene casting?
The difference lies in the shaping. In the polystyrene moulding process, a close contour mould is milled from an EPS block. The Cubes technology, on the other hand, enables precise contouring by using reusable parts. The data for the CO_2 equivalents of EPS were taken from the website of the European Manufacturers of Expanded Polystyrene (EUMEPS). EUMEPS describes itself as the voice of the European EPS industry. The EUMPES network comprises over 1000 companies from 22 European nations in the fields of raw material and additive production, EPS recycling and mechanical engineering.

A density of 20 kg/m^3 is assumed for the polystyrene, since the manufacturers of EPS casting moulds use polystyrene boards with a density of 17 - 22 kg/m^3. Also included is the electricity for milling the mould and the "End of Life - Cycle" of the EPS. In the EoL cycle, transport, combustion and the energy recovered are considered.

CO_2 – Equivalent of a component produced by polystyrene casting
= Manufacture (EPS) + mould milling (EPS) + disposal (EPS) + manufacture (PU) + component milling (PU)

Manufacture EPS = 62,13 [kg CO_2/m^3]
Mould milling EPS = 0,432 [kg CO_2/m^3]
Disposal EPS = 0,21 + 67,43 - 35,11 = 32,53 [kg CO_2/m^3]
Manufacture PU = 56,76 [kg CO_2/m^3]
Component milling PU = 86,56 [kg CO_2/m^3]

2.2. PANEL BONDING

In the panel bonding process, PU panels are glued together and then the component is milled out of this bonded assembly. This process consumes a lot of material that is not actually needed. The volumes of the bonded assembly for the components used as examples were created by using the calculation tool on the CUBES website.

CO_2 –Equivalent of a component produced by panel bonding
= Manufacture (PU) + Component milling (PU)

Manufacture (PU)= 56,76 [kg CO_2/m^3]
Component milling (PU)= 86,56 [kg CO_2/m^3]

2.3. CUBES - TECHNOLOGY

By using the CUBES technology, a mould is created that is close to the contour and its components can be reused. This saves material needed for the mould, PU raw material and milling time. As confirmed by the grid operator Salzburg AG, CUBES uses only green electricity and thus achieves 0g CO2/kWh.

CO_2 –Equivalent of a component generated by CUBES process
= Manufacture (PU) + Component milling (PU)

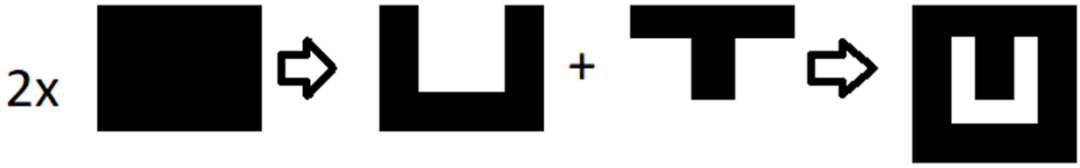
Manufacture PU = 56,76 [kg CO_2/m^3]
Component milling PU = 86,56 [kg CO_2/m^3]

3. CALCULATION

3.1. CO_2-equivalent of the EPS cycle

A polystyrene casting mould consists of two blocks of EPS. The bottom is milled from one and the lid from the other. For the calculation of the volume for the outer dimensions of the EPS mould, 100mm wall thickness of the mould on each side must be added to the maximum dimensions of the component. In this study, it is assumed that the mould including the 15mm impact is directly milled from a single EPS block only. This is because the geometries of the components are very difficult to calculate for the milling process and additionally require a separate tool for calculation. Due to this assumption, the CO_2 equivalent for milling polystyrene is actually slightly higher than calculated here, since only one of the two blocks is milled.

2 EPS blocks are milled into a mould, shown schematically



In this way, the EUMEPS data can be used to calculate the CO2 equivalent of production and disposal.

3.2. CO_2-equivalent of the production of the polyurethane

The used material consists of two components from Sika AG:

- SikaBiresin M67 BM delivered in IBC with 1250kg → CO_2e = 54.16 kg (WTW)
- SikaBiresin M70 delivered in IBC with 1000kg → CO_2e = 43.33 kg (WTW)

WTW: Emissions of CO2e in kilograms from the source including the journey to the CUBES company.
With the required mixing ratio, a value of 56.76 kg CO_2/m^3 polyurethane is calculated.

3.3. CO_2-equivalents of the milling processes

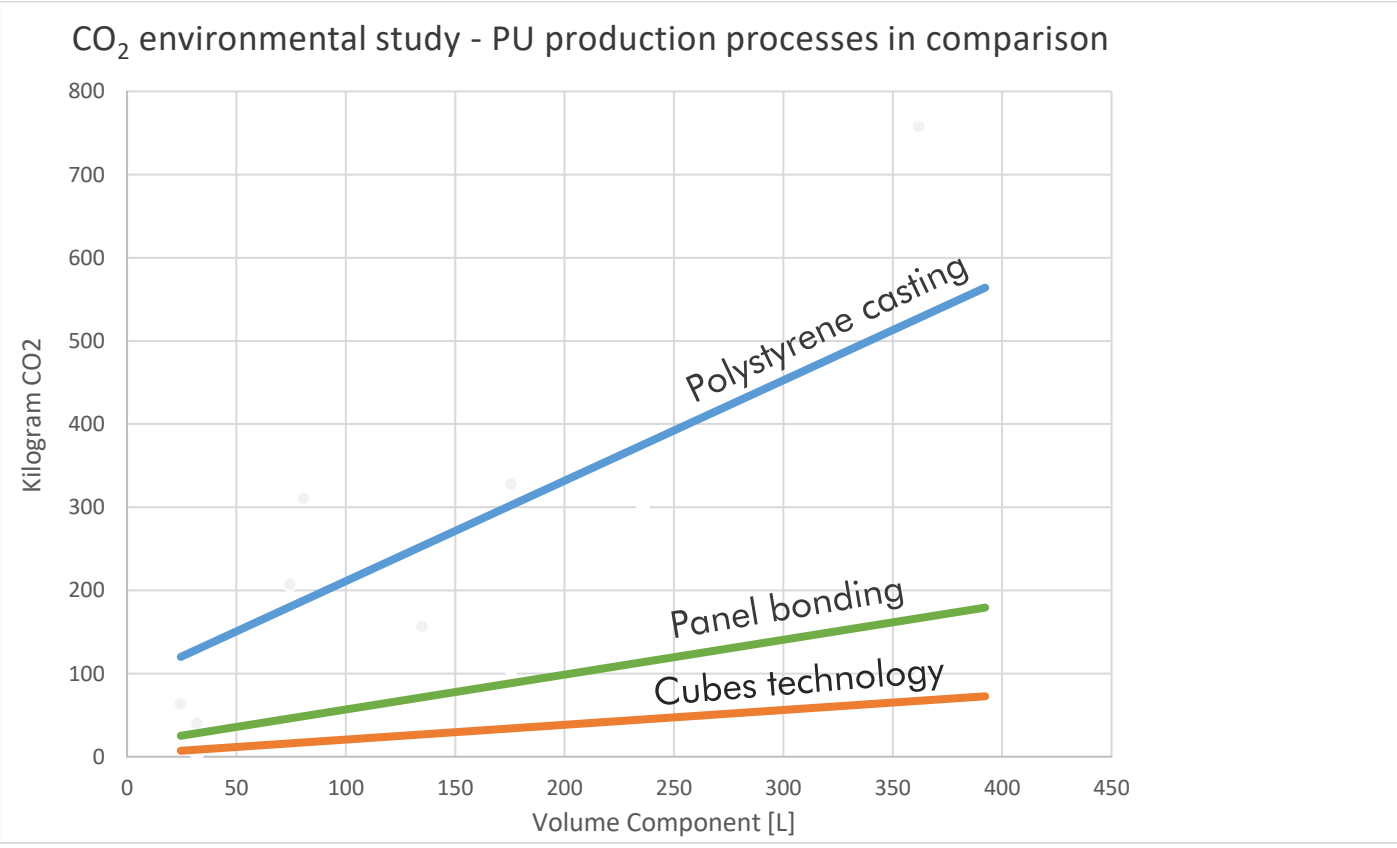
According to various enquiries from companies with CNC machinery, it is very difficult to determine an exact energy value. The energy consumed is strongly dependent on the geometry of the component. It could be possible that all 5 axes are needed, or just one. Other influences on power consumption are for example cooling, dust extraction or vacuum table. For this reason, we assumed that one third of the rated power of a CNC milling machine for plastics processing was used for milling PU and EPS.

At this point we would like to thank SFK, who measured the time of an ideal straight rough milling process without contour for us. The mass of the milled material was 10kg and it had a density of $1g/cm^3$, very similar to the material used by CUBES.
For milling polystyrene, it was assumed that it would take a quarter of the time due to its low density. The CNC milling machine has a nominal power of 90kW and the dust extraction 25kW.
With this data, the power consumption for milling $1m^3$ PU or EPS was extrapolated.
For the CO_2 equivalent of the required electricity, we took the value of the German Federal Environment Agency for the German electricity mix. For the year 2020, this value was 0.366 kg CO_2/kWh.
Since the polystyrene casting is a close contour casting, 15mm were added to the finished part dimensions as usual.

4. CO_2 ANALYSIS

For the evaluation, the production of 10 components with different geometries and different volumes was considered.

Part Nr.	**Component Volume [L]**	**CO_2 - Equivalent polystyrene casting [kg]**	**CO_2 - Equivalent panel bonding [kg]**	**CO_2 - Equivalent CUBES technology [kg]**
1	31,92	40,32674271	7,9430088	4,8974588
2	24,55	63,67431502	11,2409752	10,6060676
3	74,47	207,484636	76,86006	15,0934396
4	80,58	310,7975706	69,190976	18,813996
5	134,84	156,5452445	29,9698756	18,8539764
6	175,53	327,9295495	105,9803168	29,7770728
7	235,93	304,1181818	85,23197	27,8738728
8	176,44	437,9420818	117,3843456	55,8355716
9	392,26	335,331939	139,15217	54,7194916
10	361,91	758,2466559	213,5668208	92,0500924



Due to the large influence of the geometries, there is a wide scatter in polystyrene casting. However, the slope of the regression line still provides a very good approximation for estimating the CO_2 emissions of future projects

In summary, without considering the unnecessary transport routes for the polystyrene casting, the following applies:

CUBES TECHNOLOGY: approx. **0.178 kilograms CO_2** per litre of material

PANEL BONDING PROCESS: approx. **0.419 kilograms CO_2** per litre of material equals approx. 235% of the CUBES process.

POLYSTYRENE CASTING: approx. **1.208 kilograms CO_2** per litre of material corresponds to approx. 680% of the CUBES technology

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