UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

DEMONSTRATION OF THE USE OF LOW COST PENTANE FOAMING TECHNOLOGY FOR THE CONVERSION TO NON-ODS TECHNOLOGIES IN THE PRODUCTION OF POLYURETHANE FOAMS AT SMALL AND MEDIUM SIZED ENTERPRISES

- FINAL REPORT –

OCTOBER 2019

CONTENT

1. INTRODUCTION

In 2007, Parties to the Montreal Protocol agreed to accelerate the phase-out of the hydrochlorofluorocarbons (HCFCs) because of their increase in global consumption and taking into consideration the substantive climate benefits generated from their phase-out.

In the following years, Parties operating under the Montreal Protocol's Article 5 have formulated their HCFC Phase-out Management Plans (HPMPs) for implementation under financial assistance from the Multilateral Fund for the implementation of the Montreal Protocol (MLF).

To facilitate a smooth transition to ODS alternatives with low global warming potential (GWP), the Executive Committee of the MLF, in its decision 72/40, agreed to consider proposals for demonstration projects for additional low-GWP alternatives and invited bilateral and implementing agencies to submit demonstration project proposals for the conversion of HCFCs to low-GWP technologies in order to identify all the steps required and to assess their associated costs.

In particular, Par (b)(i)a. of Decision 72/40 indicates that project proposals should propose options to increase significantly in current know-how in terms of a low-GWP alternative technology, concept or approach or its application and practice in an Article 5 country, representing a significant technological step forward.

In the framework of Decision 72/40, on behalf of the Government of Morocco, UNIDO, as the designated implementing agency, submitted to the 75th Meeting of the Executive Committee a funding request for a Demonstration project for the use of low cost pentane foaming technology for the conversion to non-ODS technologies for polyurethane foams production at small and medium enterprises in Morocco. The project was approved at the same Meeting.

The present report describes the different steps and actions of the implementation and validation of the technology. It includes conclusions and recommendations related to costs, equipment and safety in the use of cyclo-pentane foaming technology in small and medium enterprises.

2. PROJECT DESCRIPTION

2.1. Objectives:

The focus of the project is to:

- Develop and validate a low-cost Pentane technology option for ODS phase-out at Small and Medium Enterprises (SMEs) in Morocco and in those countries with similar conditions;
- Reduce the breakeven point for the introduction of pentane technology to SME in the rigid of PU foam, while guarantee safe application of the technology;

- Demonstrate the easy applicability of the technology and, consequently, the replicability of the results to SMEs;
- Transfer the technology to interested users, in particular those currently relying on pre-blended polyol systems.

The project has therefore a substantial contribution to the HCFC phase-out plan in the manufacture of rigid polyurethane insulation foam in Morocco, by identifying the most promising foaming technology for local SMEs, which are to be converted in Stage II of the HPMP

2.2. Technology and budget:

The foam blowing pentane technology is a proven and viable technology for the replacement of HCFC-141b in the manufacturing of PU foam products. However, due to the flammability of pentanes, the additional safety-related costs increase the overall costs for the conversion above the cost-effectiveness threshold. This has limited the use of this technology particularly in SMEs, which are essential consumers in the foam sector.

The objective of this project was to explore the possibility of reducing the initial capital cost by designing a simple, standardized and easy-to-handle compact foaming machine capable of operating with flammable pentane, equipment and movable ventilation systems serving several products. The technology could be considered as a solution for enterprises that do not have a high production rate, and have a non-regular need for foaming. The sector is to be addressed in stage II of the HCFC phase-out management plan (HPMP).

In order to reduce the initial investment costs it was decided to design a complete and compact Pentane foaming technology using a pre-blended Polyol/ Pentane raw material (POL/C5) and supplied in small and dedicated tank or drums. The POL/C5 pre-blend in drum is off loaded to a compact high-pressure pentane foaming machine with two streams flow of raw material. In order to allow the safe use of pentane formulation, the unit includes all necessary safety elements of the wet and dry parts, including dedicated safety systems which allows to detect and control the possible dangerous conditions that might occur in the normal utilization of the unit. By doing so, a significant cost reduction can be achieved through a standardization of the equipment, to make sure the engineering part of the “tailored-made” equipment is over.

ENGEQUIFE, a 100% indigenous Moroccan limited liability company was selected for the implementation of the demonstration project. The SME has been using HCFC-141b pre-blended polyols in the production of insulation foam for several commercial refrigeration products (Discontinuous sandwich panels, cold-room doors, etc.). Its consumption of HCFC-141b is 1.9 metric tons.

The Cost forecasts for demonstration projects are challenging as these projects are by nature unpredictable. UNIDO has used to the extent possible guidance provided by the Secretariat in Doc 55/47 Annex III,

The Executive Committee approved funding for the execution of this project as follows:

ITEM	ACTIVITY	BUDGET USD
1	Technical study tour on existing equipment and interested technology providers	10,000
2	Chemical study tour on chemistry	10,000
3	Engineering planning and technology adaptation (definition of technical and safety features)	60,000
4	Manufacturing, purchase and delivery of Pentane dispensing machines	90,000
5	Safety installation	40,000
6	Foam testing, field evaluation	25,000
7	Technology dissemination Workshop and publication	20,000
	Sub-total incremental capital cost	**255,000**
8	Contingencies (10%)	25,500
TOTAL		**280,500**

3. IMPLEMENTATION OF THE PROJECT:

3.1. Implementation procedure:

The project was implemented through four steps. The following concrete actions were planned:

1. Chemical study & visits to select the raw material supplier
2. Equipment & Technical study & visits to identify the technology and equipment suppliers
3. Procurement
4. Installation and test Trials at a Pilot Foam Plant (ENGEQUIFE Company) to validate the technology
5. Workshop to present the project outcomes and disseminate the technology

3.2. Chemical study & visits to select the raw material supplier:

As to pre-blended systems, our research and contacts led us to the following options:

- Local supply through MANAR: Discussions were held with the company's management, after which it appeared that this option could not be pursued.

- European supply: Covestro (ex-Bayer) and HUNNTSMAN who have supplied commercially pre-blended systems in Eastern Europe. Different communication and follow up were undertaken with technical and commercial managers with no result.

- PUMEX has developed CP pre-blended systems. This company is offering these systems to several customers in South America. The company was contacted and the discussions led to the organization of a study tour to the Mexican system house.

The study tour took place in September 2017. During this visit all safety aspect of the supply and the use of cyclo-pentane pre-blended systems were discussed with the PUMEX team and with two different customers of PUMEX.

According to PUMEX, to use the polyol pre-blended with cyclo-pentane they produce for their customers, only safety modifications were required. The product can be used with the same process

conditions used for HCFC-141b systems. For the use of pre-blended cyclo-pentane polyols only electrical grounding, cleanness and some air extraction are needed. PUMEX established for its different customers a procedure for Good Security practices for the use of cyclo-pentane systems (see annex).

During this mission, the project team visited also two PUMEX clients: EQUIPOS AMHER Company in Gomez Palacio and DOORS MANUFACTORING Company in Monterrey. The two companies converted their lines from HCFC-141b to CP-pre-blended systems. They retrofitted mainly the electrical side of their existing equipment (ATEX controls, electrical earth connections …) and they installed ventilation systems and some sensors and alarms. They follow safety requirements and Good security practices developed by Pumex. According to the two companies' managers, they did not face any challenges during this conversion or any safety problems. Their product quality is as good as it was before with HCF-141b. They did not report a significant change in their production cost.
The visits to PUMEX and its customers have been important and gave the Moroccan government and the beneficiary company ENGEQUIFE full confidence in the technology.

PUMEX agreed to supply their CP-system to ENGEQUIFE in Morocco.

3.3. Equipment & Technical study, visits to identify the technology and equipment suppliers:

After the PUMEX visit, the project team organized in October 2017 a mission to ITALY to discuss with SAIP, CANNON AFROS and EKOSYSTEM the design, the technical and safety aspect of the use of CP-pre-blended system at SMEs companies producing PU Rigid foams in Morocco. The team discussed with each company the possible cost saving and safety equipment to have been put into the system design so the application of the CP-pre-blended systems in SME is technically and economically viable. All the visited companies presented to the project team their idea and technologies. All of them shared their ideas and experiences in cyclo-pentane Technology to supply the requested equipment and services.

Every company was having its own idea on how to reduce the cost of the C5 equipment. The outcome of this mission was mainly the development of detailed technical specification for the supply of equipment and services related to the demonstration project

3.4. Supply of equipment, chemicals, local works and commissioning:

Following the visits and technical discussions, detailed terms of reference were prepared for the following:

- Supply of a foaming line
- Supply of safety equipment and control systems
- Elaboration of safety system and technical assistance
- On-the-job training of technicians, operators and maintenance personnel

A call for bids for the supply of equipment was published and contract awarded to Cannon Afros after the reviews of the received offers.

The offer can be summarized as follows:

- The foaming equipment is very compact with limited piping, sensors made of two raw material streams with drum filling system and integrated control panel.
- Instead of constructing a complete moving foaming machine, CANNON proposed to install a moving mixing head with boom to serve different molds and presses.
- The cost of the safety systems is reduced by installing one Double ventilator for the wet and one big extractor fan for the dry. The two fans are connected through different ducting tubes to every critical sources of cyclo-pentane vapors. 6 Sensors and alarm detection are installed at these critical points. All safety alarms, sensors, Nitrogen equipment are connected to one control panel
- All ducting tubes were installed locally by ENGEQUIFE

A summary of the equipment provided is:

A Compact 100PB with FPL14 mixing head and boom
Nitrogen Inertization Valve
Safety Control panel
Gas Sensors
Single and double Ventilators

PUMEX supplied some drums of their Cyclo-Pentane System: URECOL C 1990-30RF in line with ENGEQUIFE specifications. The chemicals were shipped from Mexico to Morocco with no hurdles.

The commissioning was substantially delayed due to the relocation of ENGEQUIFE production to a newly constructed facility. Following the completion of the local works (ducting, electrical connections, Boom support system...), equipment installation was completed and training delivered.

3.5. Project results and dissemination:

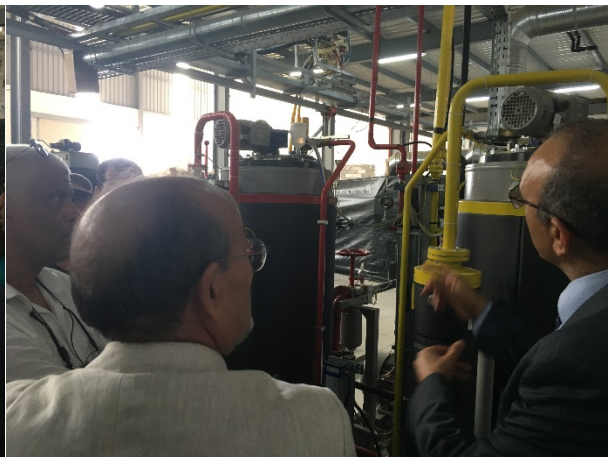
All tests and foam productions were carried out with the pre-blended system supplied by PUMEX using the equipment installed by CANNON AFROS and ENGEQUIFE.

The project has shown that:

- As an SME, ENGEQUIFE was a good choice to implement this project and to highlight the different safety issues related to this technology
- Pre-blended cyclopentane systems are sufficiently stable and can be commercially used;
- There are no specific issues for the transportation and shipment of C5-pre-blended systems in drums. They are shipped as any dangerous chemical with the corresponding extra cost.
- The foam quality produced with cyclo-pentane Systems is similar to the current HCFC-141b ones.
- There has been no specific safety issue or difficulty to use cyclo-pentane system with the supplied equipment
- There are costs savings expected from lower price of cyclo-pentane compared to HCFC-141b price.
- Nitrogen consumption is currently high and its use has to be optimized.
- This compact pentane technology can be applied in many SME enterprises in the rigid foam sub-sector and its replication can lead to potential cost savings

A workshop has been organized where outcomes of this demonstration project have been presented. The meeting was followed by a visit to Engequife's factory. Moroccan companies involved in the production of rigid foam have participated in the workshop and the plant visit.

Pictures of the meeting and the visit are shown below.


4. CONCLUSIONS

The successful implementation of this project, on the use of low cost pentane technology for the conversion to non-ODS technologies in the production of polyurethane foams at small and medium sized enterprises, has demonstrated that the initial capital cost can be reduced by designing a simple, standardized and easy-to-handle compact foaming machine capable of operating with flammable pentane with optimal safety and ventilation systems serving several products. The use of pre-blended cyclo-pentane (C5) in polyol has eliminated the need for pentane storage and blending and related equipment (mixing, tanks, piping…), thus reducing the capital cost of the conversion. In addition the foaming equipment is compact with limited piping, sensors and moving mixing head with boom to serve different molds and presses.
The cost of the safety system is optimized by installing one Double ventilator for the wet and one big extractor fan for the dry. The two fans are connected through different ducting tubes to every critical sources of cyclo-pentane vapors. Sensors and alarm detection are installed at these critical points. All safety alarms, sensors, equipment are connected to One Control panel.

Pre-blended cyclo-pentane systems are sufficiently stable and can be commercially used and the quality of the products manufactured with cyclo-pentane is similar to those produced with HCFC-141b.
The price of cyclo-pentane is lower than that of HCF-141b price, however, this can be offset by transportation cost. There are currently no system houses in Morocco offering cyclo-pentane systems, however, the replication of the technology will create to a demand that is expected to lead to the development of a local production and supply of cyclo-pentane pre-blended systems.
The technology has proved to be adapted for the conversion of small and medium enterprises to phase out the use of HCFC-141b in the production of rigid foam production. There are other SMEs using HCFC-141b pre-blended polyols in the manufacturing of PU foam, sandwich panels and soft foam for decoration in Morocco and they are planned to be converted in Stage-II of the HPMP.

Annex: Pumex's safety guideline for the use of cyclo-pentane systems