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IMPROVEMENT OF CLUPICKER, PHASE I
FINAL REPORT

DLA 900-87-D-0017, DO 0024

Submitted
to

Defense Logistics Agency
Defense Personnel Support Center

by

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March 15, 1994

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94-11021



DTIC QUALITY INSPECTED 3

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 15 March 1994	3. REPORT TYPE AND DATES COVERED Final - Phase I 9/30/91 - 09/30/93	
4. TITLE AND SUBTITLE Improvement of Clupicker, Phase I			5. FUNDING NUMBERS DLA900-87-D-0017 DO 0024	
6. AUTHOR(S) Tony Aspland				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Clemson Apparel Research 500 Lebanon Road Pendleton, SC 29670			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Defense Logistics Agency Cameron Station Alexandria, VA 22304-6100			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT <i>UNRESTRICTED</i>			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) <p>The objective of Phase I of this research project was to develop a modified Clupicker. The Clupicker is a mechanism to automatically pick up single plies of fabric. Older versions of the Clupicker have been difficult to set up and maintain. In addition, old feeder systems could not cope with sudden fabric changes and had numerous performance problems.</p> <p>The Modified Clupicker developed as a result of this research project was shown at the Bobbin Show in Atlanta, GA and was well-received. Further design modifications are necessary, however, before it will be ready for commercial sale.</p> <p>If funded, Phase II will include testing and evaluation of the Modified Clupicker at the Clemson Apparel Research facility.</p> <p style="text-align: right;">DTIC QUALITY INSPECTED 3</p>				
14. SUBJECT TERMS			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT	

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PHASE I TASK OUTLINE

From the original "Appendix 1: Specific Task Outline", listed in the original "Improvement of Clupicker" project proposal, Phase I was divided into three major tasks. These tasks provided a framework for the completion of the Phase I goals. The tasks, listed in the original proposal, were listed as follows:

PHASE I: PROTOTYPE DESIGN AND DEVELOPMENTS

Task I: Formulate Design Specifications

- A. Form a "Design Team" of specialists in design and application of ply separation systems. (NCSU)
- B. Compile a list of the factors inhibiting commercial acceptance of the Clupicker system. (NCSU/Design Team)
- C. Write a set of design specifications for eliminating or reducing the factors listed above. (Design Team)

Task II: Test and Evaluate Initial Prototype

- A. Construct an initial prototype. (NCSU)
- B. Develop a set of experiments to evaluate the performance of the initial prototype. (NCSU)
- C. Select and purchase fabrics. (NCSU)
- D. Test the initial prototype. (NCSU)
- E. Perform an estimated cost comparison between the modified system and the present system. (NCSU/Jet Sew)
- F. Analyze the test results and present them to the Design Team. (NCSU)
- G. Recommend necessary modifications to the initial prototype. (Design Team)

Task III: Construct and Test Production Prototype

- A. Incorporate recommended modifications into the construction of a production prototype. (NCSU)
- B. Repeat tests conducted in Task II and evaluate performance based on the desired specifications. (NCSU)
- C. Revise the estimated cost comparison between the modified system and the present system. (NCSU/Jet Sew)
- D. Review performance with the Design Team. (Design Team)

The Design Team, as defined in the original proposal, consisted of "A team of specialists from NCSU, CAR [Clemson Apparel Research], Jet Sew Corporation, and others [military and industrial apparel users]".

CAR'S PHASE I TASKS

Looking at the above task list, most of the work done during Phase I of the "Improvement of Clupicker" project was done by NCSU. From the original project proposal, most of the work done during Phase II of the project was to be done by

CAR. Since Phase II of the project has yet to be funded, CAR's participation has been confined to those Phase I tasks which involved the Design Team.

Condensing the task list presented on page one to those tasks involving the Design Team the following list results:

PHASE I: PROTOTYPE DESIGN AND DEVELOPMENTS INVOLVING CAR

Task I: Formulate Design Specifications

- B. Compile a list of the factors inhibiting commercial acceptance of the Clupicker system. (NCSU/Design Team)
- C. Write a set of design specifications for eliminating or reducing the factors listed above. (Design Team)

Task II: Test and Evaluate Initial Prototype

- D. Test the initial prototype. (NCSU*)
- G. Recommend necessary modifications to the initial prototype. (Design Team)

Task III: Construct and Test Production Prototype

- D. Review performance with the Design Team. (Design Team)

* CAR provided test specimens used by NCSU to complete this task

HOW CAR COMPLETED ITS CONTRACTED TASKS

The first task in which CAR contributed was Task I.B.; the compilation of a list of factors inhibiting commercial acceptance of the Clupicker system. Because CAR spends most of its time helping organizations, both military and civilian, solve apparel related problems, CAR personnel often visit the manufacturing facilities where the problems are occurring.

In visits to DPSC, Iva Manufacturing, Oxford Industries, and other apparel manufacturing facilities, CAR noticed operations which "theoretically" could have been completely automated, but were not. In the operations, workers were taking bundles of cut parts, manually separating the plies, and feeding the individual plies into continuously running automated sewing machines. When asked why commercially available feeder technologies were not being used, several reasons were given.

Feeder systems were difficult to set up. Once set up, the feeders were difficult to maintain. Even when working well, the feeders were not as reliable as humans at fully separating and properly loading the fabric plies. The feeder systems could not cope with sudden fabric changes. To be cost effective, the feeders required long process runs of the same material. Given feeder performance problems, the capital costs for feeder systems were difficult to justify. Commercially available feeder systems were also viewed as mechanically non-intuitive with operating

sequences and performance subtleties that were difficult to understand. These complaints were supported by the plant operations.

At Iva Manufacturing a Jet Sew front hemmer was being fed manually. A Swiss-made feeder, costing \$80,000, had been so unreliable that it was still sitting under plastic wrap after three years. At Oxford Industries two well trained operator/technicians were assigned to monitor four automatic feeders to ensure that if feeding errors occurred they could be quickly corrected. The operators kept busy. At another plant a CAR employee reported seeing several automatic feeders were sitting in a corner, under plastic wrap, collecting dust.

In a February 1992 meeting at Jet Sew, Design Team members shared feeder "horror stories" and discussed how to overcome the problems associated with Clupicker based feeder systems. During the discussion NCSU proposed the "self-adjusting" Clupicker concept. CAR suggested a retrofitable four-bar linkage that would allow a Modified Clupicker to engage bundle surfaces using pure translational motion, allowing various types of picking devices to be fit onto Jet Sew feeding machines. CAR also suggested a simple drive mechanism that might reduce the cost of the Modified Clupicker.

The new drive mechanism used a looped timing belt joined to a double acting air cylinder. When the cylinder was actuated the belt moved. Two prototype Clupickers were made by Jet Sew demonstrating this simple drive concept. Later in the project, CAR discovered two additional drive alternatives. The first alternative was a newly developed, small, pneumatic rotary actuator from Festo. The second alternative was a small, high torque, gear motor used in remote-control (RC) applications. While the pneumatic actuator was never incorporated into a Modified Clupicker, NCSU did develop a simple system driven directly by an RC gear motor.

With all the design possibilities, Design Team members agreed that the only way to intelligently limit feeder design alternatives was to ask users of Clupicker feeders what was needed in a Modified Clupicker system. To this end, Keith Daniel of NCSU sent out questionnaire to Jet Sew customers to determine what improvements needed to be made to Clupicker feeder systems. Keith asked Clupicker users to rank performance subheadings under the following main performance headings:

- Setup
- Maintenance
- Performance*
- Material
- Economics
- Machine Characteristics

* Here "Performance" pertains to the Original Clupicker System's ability to pick up single plies of cut material.

In the next task, Task I.C, CAR and the other Design Team members, helped write a set of design specifications based on customer requirements. The resulting list of the technical requirements, their relative importance, and the direction which designs should tend towards (↑ implies an increase is desirable, ↓ implies a decrease is desirable) is given below.

1)	1 setup per range of fabric	10.9	↑ ^a
2)	Reduce sensitivity to fabric type	10.4	↓
3)	Self governing forces	8.7	
4)	Modular components	8.6	↑
5)	1 adjustment to change fabric range	8.2	
6)	Pick from uneven stacks	7.8	↑
7)	Minimum time for setup	7.1	↓
8)	Stack quality maintained	5.9	↑
9)	Standardized setup ^b	4.4	
10)	Consistent force on fabric	4.4 ^c	
11)	Reduce number of parts	4.3 ^c	↓

^a An increase implies that 1 setup will cover a broader range of fabrics.

^b This technical requirement was listed in Keith's House of Quality: Clupicker, but not on Keith's Product Design Matrix - 1

^c These technical requirement weights are from Keith's House of Quality: Clupicker. Keith's Product Design Matrix - 1 has a typographical error in which the values are switched.

With design specifications in hand, NCSU began the tasks of developing, constructing, and testing a prototype feeding system. Testing the feeding system required obtaining a diverse range of fabric samples. CAR helped NCSU with Task II.D by providing a broad range of prepared test samples.

The following materials were spread and cut into 4"x 8" blocks with the fabric grain running parallel to the 4" side on half the samples and parallel to the 8" side of the other half of the samples. 90 blocks were cut for a total of 2160 sample pieces. NCSU used the sample pieces to conduct tests on the new Clupicker prototype.

Fabric Samples Supplied to NCSU by CAR				
Ply	Fiber Content	Mfr.	Style	Color
0	100% Cellulose	Better Methods	Spreader Paper	Brown
1	40% Poly/60% Cotton	Milliken	422412	Blue 01783
2	100% Polyester	Milliken	297812	Grey 06708
3	Nylon?	?	Tight Weave	White Mat'l w/ Black Grid
4	Tyvek 4	DuPont?	?	Light Blue
5	65% Poly/35% Cotton	Milliken	989319	White 00084
6	?	Pellon	840	White
7	100% Polyester	Milliken	297791	Red/White 01962
8	100% Cotton	Land's end	Woven	White
9	Nylon?	?	Tight Weave	Yellow
10	72% Poly/28% Cotton	Milliken	153238	Navy 01142
11	?	Pellon	4891	White
12	65% Poly/35% Cotton	Military	Dress Shirt	Green
13	100% Polyester	Milliken	297701	Peach 05062
14	?	Sommers	2769	White
15	100% Polyester	Milliken	897711	Beige 07684
16	100% Cotton	Land's end	Woven	Pink
17	?	Sommers	2358	White
18	50% Poly/50% Cotton	Military	Chambray	Blue
19	100% Cellulose	Better Methods	Spreader Tissue	Blue
20	?	Pellon	Acxel	White
21	100% Polyester	Milliken	897711	Beige 07684
22	Blend?	?	Light Canvas	Sky Blue
23	?	Better Methods	Cutter Plastic	Clear

Except for the spreading and tissue paper samples, the only plies that could not be separated from the bundles were plies four, five, and six.

Plies That Were Difficult to Separate				
Ply	Fiber Content	Mfr.	Style	Color
4	Tyvek 4	DuPont?	?	Light Blue
5	65% Poly/35% Cotton	Milliken	989319	White 00084
6	?	Pellon	840	White

Fiber entanglement made these plies difficult to separate when they were spread on top of each other. Despite difficulties handling these materials, the test results were sufficiently promising that NCSU and CAR felt it was a good idea to demonstrate the Modified Clupicker design at the September 1992 Bobbin Show.

At the time the Modified Clupicker was shown, the Jet Sew Design Team members did not feel the design was well enough refined for commercial sale. For this reason the Modified Clupicker was not demonstrated in the Jet Sew booth but rather in the ARK Incorporated booth along with NCSU's "Patented Rod Feeder". The Modified Clupicker shown at the ARK Incorporated booth boasted

- Automatic adjustment for fabric type
 - Flexible design
 - Fewer parts
- and
- >99.5% reliability for most fabrics

Although the Modified Clupicker was well received, design modifications were deemed necessary. In Task II.G the Design Team members came to agree that having Modified Clupickers which could directly replace Original Clupickers was a better way of improving feeder technology than selling entirely new feeder systems base on the prototype Modified Clupicker alone. With Jet Sew's guidance, a production prototype Modified Clupicker evolved.

The production prototype Modified Clupicker maintained many of the original design features of the prototype Modified Clupicker. The main design difference was that the production prototype could directly replace Original Clupickers in existing ply feeding machines. Based on test performed by NCSU the Design Team completed Task III.D with CAR agreeing to purchase and Jet Sew agreeing to make three Modified Clupickers for Phase II installation and testing on CAR's Jet Sew Shirt Sleeve Feeder.

As stated at the top of page two, most of the work done during Phase I of the "Improvement of Clupicker" project was done by NCSU with input from the Jet Sew and CAR Design Team members at critical design points during Phase I of the project. From the original "Improvement of Clupicker" project proposal, most of the work done during Phase II of the project was to be done by CAR.

THE FUTURE OF AUTOMATIC FEEDER SYSTEMS

As planned in the original proposal submitted to the DLA, Phase II, if funded, is divided into three major tasks. These tasks are a continuation of the Phase I tasks and provided a framework for the completion of the Phase II goals. The tasks, listed in the original proposal, are as follows:

PHASE II: PRODUCTION PROTOTYPE INSTALLATION AND EVALUATION

TASK IV: Construct a Modified Commercial Clupicker System

- A. Select one of the automated feeding operations at CAR to demonstrate the Modified Clupicker system. ("Design Team")
- B. Subcontract Jet Sew Corporation to incorporate the features of the production prototype into a commercial feeding system to replace the selected system presently in operation at Clemson. (NCSU/Jet Sew)
- C. Perform an accurate cost comparison between the modified system and the present system. (Design Team)
- D. Revise the maintenance and training manuals. (NCSU/Jet Sew)
- E. Install the modified system at Clemson. (Jet Sew/CAR)

TASK V: Evaluate Feeding System Performance

- A. Conduct direct comparisons between the modified system and the present systems in the following areas:
 - 1) production efficiency
 - 2) maintenance
 - 3) ease of adjustment
 - 4) change-over time
 - 5) operator satisfaction
 - 6) cost
- B. Install and evaluate the performance of at least two different top ply grasping devices on the modified system and demonstrate this flexibility. (NCSU)

TASK VI: Transfer Technology

- A. Demonstrate the enhanced Clupicker ply separation and feeding system at CAR. (CAR)
- B. Publish performance data and comparative studies in technical and trade journals. (CAR/NCSU)
- C. Publish and distribute interim and final reports. (CAR)

What CAR, NCSU, and Jet Sew set out to accomplish was the development of a cost effective, reliable, and efficient method of automatically feeding cut parts from bundles into automatic sewing equipment. Phase I has shown that automatic feeding has a future. Phase II hopes to make the future a reality by rigorously testing the Modified Clupicker on CAR's full-time production floor. If the Modified Clupicker stands up to the rigors of full production while delivering the design performance intended, Jet Sew will begin installing Modified Clupickers on all its automatic feeders. Commercialization to the Modified Clupicker technology will help military and civilian apparel manufacturers meet their immediate production objectives while staying internationally competitive.