PROteINSECT ENGINEERING COMPETITION

ENTODRYA

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ABSTRACT

Introduction

The concept of the ENTODRYA is based on a drum dryer, which is heated from the inside with steam. To heat up the drum and to move the drum we combined the ENTODRYA with a Combined-Heat-Power-Unit, so that the electrical and the thermal energy is used. Those CHPU's are often used to provide electricity in emerging nations, without using the thermal energy of the machine.

Method

The ENTODRYA is a drum-dryer. The to-be-dried goods are predried with hot air during the conveying of the maggots to the drum dryer. Then they are applied on a steel drum with applicator drums. Those applicator drums are forming a 1-2mm thick layer of the maggots on the steel drum. The steel drum is heated from the inside with steam at 105-110°. The water on the surface evaporates and a steam hood collects the evaporated water. The dried maggot-powder is then scratched off the steel drum by a blade. In the next step, the powder is falling on a conveyor, which transports the powder to a storage vessel.

Results

The ENTODRYA was a challenging concept to design, due to the fact that it is a uncommon drying material and a uncommon method to dry semi-solid goods with a drum dryer. Nonetheless a machine like this could be used as a method to dry insects, which are then storable for a long time.

Discussion

Further design and further investigation needs to be done to bring a machine like to the a status where it could be built.

INTRODUCTION / AIMS

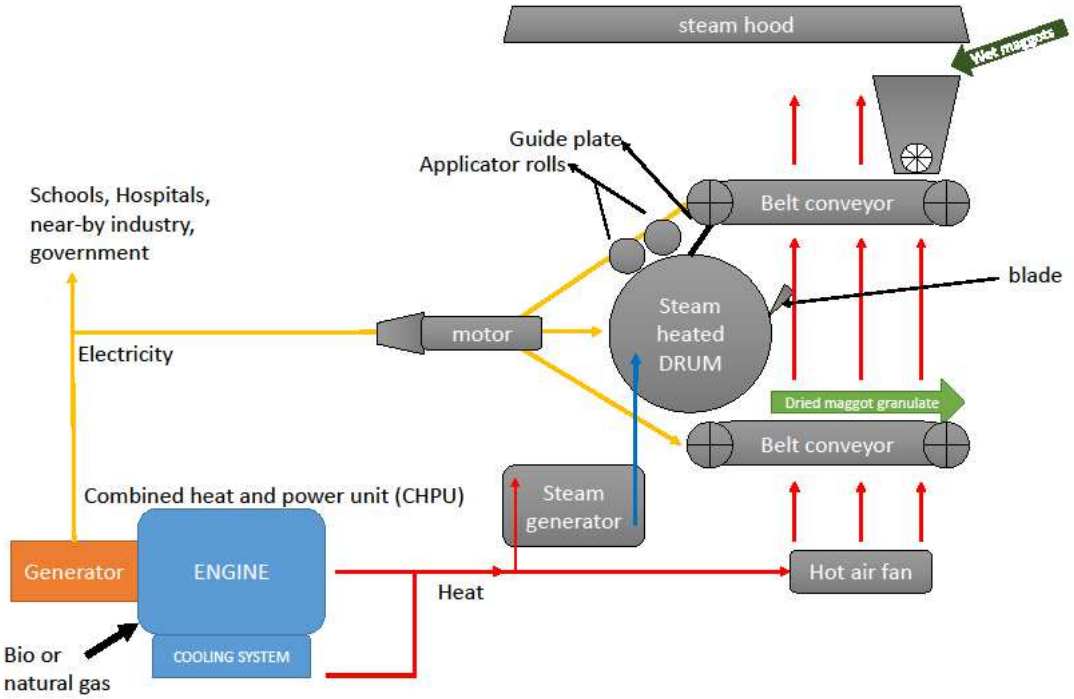
The ENTODRYA is a motor driven drum dryer, which is heated by compressed steam, which is produced with the thermal energy from a Combined-Heat-and-Power-Unit (CHPU). The drum dryer has two applicator rolls and a blade to scratch off the dried material from the drum. A conveyor belt is used to supply the drum with the moist maggots. A second belt conveyor, which is placed under the blade/drum unit, conveys the dried maggot paste/powder into a storage unit.

The ENTODRYA design is based upon the following surroundings and requirements which could be relevant factors when building it in emerging nations or regions:

- No or insufficient electrical infrastructure
- Need for electricity to light buildings and rooms in nearby buildings
- Easy design to be easily repaired
- Low risk when working with the machine
- Short run-up time
- The product should be able to be stored in sealed bags at room temperature
- The product produced by the ENTODRYA is designated to be used as feed-meal or – given that there is an opportunity to work in a proper hygienic surrounding – as insect meal used for protein enrichment of foods.

METHODOLOGY

SCHEMATIC VIEW



PROCESS- DESCRIPTION

1) Providing electrical and thermal energy by burning bio- or natural gas in a Combined-Heat-and-Power-Unit (CHPU). This CHPU could be already stationed at a industrial side or could be stationed at a hospital or school, depending of the infrastructure of the region.
2) The heat from the engine is used in two ways:
    a. To bring hot oil from the cooling system to the steam generator. The steam generator also compresses the steam which is built in the heat-exchange system. The compressed steam goes into the drum and heats the surface of the drum. The condensing water at the inside of the drum-surface runs into a condensate-drain-pipe.
    b. The thermal energy is also used to preheat the material via hot air fans on the belt conveyors and to dry the powder from the conveyor which fills the powder into storage vessels.
3) The electrical energy produced by the CHPU is used to move the drum dryer, the applicator rolls and the two belt-conveyors.
4) The drying process happens in four steps
    a. The maggots are preheated and pre-dried with hot air to 30°C. The guide plate holds the maggots in place for the applicator rolls.
    b. The Applicator rolls are rolling out the maggots on the drum dryer.
    c. The maggot-paste is heated up by the moving drum and the moisture changes its aggregation phase from liquid to vaporous. After ¾ of a turn of the drum, the moisture should be evaporated.
    d. The dried powder is detached from the drum with the blade.
5) The powder falls from the drum on the belt-conveyor, where the powder is moved to storage vessels

TECHNICAL DESCRIPTIONS & SPECIFICATIONS

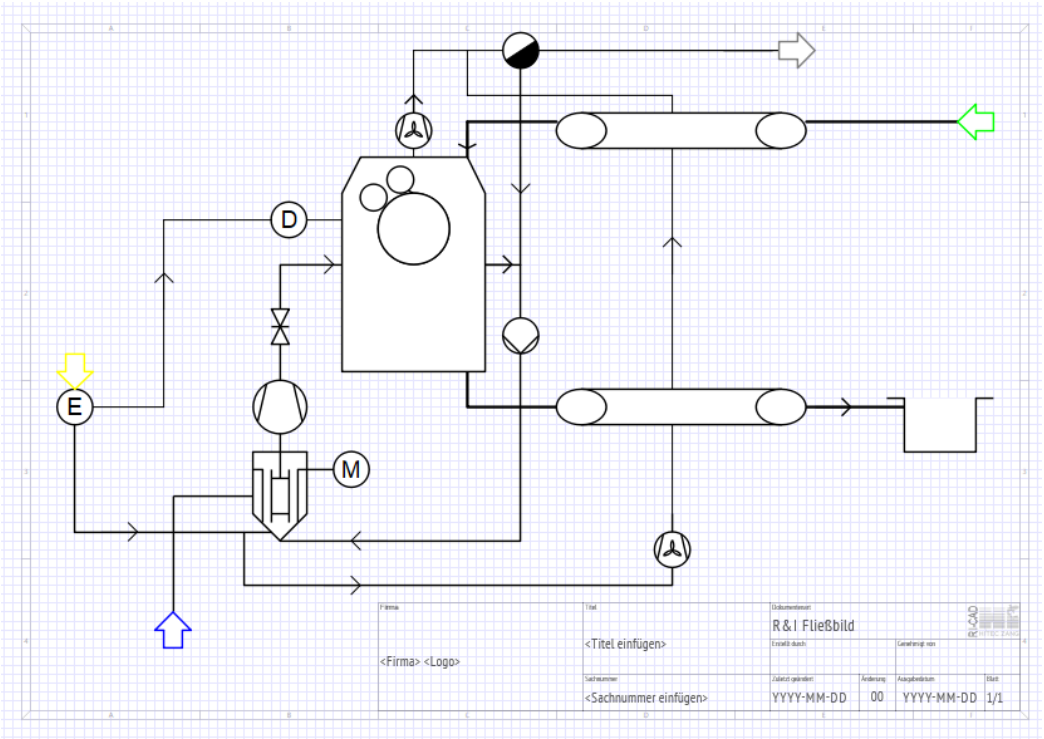
DRUM	
Length	100 cm
Diameter	50 cm
Material	V2A steel
Thickness	2,5 cm
Surface temperature	102-110°C
steam flow rate	0,1kg steam / s
Steam pressure	2-3 bar
APPLICATOR DRUMS	
Length	100 cm
Diameter	10 cm
Material	V2A steel
Thickness	0,5 cm
BLADE	
lenght	1 m
Material	V2A
Surface pressure	3 - 5*10³ N
MOTOR	
power	~2 kW
BELT CONVEYORS	* Both belt conveyors are built the same way
Length	Upper belt conveyor1m / lower belt conveyor2 m
width	1,10 m
Diameter of pull-drums	10 cm
Thickness of belt	3 mm
CHPU	** The power of the CHPU and thereby the electrical and thermal energy depends on whether it is stationed at a nearby place or at the facility.
Steam generator and compressor	
steam temperature	~115°C (regarding loss of thermal energy due to piping)
Steam pressure	2-3 bar
PIPING	*** has to be based on DIN EN ISO 6708 and DIN EN ISO 1333

TECHNICAL CALCULATIONS

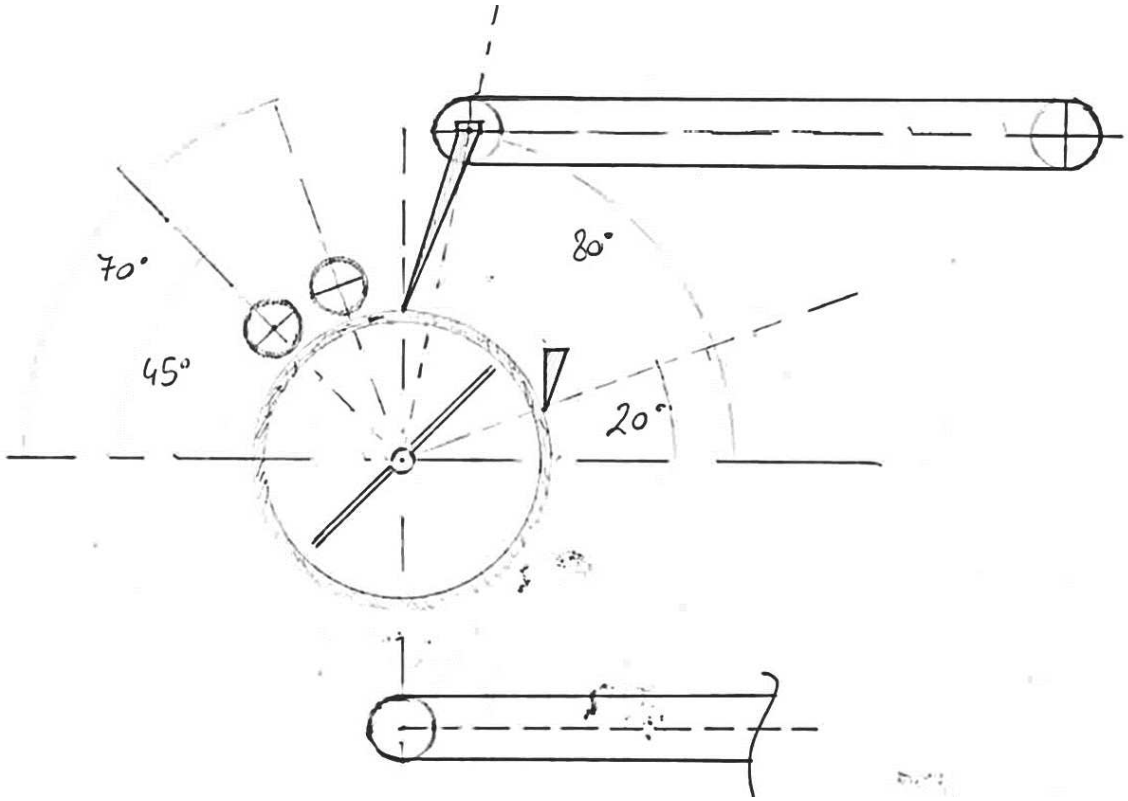
description of parameters	abbreviation		unit
diameter of drum	dd	0,5	m
Lenght of drum	l	1	m
initial moisture content	imc	0,65=65	%
initial solids content	isc	0,35=35	%
moisture content after drying	mcd	0,05=5	%
heat of contact surface	hcs	102	°C
thickness of layer	tol	0,001	mm
heat transfer coefficient	htc	1200	Wm/K
energy to evaporate water at 30°C	ee	2250	kJ/kg
density of initial product	dip	1050	kg/m³
contact area 3/4 of the drum		0,75	factor
temperature of product to be dried (preheated with hot air fans from 25°C to 30°C)	tp	30	°C
CALCULATIONS	formula		
surface of drum [sd]	pi * dd * l	1,57	m²
mass of feed on 3/4 of the drum [md]	(sd*0,75)*tol*dip	1,24	kg
weight of solid parts from initial product [wsp]	md*isc	0,43	kg
weight of solid parts with x% moisture content after drying [mx%ad]	(100/100-mcd)*wsp	0,46	kg
mass of water evaporation [mwev]	md*mx%ad	0,56	kg
energy demand for water evaporation [edwe]	Q = htc*sd*(hcs-tp)	1,36E+05	J/s
drying rate of water [dr]	(edwe/ee)/1000	0,060	kg/s
contact time (3/4 of drum) [cttq]	mwev/cttq	21	seconds
contact time (1/1 of drum) ct	(100/75)* cctq	27	seconds
rpm of drum	60/ct	2,19	rpm
time needed for 1t of maggots with x% initial moisture content	(1000*imc)/(dr*3600)	2,99	hours

TECHNICAL DRAWINGS

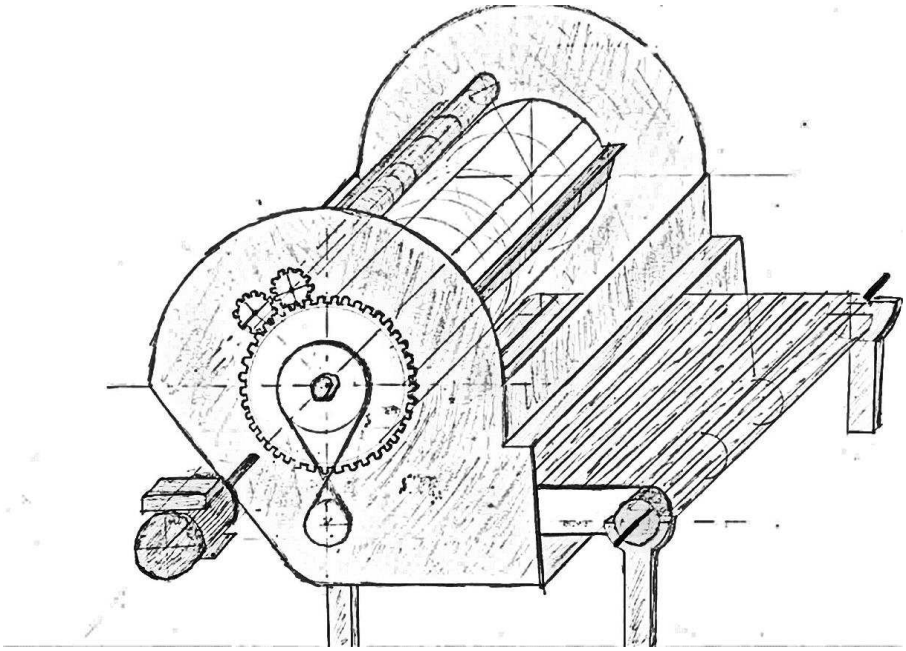
P&I Diagram



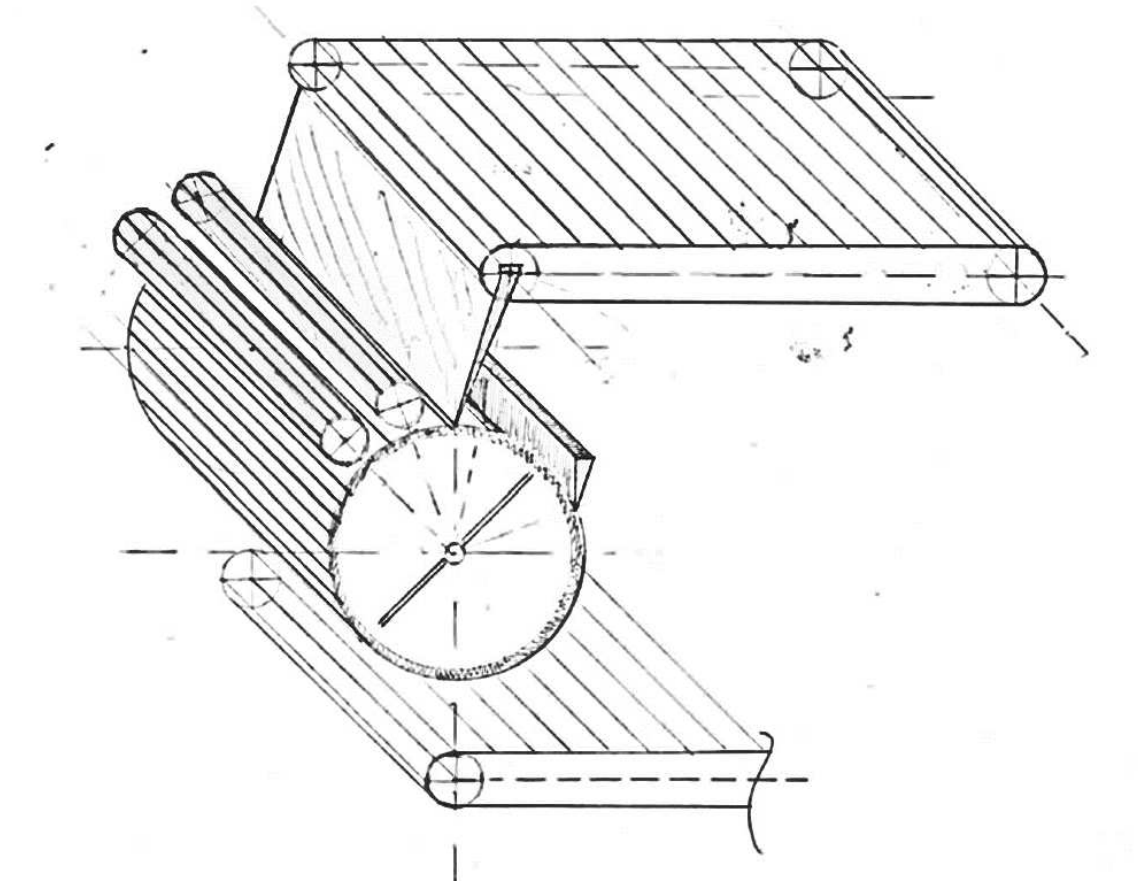
2-dimensional view



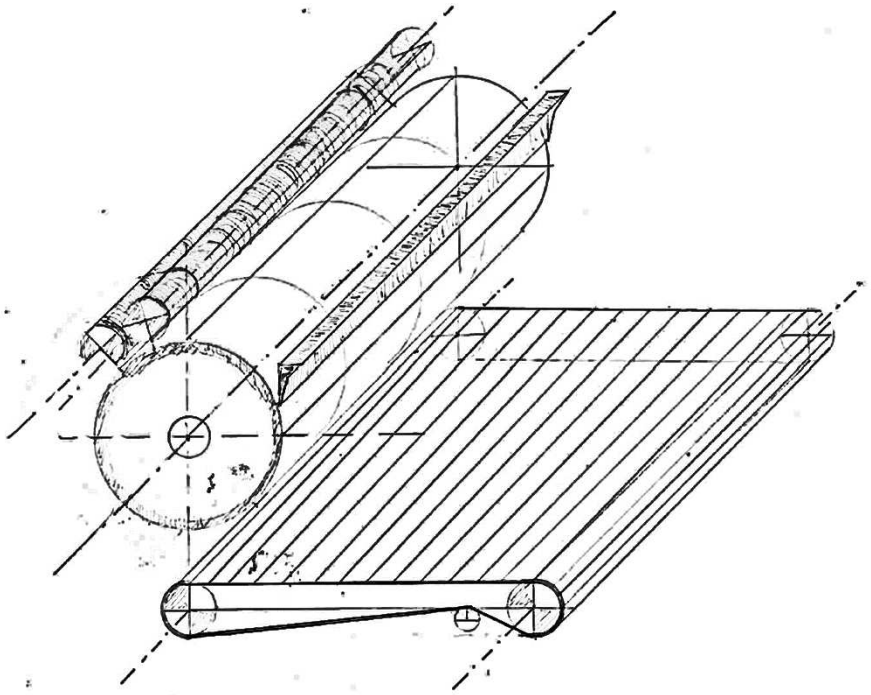
3-Dimensional Views



ENTODRYA with housing and drivetrain-parts

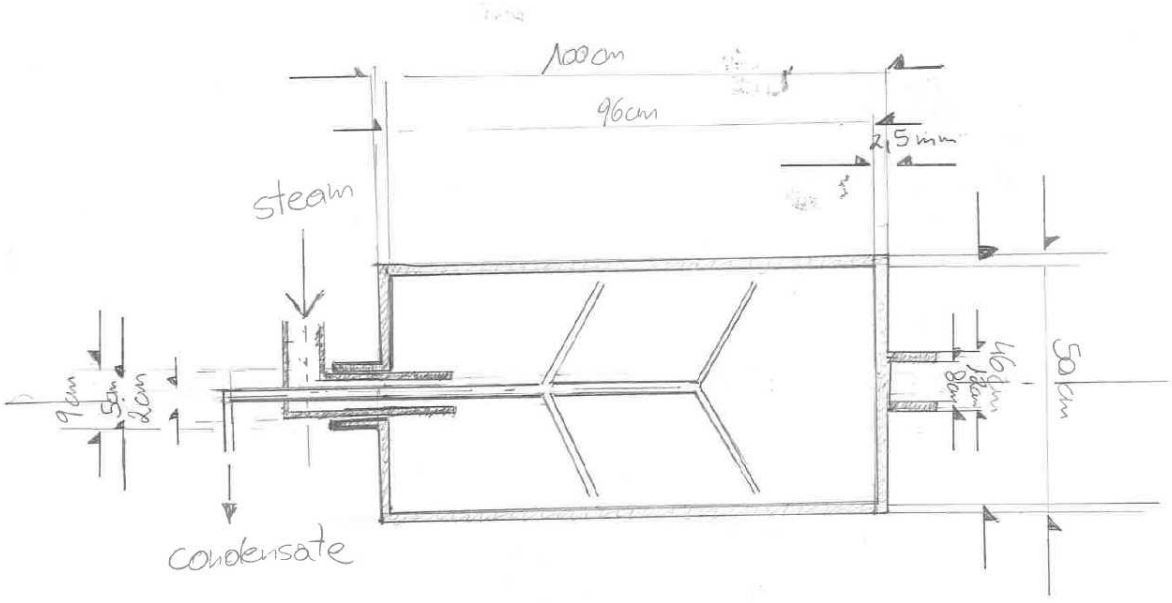


ENTODRYA with belt conveyors, guide plate, applicator rolls and blade.



ENTODRYA with applicator rolls and blade.

Construction of the drum



The drum is the most complex part of the ENTODRYA, because steam needs to be brought into the drum with a pressure of 2-3 bar and the condensate needs to be brought out of the drum. Furthermore, the drum needs to be able to be rotated with max. 3rpm.

REQUIREMENT FOR LABOR INPUT

The drying process is continuous and fully automatic. Labour input is solely needed at the following steps:

- Loading the batch feeder with maggots.
- Gathering the dried insect powder and sealing it in bags.
- Cleaning the machine.
- General process controlling

SCALABILITY

Due to the fact that this machine is able to dry 1t of insects in 3h, a scale up process can be designed easily. When the capacity of one drum dryer is exceeded, the drying process could be designed as a drying battery with multiple dryers.

ENERGY DEMAND

The energy demand is, compared to convection-dryers, relatively low. Due to the fact that the ENTODRYA concept is based on the idea that a CHPU provides the energy, it is important to see that the capacity of the CHPU is fully used.

The processes, which will need energy, are the following:

- Motorization of the drum, the applicator rolls and the conveyor belts (2kW-Motor)
- Steam production (0,1kg steam/s results in 3294 kJ/h [needs to be multiplied with a factor of ~1,3 for losses due to piping and heat emission from the sides of the drum)
- Compressor (0,75 kW)
- Hot air fans and pumps (0,75 kW -1,5kW)
- Automation and measuring-and-controlling-systems

CONCLUSION – BENEFITS AND LIMITATIONS

The ENTODRYA is a concept which shows an easy design for a drum dryer for processing maggots to insect-powder or paste. This machine is capable to dry 1t of insects to a moisture content of 5% in just 3 hours. The method is also used in milk-technology, where also protein and carbohydrates, that's why the ENTODRYA uses this approach.

The limitations are, that the heavy V2A drum needs to be built by profession steel-processing companies. Also the steam generation and the heating of the drum is a challenge.

Nonetheless, this concept could be used for processing insects to insect-meal, which then could be used as food or feed.