



Circularity and sustainability in the WORLD project

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Waste Oils Recycle and Development



Coordinator



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World Project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 873005

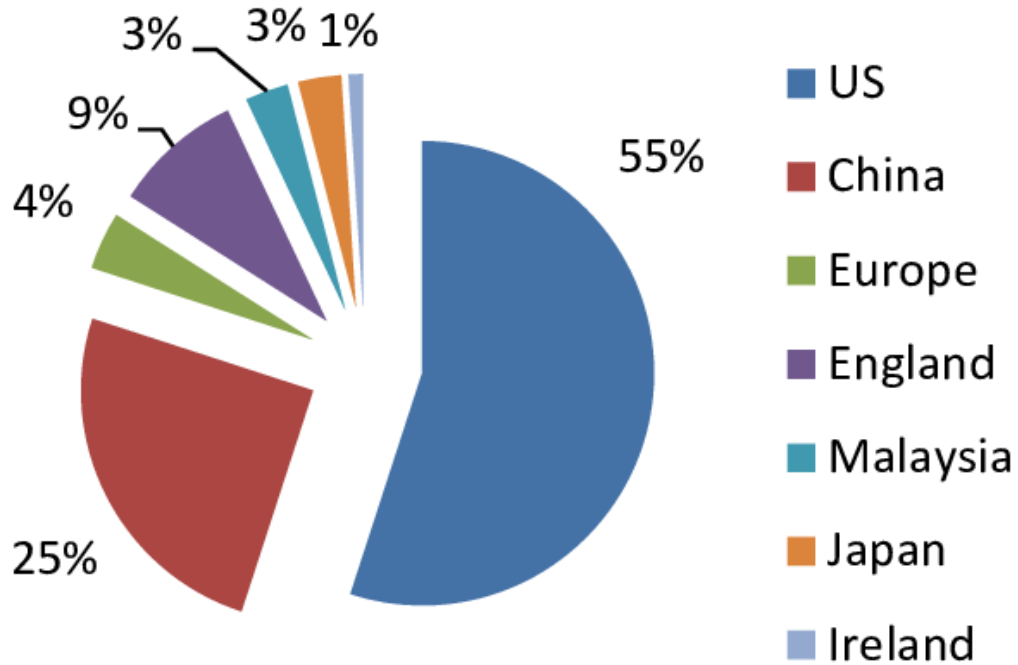


Market sharing



Europe
production
4 Mton /year

Production of Waste Cooking Oil



Estimated *pro-capita* consumption 8L WCO/year.



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London's fatberg



Develop a business plan for waste vegetable oil recycling
and lubricant production

Is it something new?

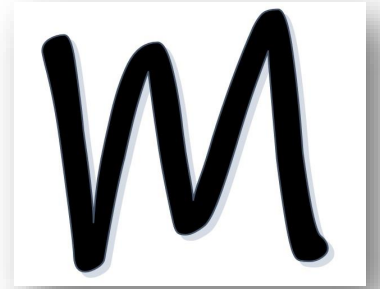


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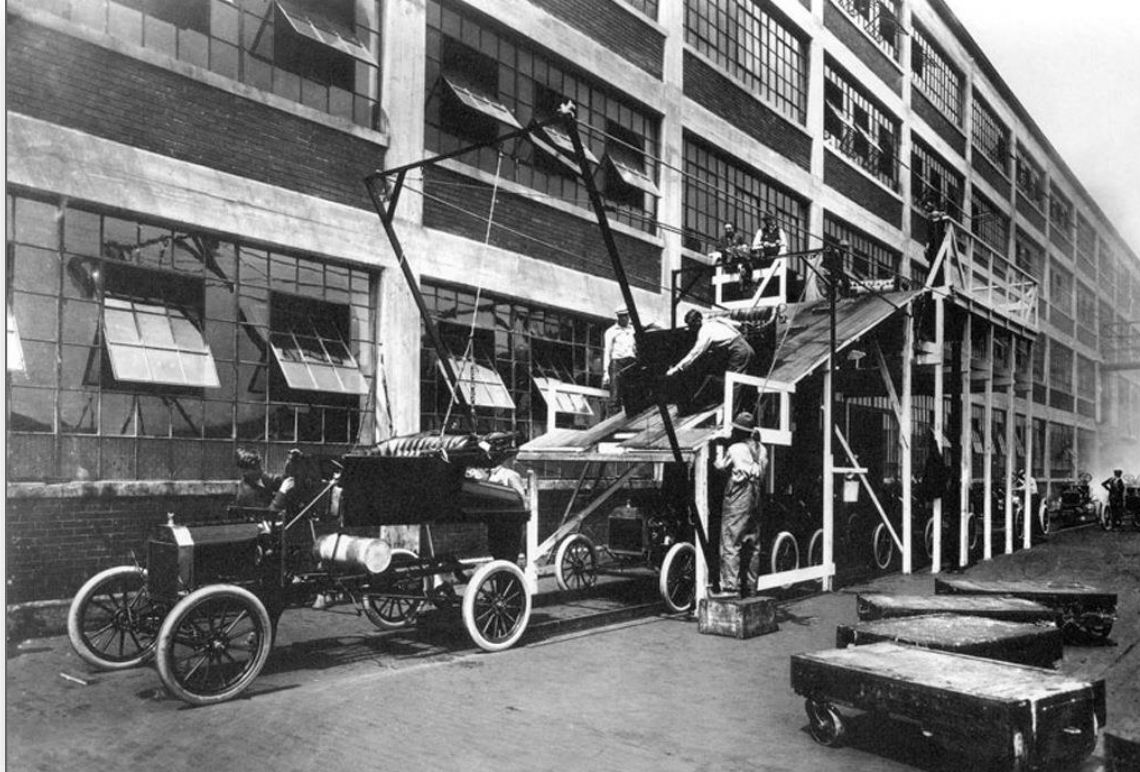
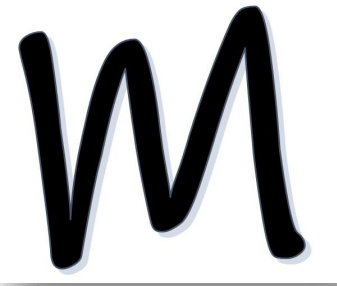
Waste Oils Recycle and Development





So, why WORLD is innovative and ground-breaking?

Why it is worth to invest in WORLD?
(EU Commission did it)



According to [Henry Ford](#) (wikipedia)

The principles of assembly are these:

- (1) Place the tools and the men in the sequence of the operation so that each component part shall travel the least possible distance while in the process of finishing.
- (2) Use work slides or some other form of the carrier so that when a workman completes his operation, he drops the part always in the same place—which place must always be the most convenient place to his hand—and if possible have gravity carry the part to the next workman for his own.
- (3) Use sliding assembling lines by which the parts to be assembled are delivered at convenient distances.



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Toyota received their inspiration for the system, not from the American automotive industry (at that time the world's largest by far), but from **visiting a supermarket**. The idea of **just-in-time production** was originated by [Kiichiro Toyoda](#), founder of Toyota. The question was how to implement the idea. In reading descriptions of American supermarkets, Ohno saw the supermarket as the model for what he was trying to accomplish in the factory. **A customer in a supermarket takes the desired amount of goods off the shelf and purchases them.** The store restocks the shelf with enough new product to fill up the shelf space. Similarly, a work-center that needed parts would go to a "store shelf" (the inventory storage point) for the particular part and "buy" (withdraw) the quantity it needed, and the "shelf" would be "restocked" by the work-center that produced the part, making only enough to replace the inventory that had been withdrawn.

Source: wikipedia





Production is based not on the offer but on the market request.

Parallel to the production, a continuous improvement of the product is pursued. The volumes of the production are related to the market requests in real time.

The worker is considered an active contributor to the company business. The worker can tune the production by operating on the process.

W

Each worker can manage multiple machines at the same time.

Fast response to market's requests. Reduction of stocks and minimal storage of materials are mandatory. Trying to avoid any unnecessary waste.

**LEAN
MANUFACTURE**





La classifica delle 10 case auto più grandi al mondo

→ Le case automobilistiche a più alta capitalizzazione

→ 1) Tesla (TSLA)

→ 2) Toyota (TM)

→ 3) Porsche (P911.DE)

→ 4) Byd (002594.SZ)

→ 5) Mercedes-Benz (MBG.DE)

→ 6) Volkswagen (VOW3.DE)

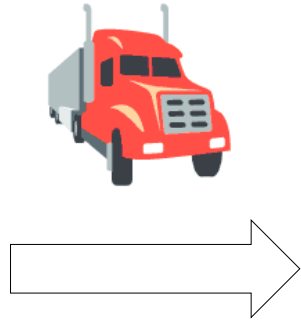
→ 7) Bmw (BMW.DE)

→ 8) Stellantis (STLA)

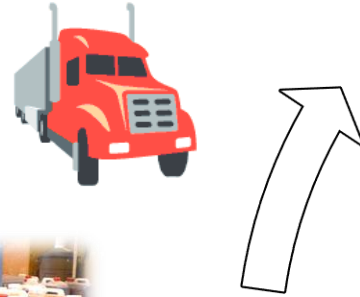
→ 9) General Motors (GM)

→ 10) Ford (F)





Collecting



Storage



Delivering



Production



Delivering



Consumption



Waste

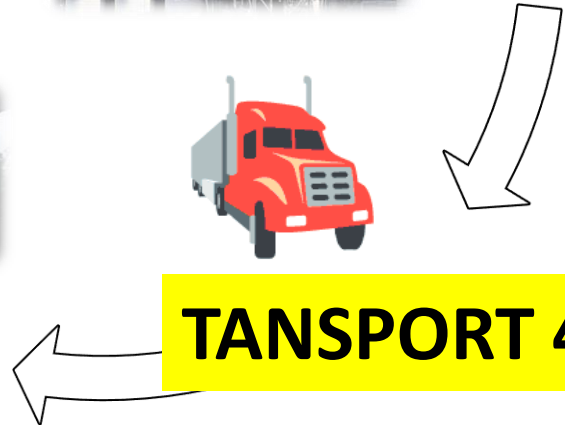




Production



Consumption



Waste





Process about 200 kg per day

Process the waste raw material from near zone

Easy to use and set

Produce a regenerated oil with different characteristics



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Institution's logo



Process about 200 kg per day

Not professional manpower

Easy to switch from a product to a different one

Process the waste raw material from near zone

Economically rentable

Low environmental impact

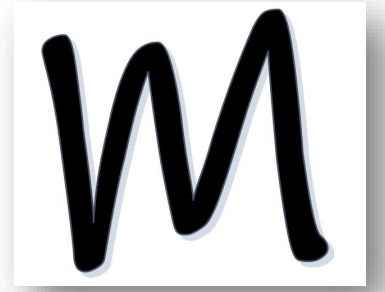
Many microplants cover large territories



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How we can develop such process?



The Design of Experiments approach (DoE)



One factor at a time (OFAT) method

(source: https://www.jmp.com/en_ph/statistics-knowledge-portal/what-is-design-of-experiments.html)

Change the value of the one factor, then measure the response, repeat the process with another factor.

Target: study the effect of water treatment on waste vegetable oil's flash point

Exp.	T (°C)	Time (h)	Oil/water ratio (%)	pH	flash point (°C)
1					
2					
3					
4					
5					

- 1) Change the temperature letting all the other parameters in fixed.
- 2) Change the Time letting all the other parameters in fixed.
- 3) Change the oil/water ratio letting all the other parameters in fixed.
- 4) Change the pH letting all the other parameters in fixed.

We can analyze just one variable per time and we will not be able to:

- Find the optimal compromise between multiple variables
- Discover any synergic effect

Also, in the case of multiple variable, the number of the experiments can be relevant





Design of Experiments (DoE) approach

(source: https://www.jmp.com/en_ph/statistics-knowledge-portal/what-is-design-of-experiments.html)

Systematic and efficient method that enables scientists to study the relationship between multiple input variables (factors) and key output variables (responses). It is a structured approach for collecting data and making discoveries.

When to use DOE?

- To determine whether a factor, or a collection of factors, has an effect on the response.
- To determine whether factors interact in their effect on the response.
- To model the behavior of the response as a function of the factors.
- To optimize the response.



Water treatment of UVOs



Full factorial 2^k screening design

Independent variables (factors): 4

Levels (n): 2

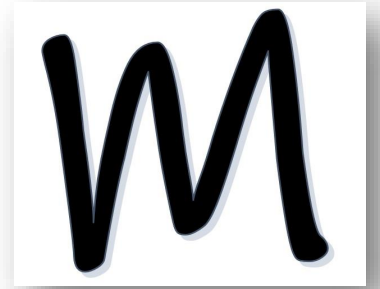
Dependent variables (responses): 2

Number of experiments: 16

Factors	Levels		Unit	Responses	Unit
pH	-1	+1	pH	Density	g/l
Oil/ H ₂ O	4	6	%	Flash point	°C
Temperature	30	60	°C		
Time	20	60	h		
	5	24			



Experiment	pH	Oil/H ₂ O (%)	Temperature (°C)	Time (h)	Flash point (°C)
1	4,0	30,0	20,0	5,0	270
2	4,0	30,0	20,0	24,0	268
3	6,0	60,0	20,0	5,0	274
4	4,0	60,0	20,0	5,0	276
5	4,0	60,0	20,0	24,0	272
6	4,0	30,0	60,0	24,0	278
7	6,0	60,0	60,0	24,0	284
8	6,0	30,0	20,0	5,0	284
9	4,0	60,0	60,0	5,0	276
10	6,0	60,0	20,0	24,0	284
11	4,0	60,0	60,0	24,0	286
12	6,0	30,0	20,0	24,0	280
13	6,0	60,0	60,0	5,0	278
14	4,0	30,0	60,0	5,0	286
15	6,0	30,0	60,0	5,0	290
16	6,0	30,0	60,0	24,0	284



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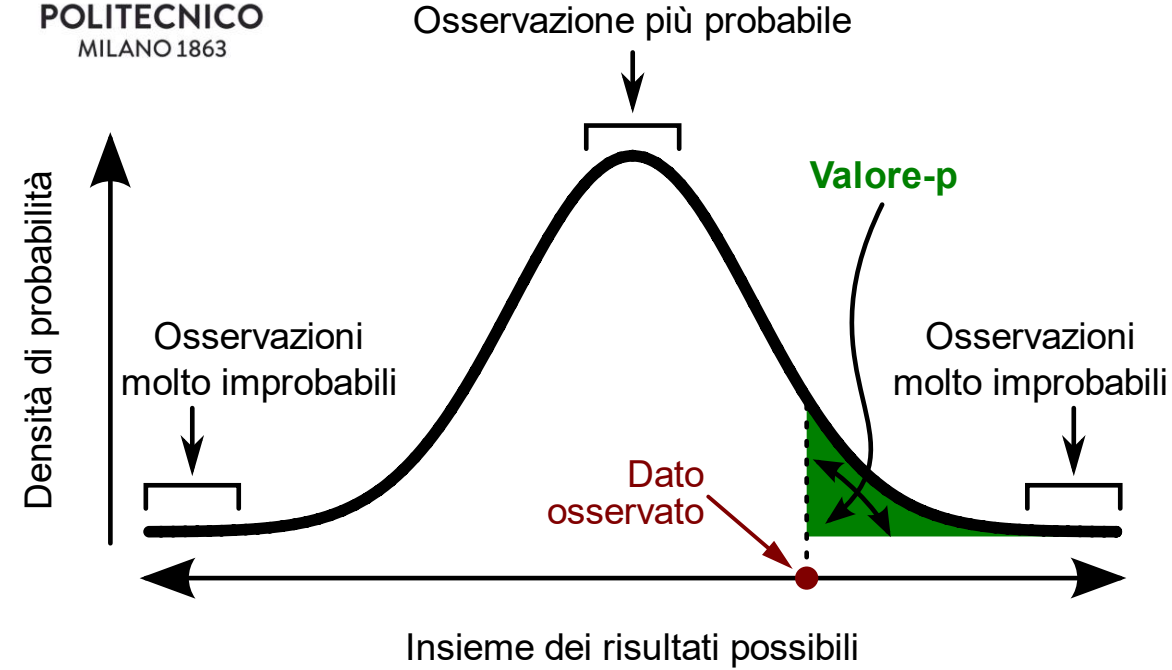
Effect	Value	P-Value
Average	279,0	-
pH	6,5	0,0375
% H ₂ O	-0,5	0,8252
Temperature	7,5	0,0241
Time	-0,5	0,8252
pH x %: H ₂ O	-4,0	0,1324
pH x temperature	-4,0	0,1324
pH x time	2,0	0,3992
?: H ₂ O x temperature	-3,0	0,2302
?: H₂O x time	6,0	0,0474
time x temperature	1,0	0,6619



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Il **valore-p** (area verde) è la probabilità di un risultato osservato (o più estremo) supponendo vera l'ipotesi nulla.

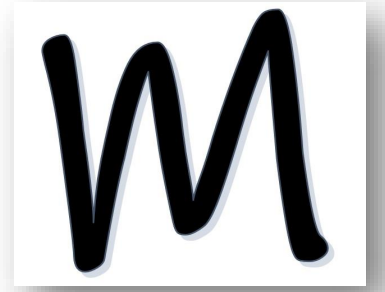
Importante:

$$\Pr(\text{osservazione} \mid \text{ipotesi}) \neq \Pr(\text{ipotesi} \mid \text{osservazione})$$

La probabilità di osservare un risultato data per vera una certa ipotesi non è *equivalente* alla probabilità che l'ipotesi sia vera dato un risultato osservato.

Usando il valore-p come “punteggio” si commette un grave errore logico:
la fallacia del condizionale trasposto.

Source: wikipedia



Multiple regression for flash point

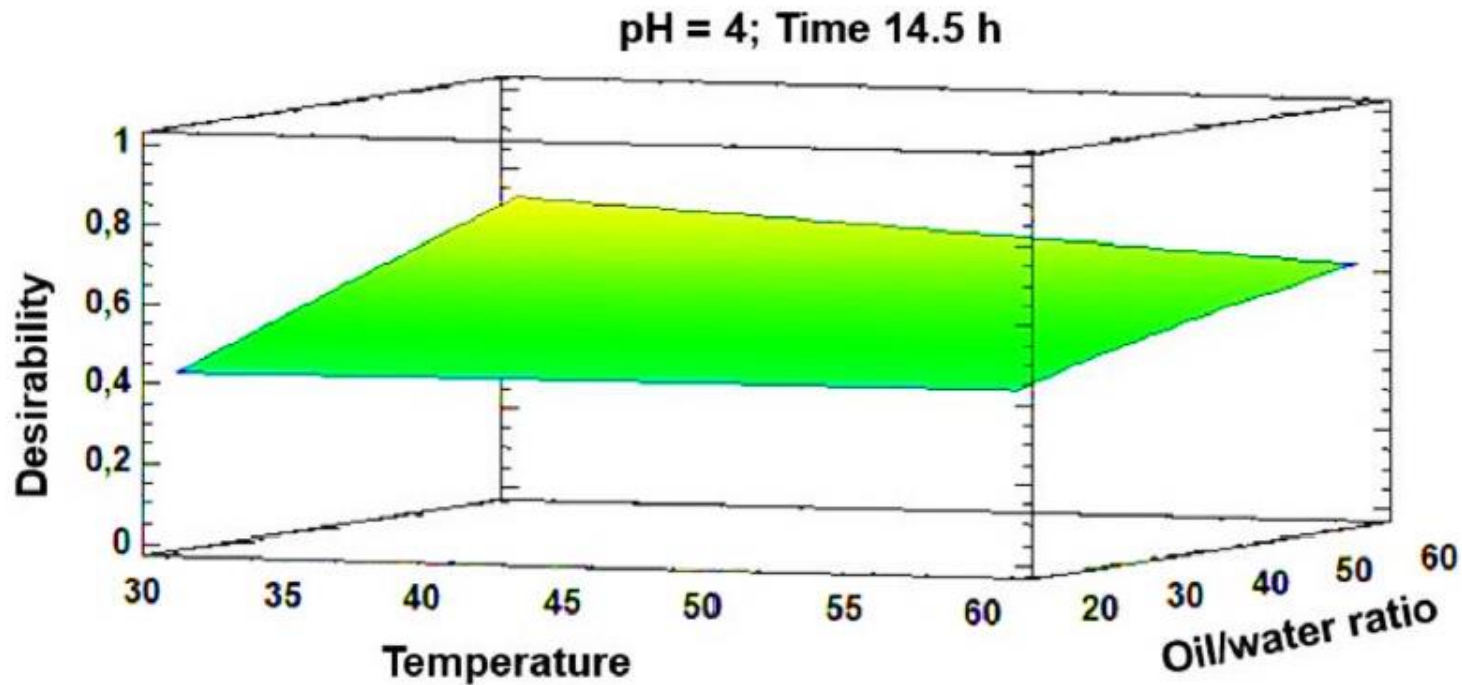
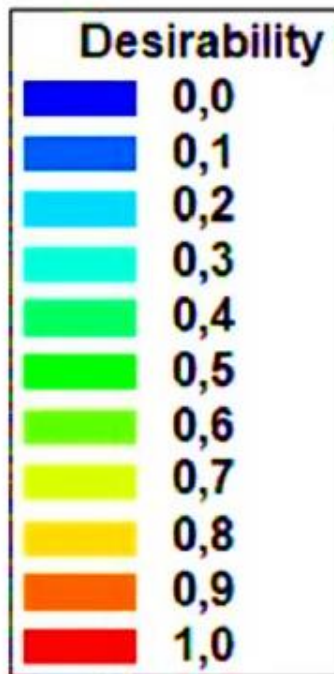
$$\begin{aligned} \text{Flash point} = & 220,276 + 11,7237 \cdot \text{pH} + 0,544737 \cdot \text{Oil}/\text{H}_2\text{O} + 0,874342 \cdot \text{Temperature} - 1,60526 \cdot \text{Time} - \\ & 0,133333 \cdot \text{pH} \cdot \text{Oil}/\text{H}_2\text{O} - 0,1 \cdot \text{pH} \cdot \text{Temperature} + 0,105263 \cdot \text{pH} \cdot \text{Time} - 0,005 \cdot \text{Oil H}_2\text{O} \cdot \text{Temperature} + \\ & 0,0210526 \cdot \text{Oil}/\text{H}_2\text{O} \cdot \text{Time} + 0,00263158 \cdot \text{Temperature} \cdot \text{Time} \end{aligned}$$

Surface Responding Analysis

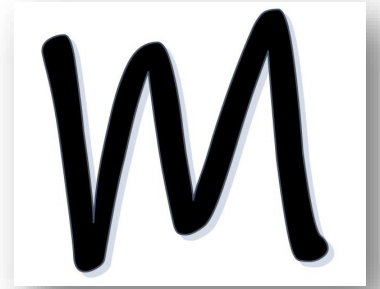


Same procedure can be applied to other responses and a **surface responding analysis** can be conducted.

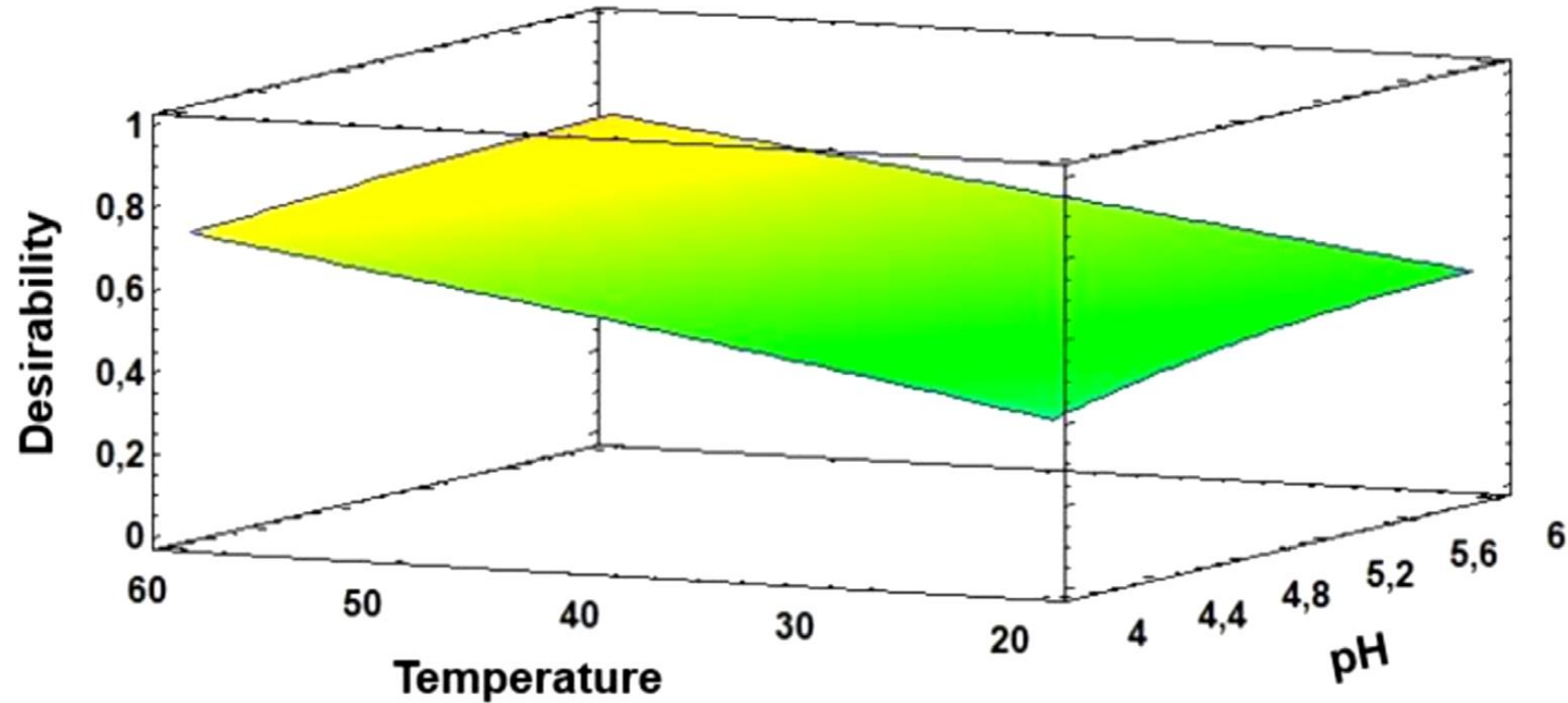
In the following example, flash point and density were combined with the aim to maximize the first and minimize the second.



Surface Responding Analysis

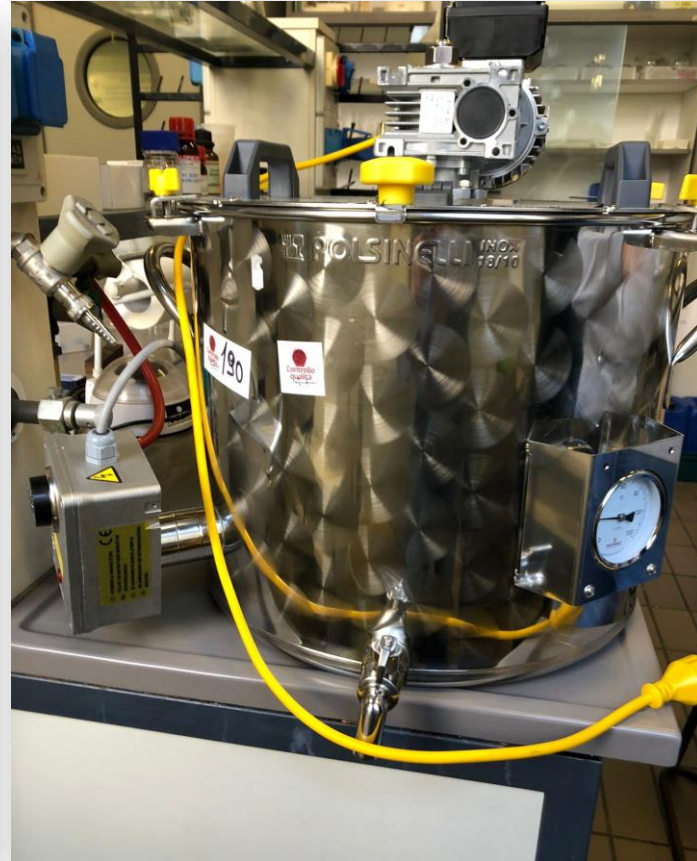


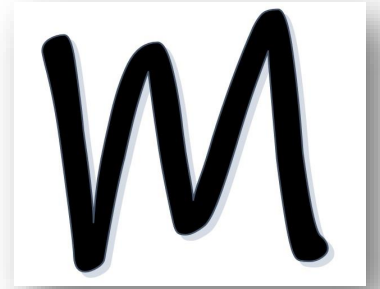
Oil/water ratio 30%; Time = 2h



Current Prototype

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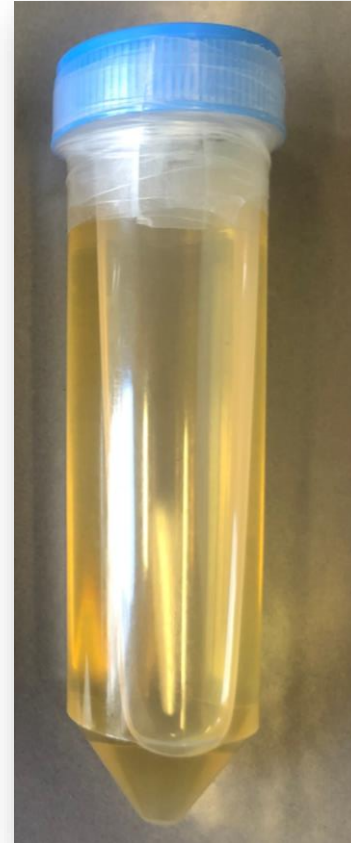
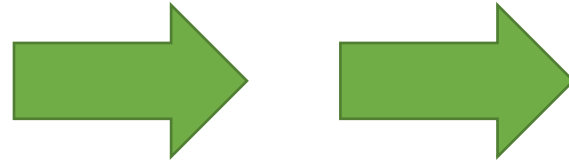
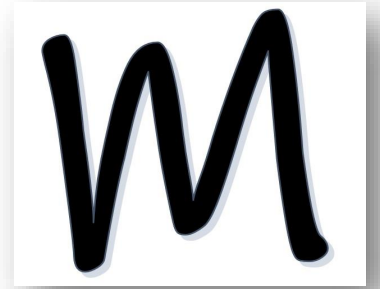




VIDEO



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Lubricant for chains



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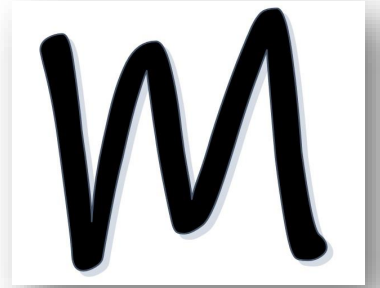


Ecological paintings





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Other aspects have been studied and many more will be investigated

www.mannuconsulting.com - www.projecteuworld.eu
albertomannu@gmail.com

If interested in

- Collaboration with WORLD Consortium
- Waste vegetable oil recycling
- Biolubricant production from wastes
- Ecological paintings
- Application of DoE for processes optimization



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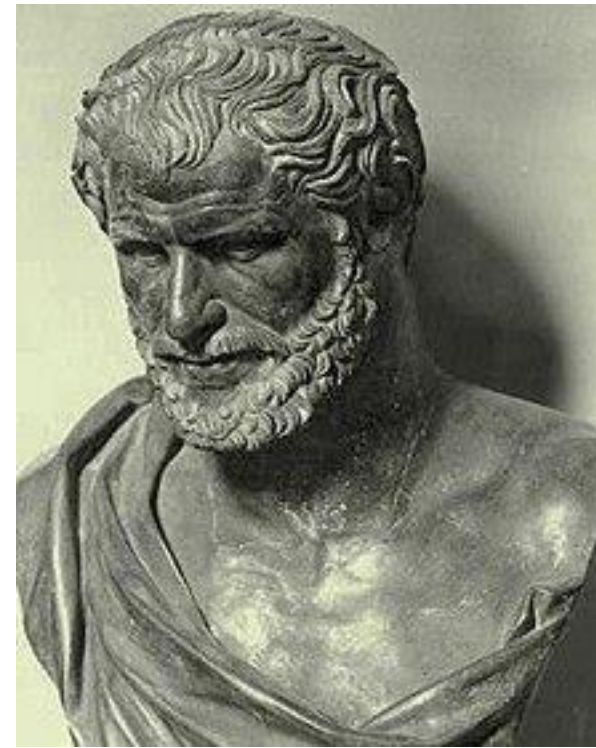
Democrito, 460-370 a.c. circa

“Se potessimo suddividere un pezzo di ferro in due parti, poi in due parti ancora e così via fino a ottenere porzioni impalpabili di materia, ci accorgeremmo a un dato punto di non poter procedere oltre. Arriveremmo fatalmente a un limite, rappresentato dall'unità-ferro che non si potrà mai suddividere ancora, perché ogni tipo di sostanza è necessariamente costituita dalla somma delle sue unità elementari.”

INDIVISIBILE IN GRECO ANTICO ἄτομος

Primo modello atomico circa 2000 anni dopo

«A volte per concretizzare una idea ci vuole parecchio tempo»





Thanks for your attention

Have a good workshop!