Arduino UNO and Design Thinking Empowers Tape Curing Process Control Advancements

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ABSTRACT

UV Curing serves two primary purposes. The initial aim is to excessively cure the tape, thereby diminishing its polymer molecular weight and breaking down cross linkages, facilitating the easy removal of materials adhered to its surface. The secondary objective is to pre-cure the tape with a newly affixed object, such as a row bar in our scenario, enabling it to securely adhere to the tape surface in readiness for cutting and subsequent procedures.

Managing the pre-cure process requires more precision compared to post-curing process because we must consistently apply the desired curing dosage to prevent scattering, slippage, and contamination.

The team has faced numerous issues in the past due to curing processes falling outside specifications, leading to yield losses and production disruptions. The objective of this project is to address these issues by utilizing IIOT Devises, specifically the Arduino UNO, which is readily accessible and user-friendly, available in the Philippine market.

1.0 INTRODUCTION

UV Curing is a process commonly used in various industries, including printing, adhesives, coatings, and electronics manufacturing. It involves the use of ultraviolet (UV) light to initiate a chemical reaction that leads to the hardening or curing of a material.

1.1 How Curing works

1.1.1 Light Source

A light source, usually a lamp or LED, emits high-energy ultraviolet light in a specific wavelength range, typically between 200 to 400 nanometers (nm). This light is used to activate photo initiators in the material being cured.

1.1.2 Photo Initiators

The material being cured, often a liquid resin or coating, contains photo initiators. These are compounds that undergo a chemical reaction when exposed to UV light, initiating the curing process.

1.1.3 Photo Initiators

When the photo initiators absorb UV light, they undergo a process called photopolymerization. This involves the formation of reactive intermediates, which initiate cross-linking or polymerization reactions in the resin or coating material.

1.1.4 Chemical reaction

As the chemical reactions progress, the liquid resin or coating gradually solidifies or cures, forming a hardened, durable surface. This process typically occurs rapidly, within seconds to minutes, depending on the material and the intensity of the UV light.

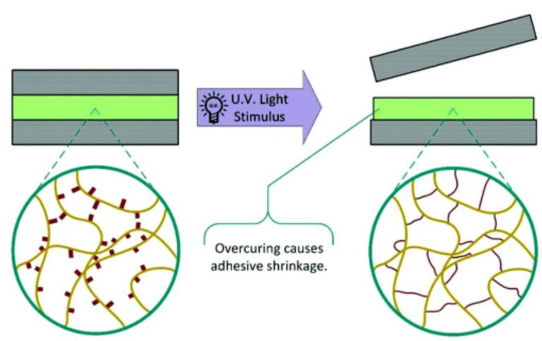

Fig. 1. How Tapes cross linkers changes molecular structures after curing.

1.2 Arduino UNO

Arduino Uno is a popular microcontroller board that serves as the foundation for countless electronics projects, from simple prototypes to advanced automations. Here's an overview:

1.2.1 Microcontroller.

This is the brain of an Arduino and is the component that we load programs into. Think of it as a tiny computer, designed to execute only a specific number of things.

1.2.2. USB port.

Used to connect your Arduino board to a computer.

1.2.3 USB to Serial chip.

The USB to Serial is an important component, as it helps translating data that comes from e.g. a computer to the on-board microcontroller. This is what makes it possible to program the Arduino board from your computer.

1.2.4 Digital pins

Pins that use digital logic (0,1 or LOW/HIGH). Commonly used for switches and to turn on/off an LED.

1.2.5 Analog pins

Pins that can read analog values in a 10 bit resolution (0-1023).

1.2.6 5V / 3.3V pins

These pins are used to power external components.

1.2.7 GND

Also known as ground, negative or simply -, is used to complete a circuit, where the electrical level is at 0 volt.

1.2.8 VIN

Stands for Voltage In, where you can connect external power supplies.

The Arduino Uno is part of the Arduino ecosystem, which is based on open-source hardware and software. This means that the design files, schematics, and software libraries are freely available for anyone to use, modify, and distribute.

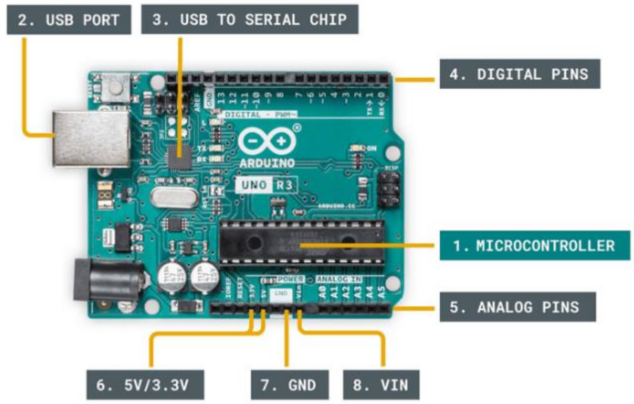

Fig. 2. Arduino UNO Main Components.

2. 0 REVIEW OF RELATED WORK

Helbert Jamito, the current WDC engineer, has conducted prior research on the impact of appropriate pre-curing levels on the interaction between the Row bar and tape during cutting. Two primary concerns identified were scatter or slider fly and contamination, investigated through a Design of Experiments (DOE).

Current understanding:

UV Curing the tapes impact Peel strength and Shear strength, the higher the UV Dosage the lower the peel strength becomes, and when it is expose to 250mJ/cm2 and above it will start to loss its adhesion. See Figure 3 for reference.

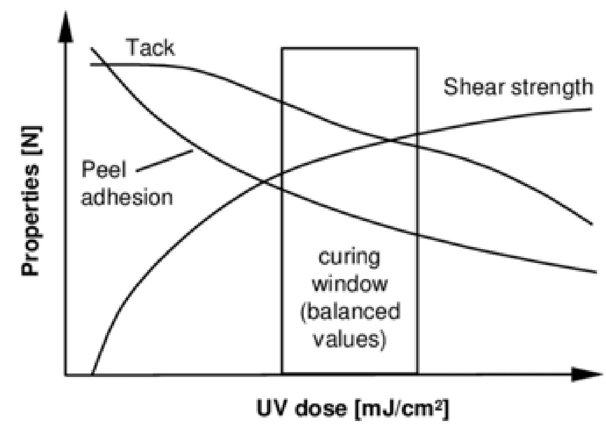

Fig. 3. UV Dosing impact on Peel adhesion and Shear Strength.

3.0 METHODOLOGY

3.1 Root Cause Analysis

Here is a collection of events where scatter fly has increased, and subsequent investigation has shown a consistent correlation with the UVCM curing performance.

No	Root Causes	Action Implement
1	Uncalibrated UV Curing dosage	Calibrate UV Dosing
2	Inconsistent tool curing performance after long tool shutdown	Replace UV Lamp
3	Increasing UV dosage	Increase UV Dosing checking from every 12 hours to every 2 hours
4	High Dosing Variability – UV Lamp near the target 4000 lamp hours replacement period	Replace UV Lamp and Calibrate UV Dosing,

Table 1. Historical Data of Scatter correlating to UVCM performance.

3.2 Design thinking

Utilizing the Design Thinking approach to tackle the present challenge, with a primary focus on detecting and predicting tool deficiencies, the team implement the 5 steps tools to ensure all areas for improvement will be look at and necessary enhancement will be implemented.

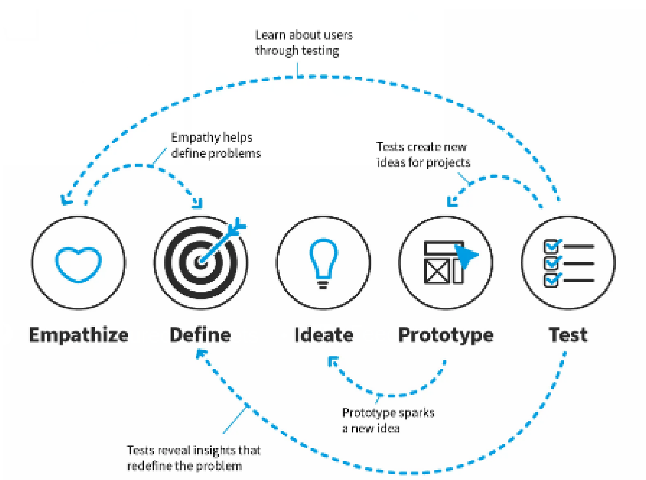

Fig. 4. Design thinking methodology

3.2.1 Empathy

Group Composition: Manufacturing Engineering, System Engineering, Manufacturing OPS and IT

Understanding what the team needs, the team came up with summarize list of current challenges.

a. Data for actual tool dosing is only being check every start of the shift.
b. No Job detectability.
c. Tool has no dose level alarm

3.2.2 Define

Problem Statement: The project was to evaluate factors to understand fundamental tape properties and the relationship to performance.

3.2.3 Ideate

List of team inputs for enhancement.

a. Real time dashboard for UV dosing and UV Curing time.
b. Include Job Scanning every loading for enhance traceability.
c. Real time tool alerts for job process outside of define curing specification.
d. Application of SPC charts to better control mean and sigma shifts.

The team has two options how to proceed with the project.

Option 1: Install factory-look. A system develops by VISTRIAN to support tool-process automation.

Option 2: Inhouse automation using Arduino UNO microcontroller harnessing the data from current tool IOT devices.

In the end the team decided to pursue inhouse automation due to below benefits:
Key Benefits: Low cost, open-source, and the ability to continuously improve internally without requiring additional vendor support, boost employees moral and motivation at the same time to handle projects using their own automation skills.

3.2.4 Prototype

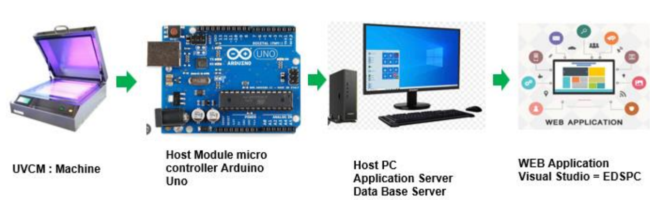

Fig. 5. UVCM Connectivity Flow

The Arduino UNO module will link up with the offline UVCM tool via its accessible IIOT sensor (Dosing Sensor). The Host Module will collect raw data, which will then be transmitted to the Host PC. On the Host PC, all data will be transformed into graphical representations for easier interpretation and utilization. Subsequently, the data will be place monitored under SPC under applicable limits and rule using Visual Studio, for any data that falls outside these limits, an email notification will be triggered alerting all stakeholder to make necessary action.

Item	Model	Image	Manufacturer part Number	RS Stock No	Description	Total Qty	Remarks
PC					use install software and gathered data	1	c/o IT
Power Supply	Okdo Plug-In AC/DC Adapter 5V dc Output, 4A Output		FJ-528H	202-3769	5volts power supply to supply the Rs232 module	4	RS punch out or any other mode of purchase
Casing	HellermannTyton Polystyrene Junction Box, IP67, 175x95x151mm		EL171	251-7668	To cover the electronics circuit	2	RS punch out or any other mode of purchase
Power supply socket	Lumberg, 16 DC Socket Rated At 500.0mA, 12.0 V, Panel Mount, length 13.2mm, Nickel, Silver		1614 19	124-1510	Cable mount plugs of power supply	4	RS punch out or any other mode of purchase
Cable wires	Lapp Multicore Data Cable, 0.5 mm², 4 Cores, 20 AWG, Unscreened, 100m, Grey Sheath		28504	491-8854	Data Transmission	4 meters	RS punch out or any other mode of purchase
RS232 connector male	MH Connectors MHDTZK 9 Way D-sub Connector		MHDTZK9-DB9P-K	765-9438	Use to data gathering	4	RS punch out or any other mode of purchase
RS232 connector female	Norcomp 191 9 Way Vertical Panel Mount D-sub Connector Socket, 2.75mm Pitch, with 0.125 Hole		191-009-223R001	205-4738	Use to data gathering	4	RS punch out or any other mode of purchase
Relay	Panasonic PCB Mount Latching Signal Relay, 5V dc Coil, 2A Switching Current, DPDT		TX2-L-5V	173-8995	Use to switch the sensor	4	RS punch out or any other mode of purchase
Inverter logic gates	Texas Instruments SN74HC14N Hex Schmitt Trigger Inverter, 14-Pin PDIP		SN74HC14N	333-2899	Use to switch the relay	4	RS punch out or any other mode of purchase

Fig. 6. List of Parts and Material Needed for the automation Project, Some of which are available already in the company. Total Spending on parts purchase is 2600php.

During the prototyping phase, the team initially employs breadboards and jumper wires to assess the Arduino Module's capability to efficiently receive data from the tool's IOT sensors see figure 6 for reference.
This to prevent unwantedly cutting the signal wires and causing potential tool failure.

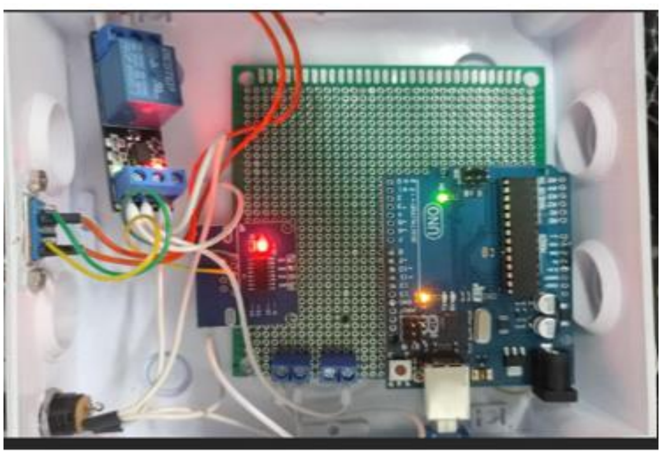

Fig. 7. Actual prototype using bread board, Jumper wires and Arduino UNO module.

Once the team successfully receives the transmitted data from the tool, the next step is to create graphs that display the actual curing information obtained from the tool.

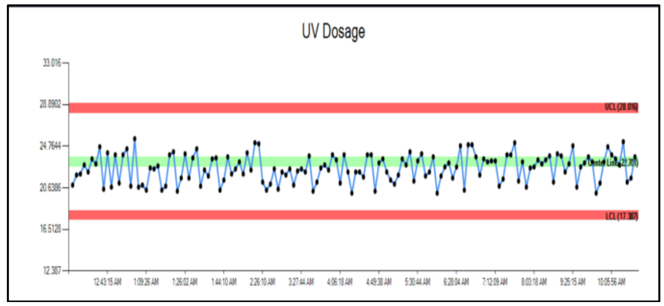

Fig. 8. Graphs develop during Proto typing stage.

3.2.5 Test

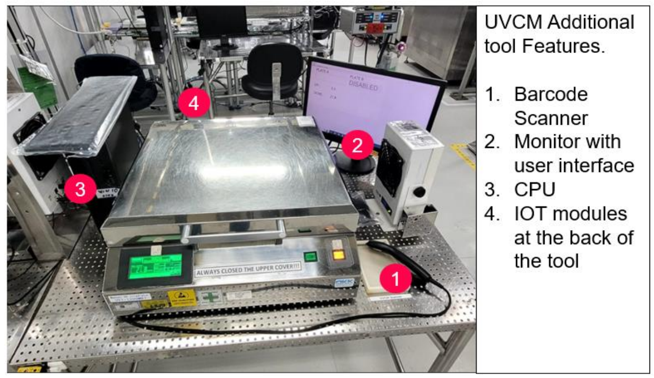

Fig. 9. UVCM with Enhancement

Test No.	Description	Result (Put a √ in either of the 2 columns)	
		Accepted	Not Accepted (Please indicate reason)
1	*New Function Testing - Scanning*	√	
2	*Data: Actual vs IOT transmission*	√	
3	*Operator User interface*	√ See fig10	
4	*Engineering User Interface*	√ See fig 11	
5	*Jobs Number: Scan vs Actual*	√	
Overall User Acceptance Test Passed			

Table 2. UAT Results

Fig. 10. Operator user interface.

The enhance UVCM process now has a job scanning function for traceability and actual Dosing will be displayed on the monitor every job processing as shown on figure 10.

If the job were process outside the upper and lower limit the signal will turn red to indicate it has to undergone OCAP. Additionally, a corresponding email will be sent for every out of specs occurrences.

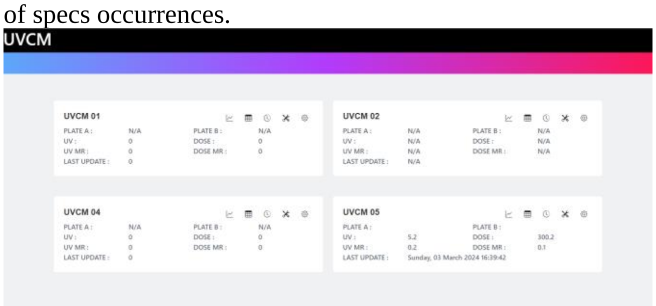

Fig. 11. Engineering user interface.

For Manufacturing Engineering team, we will have visibility to each of the UV tools.

4.0 RESULTS AND DISCUSSION

Following the completion of UVCM Enhancement, the team has effectively managed to control scatter over the past 12 months.

Furthermore, the team comprehensively grasped the tool's behavior and formulated corresponding actions.

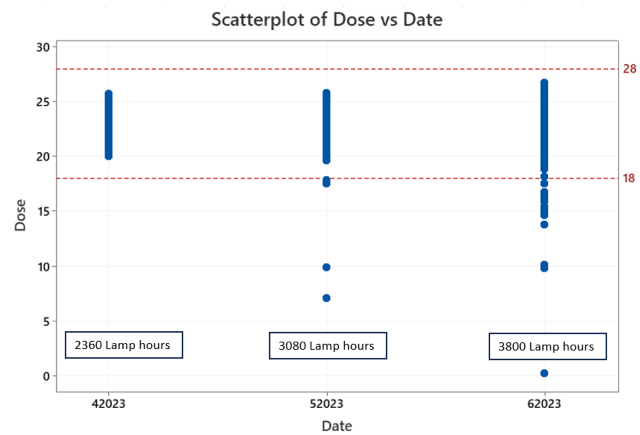

Fig. 12. Tool Dosage degrading overtime with relation to lamp hours

Summary of Benefits

Benefits	Before	After
UV event out of specs	2022 (4)	2023 (0)
PM min/day	2022 (130)	2023 (5)
UV Parameter Control	2022 (Manual)	2023 (Automated)

Table 3. Benefits of the Project.

5.0 CONCLUSION

The team successfully implemented the desired enhancement on the tool that is both cost effective and flexible in terms of sustainability and continuous improvement. Target gain was realized with added benefits for operator and technicians thru elimination of manual tool checking.

6.0 RECOMMENDATIONS

Expanding automation initiatives throughout all fabrication segments involves implementing automated systems and processes to streamline manufacturing operations. This could include integrating robotics, artificial intelligence, internet of things (IoT) devices, and other advanced technologies into production lines and workflows.

The benefits of Industry 4.0 (4IR) projects in this context are manifold. By embracing these technologies, companies can enhance efficiency, increase productivity, reduce costs, and improve quality control. Automation can optimize production schedules, minimize downtime, and enable quicker response times to market demands.

leveraging advanced problem-solving methodologies, such as design thinking or Six Sigma, in conjunction with cutting-edge devices can amplify the benefits of automation. These methodologies provide structured approaches to identifying, analyzing, and solving complex problems, thus optimizing processes and driving continuous improvement.

Moreover, there are numerous cost-effective options available in the current Philippine market suitable for personal or professional use. Given the rapidly evolving needs across various sectors, investing in learning these new technologies presents a valuable opportunity.

Finally, for the project itself, it is strongly advised to persist in advancing potential tool and process enhancements. This entails leveraging existing data for predictive maintenance, evaluating the feasibility of a maintenance-free tool, and investigating the potential for the tool to self-diagnose.

7.0 ACKNOWLEDGMENT

We extend our gratitude to all the groups whose contributions were instrumental in making this project a success. Special thanks to the System Engineering team for their efforts in developing the system tailored for this tool, to the IT team for their valuable hardware support, to the production team for providing crucial inputs, and to the Manufacturing Engineering team for their dedication to qualification and seamless release to line support.

8.0 REFERENCES

1. K.-H. Schumacher, U. Düsterwald, R. Fisch, Adhesive Technology 4 (2000) 18

2. Https://www.arduino.cc/pro/

9.0 ABOUT THE AUTHORS

Michael Detic is a 16 years WDC Manufacturing Manager, with experience in slider fabrication in the field of Equipment Maintenance and Process Engineering.

Aldrin De Vera is a 12 years WDC Manufacturing Engineer, with experience in slider fabrication in key Process of Sorting, Cutting and Pick and Place in the field of Equipment Maintenance.

Renan Dacara is a 15 years WDC Manufacturing and Engineering System Staff Engineer, with experience in Equipment Maintenance, Process Engineering and Currently handling tool automation under System Engineering.

10.0 APPENDIX

Not applicable.