SCYPRI Report Summary

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Final Report Summary - SCYPRI (SMART CYLINDERS FOR FLEXOGRAPHIC PRINTING INDUSTRY)

Executive Summary:
The SCYPRI project has been conceived to solve some important problems of the Flexographic printing industry and in particular to have the possibility to see in real time, for each printing cylinder of each color, the printing behavior and hence the printing quality. This could permit, to the press control system, to immediately react and adjust the speed and pressure parameters in order to improve quality, avoid waste of material and simplify the work of the operators.
A second problem, for the state of the art carbon fiber printing mandrels, is connected to the high thermal stresses coming from the characteristics of the composite tube (high thickness, considerable high modulus fibre quantity, high curing temperature)
A third problem is related to the weak standard connection used between adapters and cylinder, which loses part of its performance when an adapter is installed, reducing the printing quality or the printing speed.

The targets foreseen in the project were:
- to design and build a novel multifunction sensing system inserted in the carbon fiber cylinder body, able to transmit through a wireless system the data of the running behavior of the cylinder to an external computer
- to develop a dedicated software which can, a priori, demonstrate the stress levels during the curing process allowing an optimization of the layers in order to minimize them and increase the cylinder performance.
- to develop a simple and effective connection system between the cylinder and the adapters through the use of electro-active polymers

The project has been very successful in the first 2 targets obtaining:
- a very effective sensing system able to detect deflections as lower as 1 micron and to transmit the cylinder behavior also with machine speeds higher than 500 m/1' opening the way for further applications
- a comprehensive software which allows to deeply look into the thermal reaction of the composite material and its thermal residual stresses and permitted to build a high performance cylinder.

The third target has permitted a good experience on electro active polymers but has been unsuccessful for the creation of a good connection system due to the opposite needs between sufficient expansion and acceptable stiffness of the material.

All in all the project has been quite successful since the failure to achieve the third target doesn't affect the full effectiveness of the other 2 goals and the third one can be considered as a lower importance target.

Next steps will involve:
- the industrialization of the sensing system to be easily applied both in the printing cylinders and other rotating applications with a suitable cost
- the extensive use of the software in order to obtain a full understanding of the composite behavior during the polymerization and adopt the best lamination strategies
- an alternative use of the know-how created with the electro-active polymers study and a possible different way to solve the problem of the adapter-cylinder connection system.

Project Context and Objectives:
Flexographic printing is one of the main printing technologies, widely used in packaging printing thanks to its flexibility and easiness. Flexo printing, unlike roto and offset printing, uses a relatively thick polymeric plate, similar to a stamp, wrapped on a cylinder rotating over the web to be printed.
Notwithstanding its increasing use and importance it has still some main problems:
- The management of the printing machine requires some very skilled persons to finely tune the system losing time, wasting material and being continuously ready to intervene for malfunctions.
- The printing cylinders require a very high stiffness to avoid bounces and the state of the art are the carbon fiber cylinders which are not yet fully optimized
- The adapters needed to print different plate formats use a connection system with the cylinder that is opened and locked supplying and closing compressed air so this system requires an elastic part which reduces the stiffness of the whole printing body

The SCYPRI project proposed the design, implementation and validation of an innovative and smart plate cylinder to eliminate some of the main Flexographic Printing Industry problems:
- The first target was to obtain, through the integration of a novel multifunction sensing system within the carbon fiber body cylinder, the data of the running behavior of the cylinder which can transfer them to the press control system in order to dynamically adjust in real time the driving parameters of the process. In this way a higher print speed and a much better print quality can be obtained. Furthermore, being the machine tuning now more automatic, the operators can be free to follow other activities.
- The second target was related to the optimization of the carbon fibre cylinder: the composite lamination, due to the physical and geometrical characteristics of the composite tube (high thickness,
considerable high modulus fibre quantity, high curing temperature) suffers of some limitation due to the need of avoiding noticeable composite thermal stresses. The development of a dedicated software which can calculate the stress levels during the curing process helps to make an optimization of the layers in order to minimize the stress and increase the cylinder performance.
- The last target was to develop a simple and effective connection system between the cylinder and the adapters, as explained before, to improve the stiffness characteristics of the system.

The Technological Objectives were consequently:
- To develop a new sensing system able to provide static and dynamic strain measurements with a resolution of 1με up to a frequency of 500Hz.and to integrate it inside the cylinder
- To integrate Fiber Bragg Grating (FBG) sensors network inside the composite structure during its fabrication to perform a real time monitoring of several parameters involved in the process.
- To develop a systematic approach to predict curing-thermal stresses induced during the manufacturing process of a composite cylinder component able to optimize the composite layup and process settings in respect to the component requirements and system integrity.
- To optimize with this approach the carbon fiber plate cylinder
- To design a simple and effective connection system between the cylinder and the adapters.

Project Results:
The main scientific and technical results of the project have been:
- The development and realization of a very effective sensing system able to detect deflections as lower as 1 micron and to transmit the cylinder behavior also with machine speeds higher than 500 m/1' opening the way for further applications
- The definition and implementation of a dedicated software able to examine in a deep way the behavior of the composite during the polymerization and cooling phases and to calculate the residual thermal stresses in dependence of the material characteristics, the lamination, the geometry and the temperature, pressure and time of the curing cycle
- The development of constitutive composite material models, heat transfer models in the autoclave and viscoelastic analysis for the above indicated software
- The development and realization of a fiber optic sensing system for cure monitoring based on a FBG sensor network embedded in the composite laminate to monitor the thermal distribution and residual-stress phenomena during the autoclave curing process. This system has been used to finely tune and validate the results of the software
- The development and realization of a new carbon fiber printing cylinder with the embedded wireless sensing system and its integration and test in a real flexo printing press
- The study of the behavior of the main useful electro active polymers as connection devices. This study has been interesting as experience in electro-active materials but has been unsuccessful for the creation of a good connection system due to the opposite needs between sufficient expansion and acceptable stiffness of the material.
- The failure to reach the third target of the project doesn't affect the effectiveness and functionality of the other 2 targets which are both related to obtain a high performance cylinder. It only means that some performance, when an adapter is used, will be increased less than expected in front of a traditional system.

Potential Impact:
The European market of flexography printing has been constantly growing over the last ten years, its value going up from 2001's € 14.7 billion to € 18.3 billion in 2011, the second largest growth after digital printing (+24%). Flexography has been constantly conquering new market sectors by
replacing other techniques, and this process is expected to continue over the next years.
In the last years flexo printing technology has made a noticeable progress attaining to a printing level, formerly quite poor, to nearly comparable with rotogravure and offset printing. This printing technology is mainly characterized by the simplicity, flexibility and easiness, can print on a wide
range of materials and can allow rapid changes of the printing subjects and, consequently, small print productions. This is very useful, for instance, in food packaging in which every some days the packaging design has to be changed.
The SCYPRI project aims to improve performance and material saving through the development of a smart plate cylinder characterized by a wi-fi sensor monitoring system which will be able to acquire fundamental data in term of processing parameter during the manufacturing process and the health state of the element during its normal service life.
Failure of these components generally lead to time consuming and cost loadings for the printing industry. For this reason few EU specialized composite cylinder producers face a strong competition mainly from the US countries and Cina.
The final goal of the project will be the realization of a new generation of smart plate cylinder for the flexo printing with extended service life and optimal configuration capable of reducing the dynamic load and vibration during its service.
Three elements classify the progress beyond the state of the art contained in the SCYPRI proposal and important for the market penetration are:
actually, no conventional technology is able to perform a similar function due to sensors dimension limiting the

integration level
the capability of multiparameter sensing using s single technological platform as the case of FBG technology enabling also a simple multiplexing of many sensors over a single optical fiber cable
the ability to provide a wireless and low power consumption optoelectronic interface thanks to the use of a single sensor technology enabling sensors number reduction and thus a more compact interrogation unit.
We expect to bring the technology developed during the project to market by the second year after the project completion date and we will begin licensing it to other manufacturers within the EU and internationally.
During the project the planned approach to disseminate the knowledge generated during the second year of the project as well as a list of performed dissemination activities and produced dissemination materials have been implemented.
In particular, in the SCYPRI project the project partnership produced the following dissemination
material and activities:
Project website
10 Project poster
1,000 Project brochures
800 Project flyersThe European market of flexographic printing has been constantly growing over the last ten years, its value going up from 2001's € 14.7 billion to € 18.3 billion in 2011, the second largest growth after digital printing (+24%). Flexography has been constantly conquering new market sectors by replacing other techniques, and this process is expected to continue over the next years. In the last years flexo printing technology has made a noticeable progress attaining to a printing level, formerly quite poor, to nearly comparable with rotogravure and offset printing.
In the market of large flexo printing units (from 1 to 2 m of printing width) the present sales are of about 350 machines/year for a total of about 2800 printing cylinders which comprises steel and carbon fiber cylinders. .
SCYPRI project has been developed for this market and the final goal of the project will be the realization of a new generation of smart plate cylinder for the flexo printing with extended service life and optimal configuration capable of reducing the dynamic load and vibration during its service
With the above figures this market is therefore quite interesting but, to fully exploit the technologies developed in the project and obtaining suitable costs, it would be important to face other markets which can increase the figures for the production.
Considering every single technology developed in the project:
Sensing wireless system:
- at the moment, no conventional technology is able to perform a similar function with the precision, the number of parameters transmitted and the bit rate developed in SCYPRI project, nevertheless this system has to be industrialized for:
- better miniaturization in order to improve its installability in different systems
- lower power consumption and, possibly, energy harvesting
- to obtain the maximum cost reduction in the industrialization process, it would be better to increase the production quantity and this can be done looking at other applications in printing (like anilox rollers in flexo and some other rollers in digital printing) and in other fields like nonwoven industry, tissue industry, oil centrifuges and other industries in which flexible rotating bodies are the main components of the machine.
Fiber optic sensing system for cure monitoring
this system, based on a FBG sensor network, can be offered as service or technological know-how in licensing conditions for autoclave based composite production companies not in competition with the SCYPRI partners
Software for thermal stresses simulation
this software can be offered, as above, both as engineering service or software license (through a suitable software company) since no other software is able to take into account so high number of parameters for the production of composite tubes
Systems with electro active polymers
notwithstanding the target not achieved this research has identified an applicability domain which can suggest some possible uses in soft connection systems. In the next future a range of possible sport applications will be explored.
We expect to bring the technology developed during the project to be ready to market by the second year after the project completion date and, at that time, we will begin licensing the technology results to other manufacturers within the EU and internationally.

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After the end of the project, ENIA with the collaboration of all the partners is preparing the following dissemination material:
- General video of the SCYPRI project
- SCYPRI Best Practice report

List of Websites:
www.scypri.eu

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