PlastiCircle
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D4.4 Perfomance test of prototype

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Abstract

One of the objectives of the Plasticircle project is to improve the sorting of post-consumer packaging. Near Infrared (NIR) sorting is used commonly in the waste industry to recover materials of value from mixed streams. A high level review of the waste composition in the three pilot cities has been carried out, along with specification of the sorted product requirements and an initial study into the sorting efficiency of the Picvisa NIR unit.

Present document report compiling the results of the testing and validations of the sorting prototype of the new film-stabilizing conveyor for plastic sorter.

Abbreviations

HDPE	High density polyethylene
LDPE	Low density polyethylene
MRF	Materials recovery facility
NIR	Near Infrared
PET	Polyethylene terephthalate
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride

Partners short names

1. ITENE: INSTITUTO TECNOLÓGICO DEL EMBALAJE, TRANSPORTE Y LOGÍSTICA
2. SINTEF: STIFTELSEN SINTEF
3.
4. AXION: AXION RECYCLING
5. CRF: CENTRO RICERCHE FIAT
6. UTRECHT: GEMEENTE UTRECHT
7. Las Naves: FUNDACION DE LA COMUNITAT VALENCIANA PARA LA PROMOCION ESTRATEGICA EL DESARROLLO Y LA INNOVACION URBANA
8. ALBA: PRIMARIA MUNICIPIULUI ALBA IULIA
9. MOV: MESTNA OBCINA VELENJE
10. SAV: SOCIEDAD ANONIMA AGRICULTORES DE LAVEGA DE VALENCIA, Spain
11. POLARIS: POLARIS M HOLDING
12. INTERVAL: INDUSTRIAS TERMOPLÁSTICAS VALENCIANAS
13. ARMACELL: ARMACELL Benelux S.C.S.
14. DERBIGUM: DERBIGUM N.V.
15. PROPLAST: CONSORZIO PER LA PROMOZIONE DELLA CULTURA PLASTICA PROPLAST
16. HAHN: HAHN PLASTICS Ltd.

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Publishable summary

One of the objectives of the Plasticircle project is to improve the classification of post-consumer packaging.

Near Infrared (NIR) sorting is commonly used in the waste industry to recover valuable materials from mixed streams. The technology uses differences in the wavelengths of infrared light that is reflected by polymers with different chemical structures. The wavelengths of light that are reflected depend on the covalent bonds in the polymer structure.

But it is not only on this technology that we have wanted to make improvements to equipment with the lowest recovery rates, such as lightweight materials.

It is also known that mechanical errors can affect this type of materials as much or more than other aspects of the technology.

For this reason a transport system has been developed to improve the stability of the material in the optical separation equipment. So we not only want to improve its detection but also to improve its overcoming.

In this document we detail preliminary data of this first prototype of transport system.

Introduction

The initial objective of the project within WP4 is to improve the classification of post-consumer packaging. In particular the separation of 5 plastic fractions:

- Separation of 5 fractions of plastic:
    - PET Bottle.
    - PET Tray mono-layer.
    - HDPE Bottle.
    - PP rigid and flexible.
    - LDPE film.
- Loss of material <20%, classification purity >95%.
- PE Film and PP film with contaminants <5%.
- Final rejection fraction with presence of <7% PET, <6% rigid PE, and <8% PP-PE films.
- Presence of biodegradables materials and PVC <0,3% in the classified fractions.

To achieve these objectives, in the previous tasks of the WP, specific work has been done on the technology and algorithms to improve the detection and classification of optical separators.

But already in the previous task in a more preliminary way and now in this one, it is intended to improve another of the existing needs in the recycling plants. Specifically on light materials, which are the mechanical errors that limit the capabilities of the equipment to achieve good recovery and purity data.

In this deliverable we are going to report the preliminary results collected during the last test and validation task of the new film-stabilizing conveyor for plastic sorter prototype.

IPR Strategy

The PLASTICIRCLE solution corresponds to two main conceptual components: (i) a machine-vision sorter of plastic packaging issued from municipal solid waste, (ii) a pre-treatment process technology to be applied in plastic sorting facilities, including mechanical separation of materials and optical sorting at the end of the process line.

PICVISA intends to develop the IPR strategy, referred to the PLASTICIRCLE developments in material sorting, in terms of Patent and Industrial Design applications.

On the other hand, Industrial and Trade Secrecy measures are currently been carried out by the company.

Furthermore, reliable evidence will be established for a first registration in the Intellectual Property Registry of Spain and the use of the symbol ©, including software (source code, object code, algorithms, software architecture), the preparatory documentation and technical documentation concerning the methodology of material sorting, as well as the user manuals and original technical documentation of drawings, designs, graphics, procedures.

In this aim, PICVISA has identified and classified the confidential information being developed during the PLASTICIRCLE project, and has implemented an internal procedure considering the accumulated knowledge as business secrecy. Information and documentation, which is the subject of industrial secrecy, correspond to drawings, mechanical, electrical, electronic, pneumatics and hardware specifications, as well as the technical information related to the software of both the optical sorting equipment and the process line of the PLASTICIRCLE project.

Likewise, all PLASTICIRCLE improvements obtained in machine-vision and materials sorting, with applications to other materials than plastics, are also considered by the company as part of its expertise and a matter of industrial secrecy.

PICVISA already includes in its product and service contracts a regime of industrial and intellectual property rights, as well as the corresponding clauses of confidentiality according to the model of design and exploitation that are determined by the PLASTICIRCLE solution.

1 Belt conveyor prototype

1.1 Belt conveyor prototype tests

1.1.1 Prototype description

The light material stabilization belt prototype was born from the study carried out to improve the stabilization of light materials in accelerator belts currently used by optical separators.

The study carried out to arrive at this prototype has been detailed and explained in the previous deliverable D4.3 Preliminary prototype of the new film-stabilizing conveyor for plastic sorter.

The result of this study is a concept based on two conveyor belts. The **lower belt** is the current belt already used by the optical separators, which are acceleration belts to generate a disintegration of the material on the belt that helps the reading and pneumatic separation carried out by the optical separators.

The innovation is focused on the **upper belt**, which is located over the acceleration belt at a certain distance (HREF) to generate a wind tunnel effect for the transported material.

This effect is achieved by means of fingers incorporated into the upper belt. These fingers generate a current in the same direction as the material at a certain speed. So we manage to avoid that light materials glide or slip over the accelerator belt when it is going at high speed.

1.1.2 Prototype especifications

Specifications of the two belts in the system.

Lower belt especifications:

- ✓ Lower belt conveyor length = 513 cm
- ✓ Lower belt conveyor width = 150 cm
- ✓ Lower belt conveyor Adjustable heigth
- ✓ Speed adjustable from 0 to 3.5 m/s

Upper belt especifications:

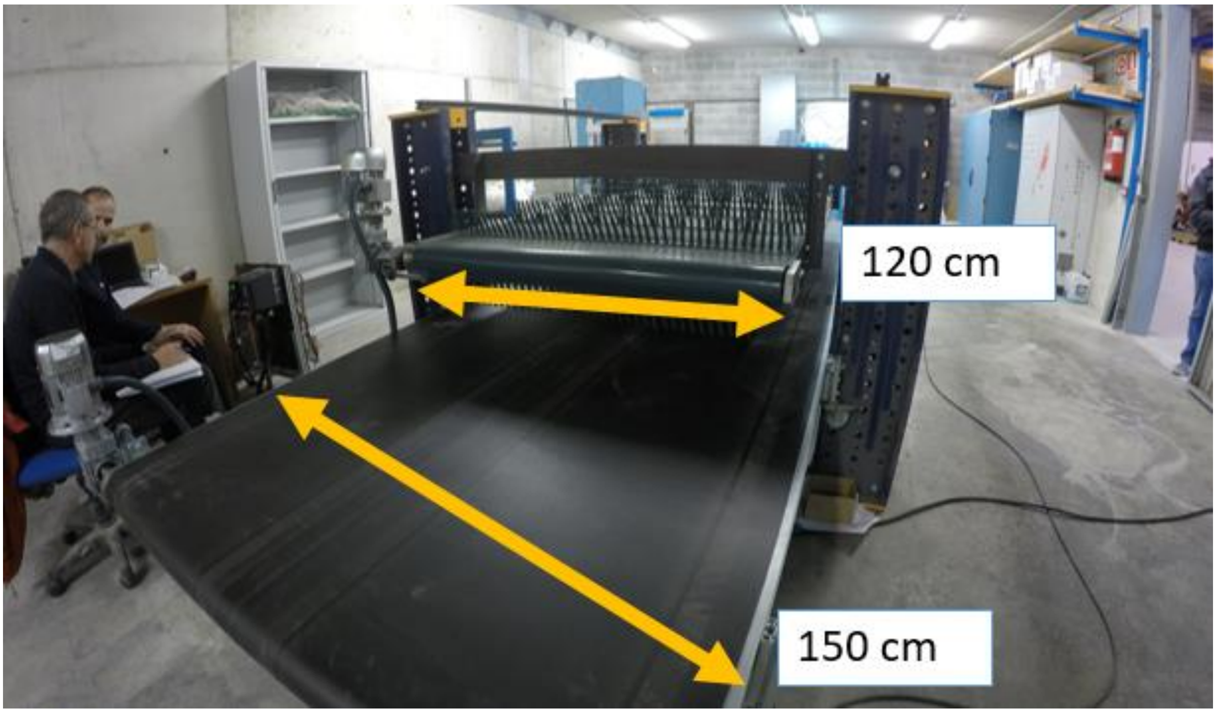
- ✓ Upper belt conveyor length = 293 cm
- ✓ Upper belt conveyor width = 120 cm
- ✓ Upper belt conveyor Adjustable heigth
- ✓ Upper belt conveyor teeth distance = 34 cm
- ✓ Teeth height = 10 cm
- ✓ Teeth material is cautcho, same as the upper belt conveyor
- ✓ Speed adjustable from 0 to 3.5 m/s

System settings:

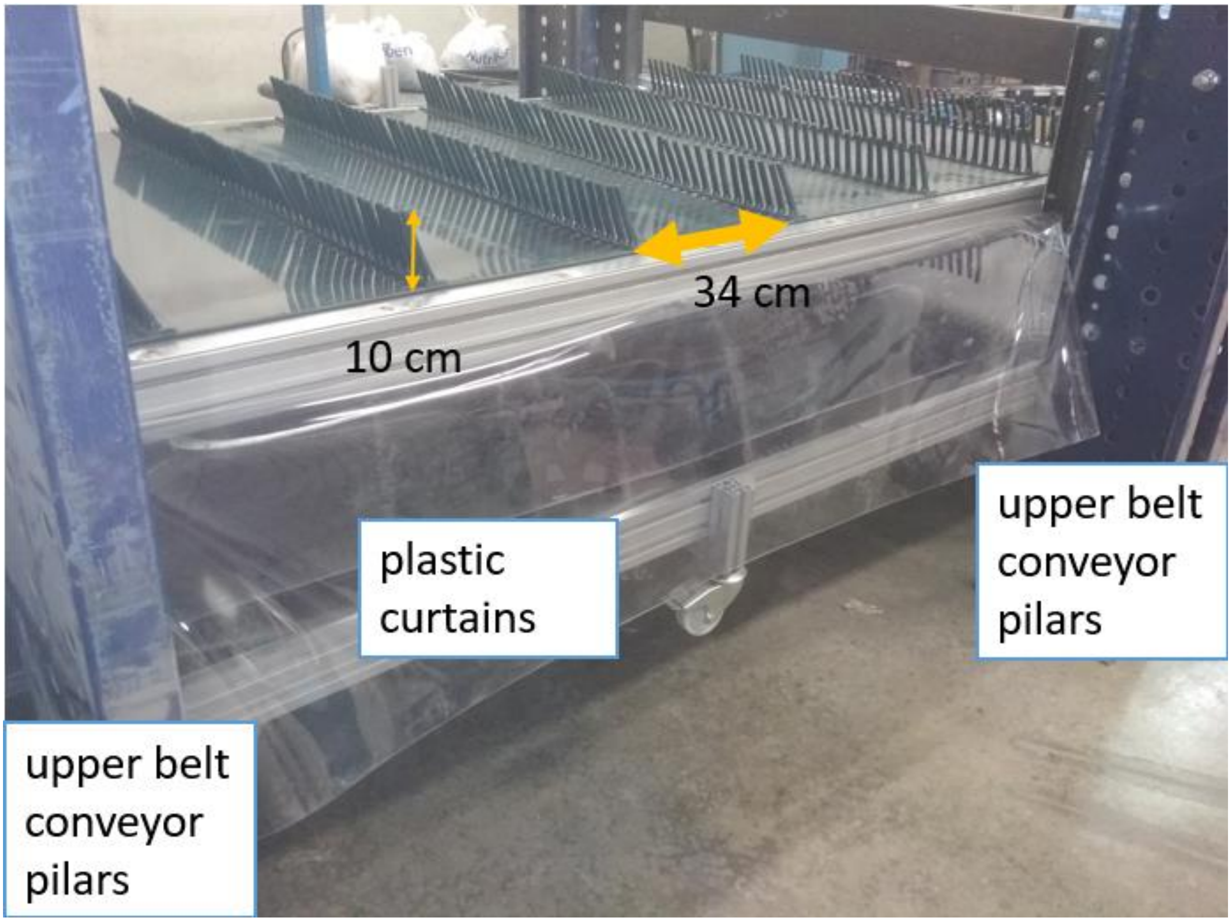
- ✓ Offset upper/lower belt conveyors variable

The following figures indicate some prototype view shots:

Prototype length



Prototype width



Prototype teeth configuration

1.1.3 Test objective

The objective of the test campaign is to caracterize the stabilization of 2D plastic film provided by the prototype.

1.1.4 Test Criteria

The evaluation criteria to determine if tests results are satisfactory is visually.

Tests are evaluated visually at the moment of test and later processed by video : 2 videos are done per test.

1.1.5 Test setup

A test bench with 2 conveyors is created to simulate the possible scenarios in a production equipment with the following configurations and settings:

- Adjustable speed for upper conveyor with forward and reverse belt movement.

- Adjustable speed for lower conveyor with forward and reverse belt movement.

- Adjustable relative heigth between two belt conveyors. HREF.

With these configurations we aim to find the combination of higher speed for the highest production, with the best stabilization of the material on the belt for improved reading and subsequent separation for the optical separation equipment.

Let us now look at all these settings and parameters in detail with the range of possible values.

1.1.5.1 Prototype set up

Two wood blocks were added at motors position to stabilize the belt conveyors due to vibrations not desirable at speed above 2m/s.

This will be mitagated by generating high stiffness of the prototype at those locations.

Prototype anti vibration system

1.1.5.2 HREF values

HREF is distance between lower conveyor belt to termination of upper conveyor tooth. Measured at the tooth closest to roll tambor axis.

HREF values tested	**Distance (cm)**
HREF #1	13 cm
HREF #2	24 cm
HREF #3	46 cm

The values of HREF are changed by moving the upper conveyor heigth. This was done with a fork lift.

1.1.5.3 Speed tested

For upper and lower belts , belts speed tested were :

V values tested	Speed (m/min) [m/s]
V #1	120 m/min [2m/s]
V #2	162 m/min [2.7 m/s]
V #3	205 m/min [3.4 m/s]
V #4	210 m / min [3.5 m/s]

The programming of the speed was done via PLC and frequency controller.

The maximum speed tested was 3.5 m/s tested at lower and upper belt conveyors, working at the same time. The maximum continuous speed was maintained 3 minutes.

This maximum speed is considered suitable for maximum speed test as it is above maximum belt conventional speed [2.7m/s] and generated rolling movement of 2D plastic film if no use of stabilization system.

1.1.5.4 Material tested

2D plastic film

A bucket was filled with 2D plastic film sample.
The same plastic film sample was used for all the test.

Paper / cardboard

At the end of the tests (T11 and T12) paper and cardboard were tested.

1.2Test results

The following table indicate test parameters.

		Upper belt speed (m/s)	tr/min		Lower belt Speed (m/s)	tr/min		HREF (cm)	Material tested
24/10/2019	T1	**2,7**	162		**2,8**	168		**13**	2D plastic film
24/10/2019	T2	0,0	0		**3,4**	204		**13**	2D plastic film
24/10/2019	T3	0,0	0		**2,7**	162		46	2D plastic film
24/10/2019	T4	**2,7**	162		**2,7**	162		46	2D plastic film
24/10/2019	T5	0,0	0		**2,0**	120		46	2D plastic film
24/10/2019	T6	0,0	0		**2,0**	120		**13**	2D plastic film
24/10/2019	T7	**2,4**	144		**2,0**	120		**13**	2D plastic film
24/10/2019	T8	0,0	0		**2,7**	162		**13**	2D plastic film
24/10/2019	T9	**2,4**	144		**2,7**	162		**13**	2D plastic film
24/10/2019	T10	**2,7**	162		**2,7**	162		**13**	2D plastic film
24/10/2019	T11	**2,7**	162		**2,7**	162		**13**	cardboard and paper
24/10/2019	T12	**0,0**	0		**2,7**	162		**13**	cardboard and paper
07/11/2019	T13	0,0	0		**2,9**	176		**13**	2D plastic film
07/11/2019	T14	**2,7**	162	2900	**2,9**	176	2970	**13**	2D plastic film
07/11/2019	T15	**2,7**	162	2900	**3,5**	210	3500	**13**	2D plastic film
07/11/2019	T16	**3,5**	210	3500	**3,5**	210	3500	**13**	2D plastic film
07/11/2019	T17	**3,5**	210	3500	**3,5**	210	3500	**24**	2D plastic film
07/11/2019	T18	**3,5**	210	3500	**3,5**	210	3500	**24**	cardboard and paper

in red : values identified as not desirable
in green : test results satisfactory
in orange : value that could be optimized, estimated close to optimized value

The following table indicate test results:

	Upper belt speed (m/s)	Lower belt Speed (m/s)	HREF (cm)	Material tested	Notas	Test Result
T1	2,7	2,8	13	2D plastic film		set up test
T2	0,0	3,4	13	2D plastic film		set up test
T3	0,0	2,7	46	2D plastic film		No stabilization achieved with upper conveyor stopped
T4	2,7	2,7	46	2D plastic film		No stabilization achieved due to HREF to important
T5	0,0	2,0	46	2D plastic film		No stabilization achieved with upper conveyor stopped and HREF 46
T6	0,0	2,0	13	2D plastic film		No stabilization achieved. No interest to let upper conveyor stopped. Some plastics are stuck due to low HREF and no movement of upper conveyor
T7	2,4	2,0	13	2D plastic film		HREF 13 is correct, stabilization achieved. Some rolling due to speed belt difference
T8	0,0	2,7	13	2D plastic film		Some plastics are stuck and rolling of the material not eliminated. No interest to stop upper belt conveyor
T9	2,4	2,7	13	2D plastic film		Stabilization ok but not optimal : some rolling due to slight speed difference between upper and lower belt
T10	2,7	2,7	13	2D plastic film		Stabilization ok
T11	2,7	2,7	13	cardboard and paper		Stabilization ok
T12	0,0	2,7	13	cardboard and paper		To use as reference to compare with test T11
T13	0,0	2,9	13	2D plastic film	side curtains	most voluminus material is stuck due to upper conveyor stopped. Teeth angle could be changed (sign change) but no need as upper belt conveyor stopped is useless
T14	2,7	2,9	13	2D plastic film	side curtains + conveyor marks each lower conveyor meter	Stabilization ok
T15	2,7	3,5	13	2D plastic film		Stabilization ok
T16	3,5	3,5	13	2D plastic film		Stabilization ok
T17	3,5	3,5	24	2D plastic film		2D plastic film is less stabilized due to HREF 24 cm is too important
T18	3,5	3,5	24	cardboard and paper		cardboard and paper is less stabilized due to HREF 24 cm is too important

1.3 Test analysis summary

A test campaign of 18 tests was performed on 24th of october and 07th november 2019 at PICVISA test center, Calaf. It consisted in testing a prototype machine of 2D light film stabilization. The objective of the tests were to evaluate the efficiency of the test prototype (increase of plastic 2D film stabilization) for different configurations set up of the prototype. The parameters studied were the speed of the belt conveyors [from 0 to 3.5m/s] and the offset between upper and lower conveyors [HREF 13/24/46 cm].

As a result, tests realized with HREF of 46cm (Tests T3 T4 T5) indicate that the **stabilization is not obtained,** due to too much space between upper and lower conveyors, even with the movement of both conveyors belts at high speed of 2.7m/s (Test T4). The speed of upper belt conveyor doesn't generate an air flow which would benefit the stabilizaiton and the value of HREF = 46 cm is too high.

Tests with no speed (Speed=0) at the upper belt conveyor **are not satisfactory** whatsoever the value of HREF. With HREF of 13cm, some plastic films are stuck in between both conveyors resulting in a an inacceptable accumulation of material between the two conveyors (Tests T2 T6 T8 T13).

Results tests with HREF = 24 cm **could be improved** as some rolling is observed in the movement of the material in its passage under the upper conveyor.

Results of tests T7 T9 T10 T14 T15, with HREF of 13cm **are satisfactory** due to there is no accumulation of material and stabilization of the material at the end of the lower conveyor. The maxium speed 3.5 m/s is achieved (Test T16) and is an improve respect to usual 2m/s speed for 2D plastic film conveyors. It is observed that material begins to roll again, at the end of its way out from the upper conveyor at an aproximate distance of 60cm from the end of upper conveoyr belt.

3 additionnal test were performed (Test T11 T12 and T17) with cardboard and paper and the same satisfactory statement is obtained than with 2D plastic film.

Finally, this test campaign indicate that the prototype with a speed of 3.5m/s for upper and lower conveyors and HREF of 13 cm is satisfactory in order to improve the light film plastic 2D stabilization. Moreover the maximum distance to place the vision system is determined and is in the order of 60cm from the end of upper belt conveyor.

1.4 Industrial system recommendations

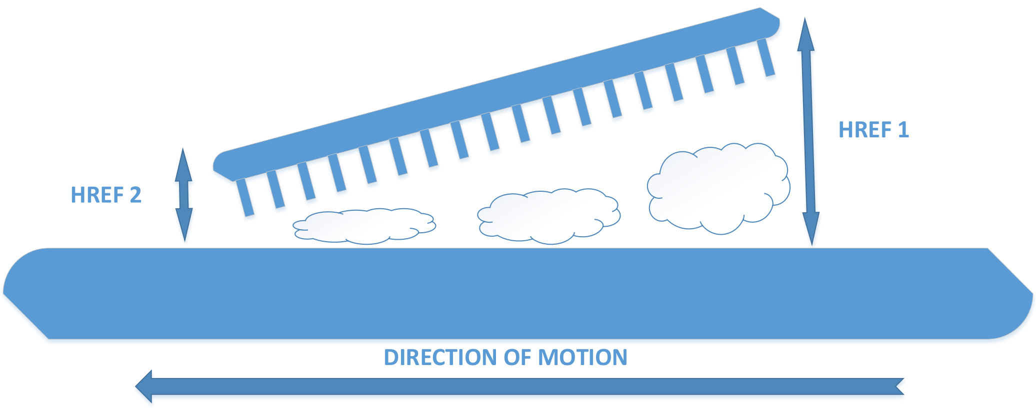
HREF REGULATION

- ✓ It is recommended to create a system of easy HREF change that could be with a worm screw.

- ✓ Values of HREF could be from 10 cm - 20 cm.

- ✓ The setting of HREF could be a parameter that the industrial end user moves to adapt to the production. This will depend on the size of the material to be transported. It must be adjusted proportionally.

- ✓ It would be a nice to have HREF regulation at begining HREF1 and end of upper belt conveyor HREF 2. The idea would be to generate a wrapping effect of the material, to collect the material with more volume to stabilize and flatten on the band (see example drawing)



VIBRATION

- ✓ During test realization , vibrations of upper and lower conveyors were observed at the rolls position. This was due to lack of stiffness of the prototype at those locations. Industrial design should take into account this parameter.

- ✓ It is recommended to support the upper belt conveyor with strong attachment system to the ground due to vibrations at high speed

[3.5m/s].

UPPER CONVEYOR MOTOR PLACE

- ✓ Due to lack of space at end of upper conveyor (proximity of vision system machine) it is recommended to place upper conveyor motor at the other side of the conveyor.

UPPER BELT CONVEYOR AS OPTIONNAL SYSTEM ON EXISTING SORTERS

- ✓ It was observed that the upper conveyor could be added to existing 2D plastic film sorter with minimum changes, modifications. This is a good solution as the system could be sold separately without requiring the change of the whole conveyor [lower and upper] resulting in a decrease of invsetment for similar result.

ATTACHMENT OF UPPER CONVEYOR

- ✓ Upper conveyor is supported to the ground with 4 supports. Attachment to the sealing was thought but discarded due to balancing and vibrations.

- ✓ A study of the industrial plants of 2D plastic film sorters is recommended in order to design a system that could adapt to most existing sorters.

- ✓ In the test section in the Test Center, we can see an implementation on existing machine.

ATTACHEMENT of BELT / NOISE

- ✓ It is detected that as the upper belt moves, the belt is generating a noise at each passage, at the belt attaching / clipping system.

DIAMETER OF THE ROLLS

- ✓ It is recommended to increase the diameter of the rolls of upper belt conveyor in order to reduce the tensions at the belt passage from low to up passage and vice versa. The more the diameter of the rolls, the least the belt teeth suffers.

- ✓ In the system tested in the Picvisa laboratory, have been used 100mm diameter drums. We recommend drums with a minimum diameter of 200mm.

OPTIMAL DISTANCE OF VISION MACHINE

- The closer the vision system is to the end of upper belt conveyor, the better. Recommended distance is 50 cm.

2 Installation to Test Center PICVISA

A study to investigate the installation of prototype to 2D plastic film sorter of PICVISA was performed.

The proposed amendments are set out below and the points described below:

- **Current installation:** The assembly of the new lightweight material stabilisation system involves modifying the existing equipment.

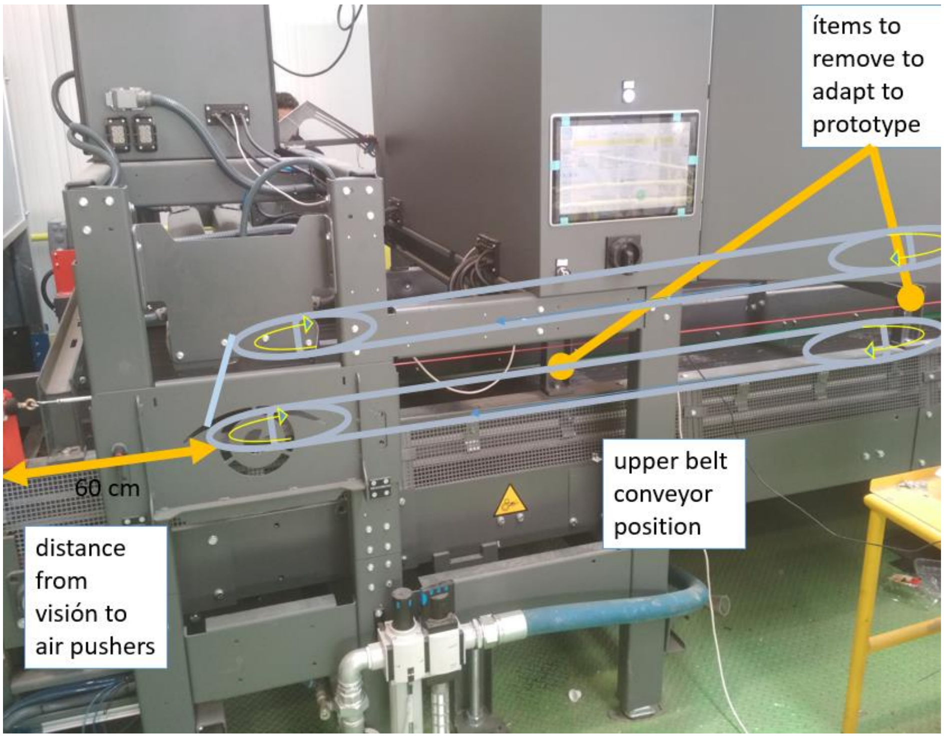
  In the following image we show the current situation of the equipment in the test center and the area where the material must arrive to be stabilized before the reading of the optic.

Test Center 2D plastic film sorter

- **Track divisor:** The current equipment has a track divider to treat two independent flows of material. The installation of the new system is planned on the track on the right in the direction of material, as it is called in the argot of this type of equipment, on track 1.

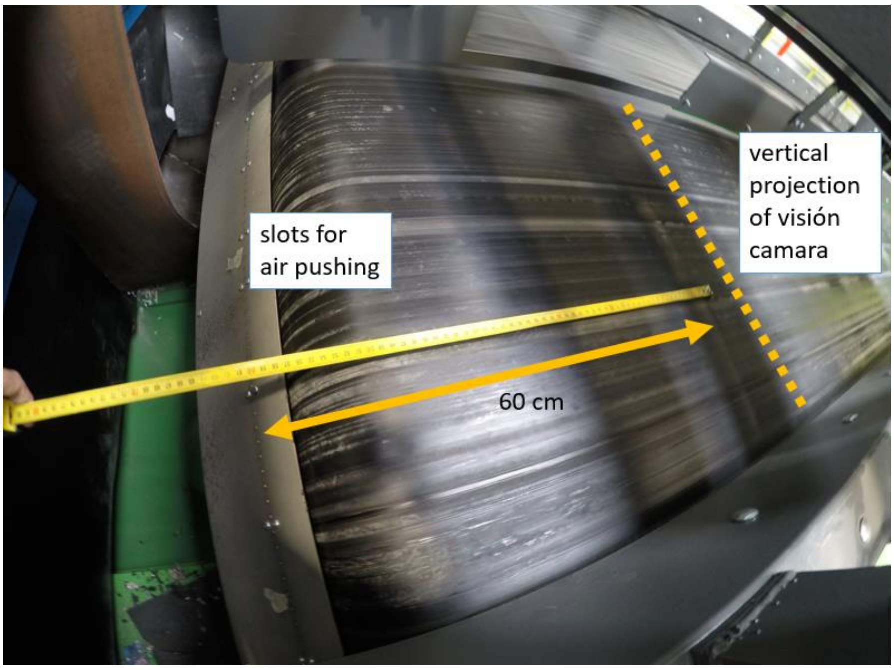
Items to remove

- **Structure of the sorter:** The structure of the current sorter must be modified, to install the new equipment under the control cabinets. To do this, the current supports must be modified to obtain the necessary space underneath.



Proposal of upper belt installation

- **Available distance:** For the position on the optical separator, the available distance between the reading of the optical system and the blowing out must also be considered.



Avalable distance

With all these considerations collected, plus the information generated during the system tests in the laboratory, the mechanical design is made to manufacture and adapt the new equipment in Picvisa's Test Center facilities.

2.1 Installation of the stabilization conveyor belt

Once this point has been reached, the first prototype is manufactured and assembled on an industrial machine. The equipment and installation chosen for this first version is the EcoPack EP2000 from Picvisa's Test Center located in the Calaf (Barcelona) facilities.

This equipment will allow us to test exhaustively the improvements and difficulties that we will be able to find with this new stabilization system for industrial productions.

Picvisa's Test Center is a controlled environment where the processes and characteristics of typical waste treatment plants are simulated.

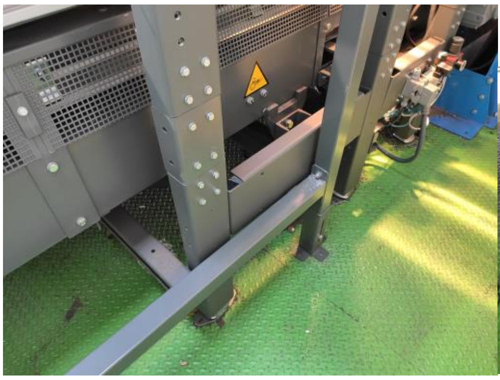
2.1.1 Prototype installation on test center

Install prototype and modify what is needed on test center sorter.

- ✓ Remove items indicated on test center sorter
- ✓ Install prototype on test center with lowest HREF
- ✓ Increase HREF as much as possible close to 13 cm

One of the challenges we have encountered in installing the new stabilization system on existing equipment has been to modify the structure of the existing equipment to allow the system to be installed below the control panel. Since the stabilization system must be applied from the beginning of the belt to the inspection area.

To solve this point, it has been decided to manufacture new supports that raise the control panel sufficiently to place the new stabilising system underneath.



The next point was to manufacture a structure to support the new equipment above the current belt.

The structure must allow two working height positions:

- **Position 1**: Would be to work **with** the stabilization system, that is to say with 2D material and the system adjusted to the height defined in HREF.

- **Position 2**: Would be to work **without** the stabilization system, that is to say with 3D material or another type of material that does not need a light material stabilization system. In this case, we raise the new equipment to release height between the belts.

2.1.2 Test without sorting

Before going through production the equipment has been tested for adjustments without sorting.

At different speeds and with the stabilization system stopped and turned on, to validate that all scenarios are controlled.

These 6 simulations have been carried out without activating the optical sorter:

#	Speed	Stabilization	Stabilized	Vibration
1.	2 m/s	OFF	Slightl	-
2.	2 m/s	ON	Slight	Soft
3.	2,7 m/s	OFF	Low	-
4.	2,7 m/s	ON	High	Soft
5.	3,5 m/s	OFF	High	-
6.	3,5 m/s	ON	High	High

From these first empty tests we detected that at high speeds the stabilization system transmits important vibrations to the support structure of the equipment. For initial tests this is not a problem, but this effect could eventually lead to major breakdowns in the vision and electronic systems.

Therefore it was decided to reinforce the bridge structure of the stabilization system to reduce these vibrations in operation.

2.1.3 Test with sorting

Once the vacuum validation tests have been carried out and the defects detected have been resolved, the same test configuration is carried out as in the previous point, but in this case with a production of material and with the optical sorter activated, in order to collect the improvement results empirically as an added value of the system.

The methodology applied for the calculation of performance in each scenario has been to replicate the test 3 times and make the average of these.

A standard material has been selected to carry out these tests, consisting of 2D material with mainly FILM in the proportion of 50% LDPE and 50% other plastics.

For the different tests, the same material flow is used and the optical separation equipment configured to blow the LDPE in positive. And these are the results obtained:

#	Speed	Stabilization	Results	
			Yield	Purity
1.	2 m/s	OFF	72%	65%
2.	2 m/s	ON	68%	71%
3.	2,7 m/s	OFF	54%	66%
4.	2,7 m/s	ON	81%	78%
5.	3,5 m/s	OFF	48%	58%
6.	3,5 m/s	ON	89%	91%

This table is a summary of the different tests that have been carried out and the average values obtained.

It can be clearly seen that the effect of activating or not activating the stabilization system results in an increase in recovery and purity in both cases. And another very curious fact to bear in mind is that without the stabilization system, as we increase speed, the efficiency is reduced, whereas the opposite happens with the stabilization system. In other words, **at higher speeds, efficiencies are improved.**

This is due to two reasons:

- **The stabilization system**. This has the function of stabilizing the material on the conveyor belt, which allows a correct reading of the optical separator and an efficient separation by subsequent blowing.

- **Higher speed, greater separation of objects.** The effect of increasing speed in the separation equipment is applied to generate distance between the objects passing under the detection system. But this benefit cannot be applied always and to every material. It is precisely this stabilisation system that has been developed, since light material is one of the materials that behaves the least with increased speed. But with the new prototype we have managed to increase speed by taking advantage of the benefits this generates in terms of material separation.

2.2 Industrialization

Once the benefits of the new light material stabilization prototype have been validated, the next step would be the industrialization of the prototype. For this we are going to explain simplifying what the development should be in order to have this product on the market.

2.2.1 Design

The current design does not contemplate different phases that a product must fulfill to be industrialized, such as security, maintenance, usability, robustness, etc.

It is clear that this prototype, once validated, requires a redesign to meet all these needs in an industrial environment.

Security: On a safety level, the fingers of the belt should be protected, so as not to get caught or snagged by plant personnel.

Maintenance: A system should be developed that allows convenient access between the two belts.

Usability: The durability of these fingers should be studied, because although they do not have to support load, the rotation movement and speed to which they are submitted can cause a deterioration of the weld to the belt.

Robustness: One of the problems we had most in the prototype was this point. Because the type of belt, speed and high supports, causes great vibration of the equipment. A support system with a structure that ensures sufficient robustness to minimize vibrations should be studied.

2.2.2 Consumption

Any product should always take into account a reduced electrical consumption and in this case, already in the study phase, the possibility of carrying out the movement of the transport by means of the same motor of the conveyor of the optical sorter was considered.

The proposed idea is to use a system of pulleys and reductions to move the two belts with the same engine.

This would be a good optimization of this type of product and an advantage over the current market options that work with air turbines, a system that is energetically unsustainable.

2.2.3 Manufacturing and installation

For both the manufacture and the installation of this equipment, two different assembly possibilities must be taken into account:

- ✓ **In new equipment:** The product is already designed and manufactured taking into account the tape with which it must combine its functionality. This greatly simplifies its design and implementation.
- ✓ **In already manufactured equipment:** Another advantage of this prototype is that it can be installed in already manufactured machines. But these cases have an added difficulty, which is to study in each case which should be the best application of the equipment

to adapt to the already manufactured one. This is similar to the challenges we have encountered in designing the prototype to be adapted to the EcoPack in the Test Center.

2.3 Conclusions

The results obtained in the tests in an industrial simulation environment with material simulating a 2D material flow in a treatment plant, show that **the new stabilization system improves the recovery and purity results.**

From the results obtained, it can be seen that the improvement in recovery is more important than the result obtained in purity. This is due to the fact that, as already mentioned in previous deliveries, the 2D material has two major problems for the optical sorters.

On the one hand, as it is a light material, its behaviour on a conveyor belt is unpredictable and unstable, which makes detection very difficult of the optical sorters as these need to have a stable reading of the material and a stable position on the conveyor for subsequent blowing.

This point has been solved or significantly reduced with the stabilization prototype developed by Picvisa in the Plasticircle project as can be seen in the results table in the previous point.

But the other important problem that lightweight or 2D materials have, is the thickness of this material and of the layers in the multilayers. The technologies used to detect and classify them have a certain penetration depending on the thickness and number of layers, but unfortunately they cannot read or discriminate all the variety of compositions that exist today.

Within the project, Picvisa has studied new technologies and developed new algorithms to improve the detection and classification of monolayer and multilayer materials, but it is clear that it is not possible to solve all existing cases and all those that are to come.

At Picvisa, we understand that technology and the development of our equipment must always be directed towards the challenges that the industry sets for us, but we think that the manufacture of new materials and compositions should be legislated to ensure that with existing technologies all new packaging is recoverable and recyclable.

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