FLEXCAP – Cost competitive flexible process for highly aesthetic closures manufacturing

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***Abstract* - Flexibility is one of the main pillars in the Industry 4.0 era. More specifically, flexible automation can give the ability, robots or systems to handle different kind of jobs or to treat different kind of articles every time. This adding feature can improve the quality of the products, the production costs and to eliminate safety issues in the plant.**
In case of assembly, flexible automation can be used in production lines of different kind of products, regarding the dimensions but with similar shapes. This will give the ability to the plants, under industry 4.0 flow management standards, to keep one or more flexible lines busy instead having multiple lines under-operating.

***Keywords* – Industry 4.0, flexible automation, Robotic Pick and Place.**

I. INTRODUCTION

To design a flexible assembly line is necessary to investigate where we can apply smart solutions. The feeding systems are one candidate and smart tooling in the main assembly is the other. The closures industry for spirits and wines has been selected for this study. Closures consisting of three articles (plastic over-cap, glue, cork) will be the products to be assembled.

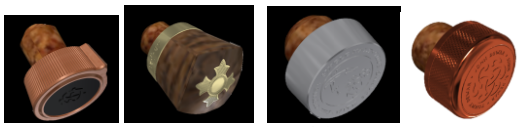

Fig. 1: An Overview of the Articles

Therefore, in this paper we are introducing an overview of a flexible feeding system that leads the plastic over-cap to the position for assembly.
The general process flow of the solution proposed can be divided in three tasks: 1. Identification of the parts and check of the orientation on the conveyor 2. Pick and Place from a 4 Axis Robot 3. Treatment and refeeding of the not well oriented parts.

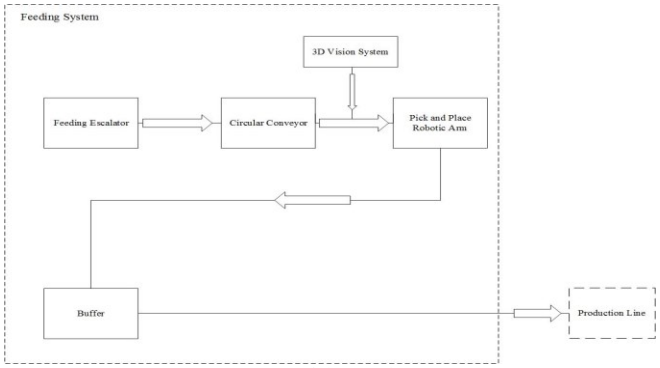

Fig. 2: Description of the Feeding System

In fig.2 the feeding system is described. A feeding escalator moves the parts to a circular conveyor. A 2D vision System inspects the orientation and then the well oriented parts are being picked from a robot and placed in a buffer ready to move in the assembly line. The not well oriented parts continue in the circular conveyor, where after some tricks are getting the desired orientation and re-fed.

II. REQUIREMENTS

The production line to be cost effective should produce 1 part per second, a very important prerequisite. Additionally, the plastic over cap should be oriented in a way that it needs no more reorientation at the assembly line. This means that it must be upside down while it is being presented at the pick position. Furthermore, as the objects are high aesthetical caps, they must be treated very carefully as the material is very delicate. Moreover, the gripping must be able to hold an object between 10gr and 90gr.

III. AUTOMATIZATION ROADMAP

The automatization roadmap is being described in the following flow diagram. It has been divided at three separated steps. The mechanical, the control and the process solution.
In the mechanical solution three elements must be investigated. The image recognition system, the robot and the gripper selection, respecting the above requirements.

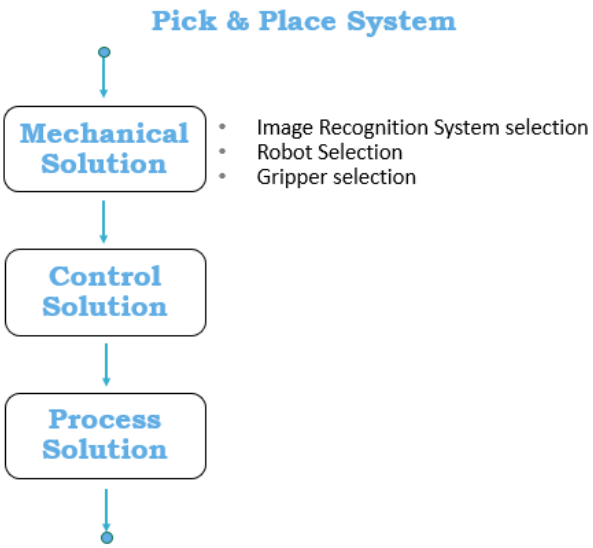

Fig.3: Automatization Roadmap

A. MECHANICAL SOLUTION

1. IMAGE RECOGNITION SYSTEM SELECTION

To achieve flexibility in the feeding line, it is needed not to change anything in terms of adjustments on the vision system while we are using the same settings and the same program for every single object. As the main goal is the camera to recognize the orientation of the cap and not shapes, a 2D camera is enough for our application. Given these requirements a few tests where being done
under that perspective and the results are following:

Fig 3.1: Cap 1 Identified by 2D Visioning System

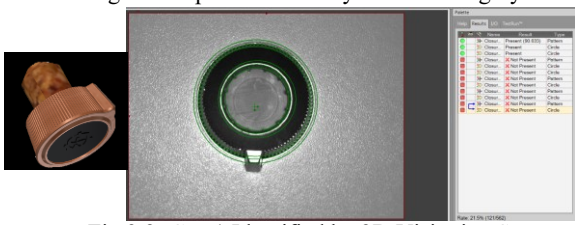

Fig 3.2: Cap 1 Identified by 2D Visioning System

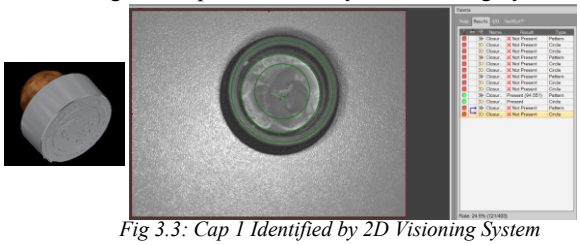

Fig 3.3: Cap 1 Identified by 2D Visioning System

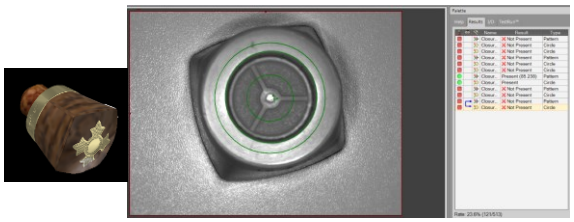

Fig 3.3: Cap 1 Identified by 2D Visioning System

As we can see in figures 3.1-4, all the plastic closures are being identifying from the same 2D visioning system, under the same settings and adjustments.
The camera used was a Cognex Insight 2000 with the following characteristics:

Image Mode	800X600(2x magnification)
Lighting	Standard
Maximum Acquisition Speed	75 fps
Relative Processing Speed	2x

2. ROBOT SELECTION

For the Pick and Place System, a robotic arm is needed, fast enough to perform 1 part per second. As the object arrives to the pick position already oriented we don't need to grab it from an angle but we can perform horizontal and vertical movements, thus a 4 axis robot should be sufficient for our application. In that case, two families of robots are being considered as options, SCARA and DELTA.
SCARA robots are having good levels of precision and repeatability, are cost competitive and very easy in programming. The disadvantages are that they are limited in tool orientation.
DELTA robots are having outstanding levels of precision and repeatability. The big disadvantages are that they are limited in carrying heavy loads and they are not cost competitive comparing to the SCARA.

1. GRIPPER SELECTION

For the gripping system we must take account of the fragility of the products. Therefore, we need a gripper that can not harm the objects in any way. Therefore, we can consider only two families: the vacuum and the centric/mechanical grippers.
The centric/mechanical grippers can handle heavy loads and grab different kind of shapes. The main disadvantage is that maybe they will be harmful for the closures and also they are not cost competitive.
The vacuum grippers can not handle heavy loads, but they are covering our requirements. They are not harmful at all and they are cost competitive.

IV. CONCLUSION AND FUTURE WORK

This paper is an introduction to an industrial project, giving possible solution to the main topic of flexibility in industry 4.0. From the first approach and the comparison between different kind of solutions on our project it seems that a 2D camera, with a SCARA robot and a vacuum gripper should be the right solution. But to come up with a safe conclusion we need to go deeper in each technology separately and to build the correct arguments.

As a future work we need to get deeper in the literature, to investigate any other possible solution and to test them. Using the equipment of the laboratory, we need to investigate this different solution in pick and place in order to offer a robust, cost competitive and innovative system at the end.

V. REFERENSES

[1] Ganjeizadeh Farnaz. *Robotics And Computer-Integrated Manufacturing.* Elsevier Ltd, 2011.

[2] X. Fan, X. Wang, Y. Xiao. *A combined 2D-3D vision system for automatic robot picking.* ICAMechS, 2014.

[3] Sprovieri, John. *Motion Control: Rigid vs. Flexible*. Assembly, Vol.56(7), 2013.

[4] T. Takahashi, K. Nagato, M. Suzuki, S. Aoyagi. *Flexible vacuum gripper with autonomous switchable valves*. IEEE International Conference on Robotics and Automation. 2013.

[5] C.I. Basson, G. Bright, A.J. Walker. *Testing flexible grippers for geometric and surface grasping conformity in reconfigurable assembly systems.* SAJoIE, 2018.

[6] Hsiang-Chen Hsu, Li-Ming Chu, Jong-Kun Wang, Shu-Chi Tsao . *Position Control and Novel Application of SCARA Robot with Vision System.* Advances in Technology Innovation, Vol.2(2). 2017.

[7] Abir Galala, Bassem Hichri, Meysam Minoufekr, Peter Plapper. Robotic peg-in-hole process for assembly of light weight structures. RACIR, 2017.