Honeywell

Diamond Measuring Machine

Federal Manufacturing & Technologies

J. F. Krstulic

KCP-613-6280

Published January 2000

Final Report/CRADA Project Accomplishments Summary

CRADA Number 98KCP1072

Approved for public release; distribution is unlimited.

Prepared Under Contract Number DE-ACO4-76-DP00613 for the

United States Department of Energy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees,

Honeywell

Federal Manufacturing
& Technologies

P. O. Box 419159

Kansas City, Missouri

64141-6159

A prime contractor with the United States

Department of Energy under Contract Number

DE-ACO4-76-DP00613.

Honeywell

KCP-613-6280

Distribution Category UC-706

Approved for public release; distribution is unlimited.

DIAMOND MEASURING MACHINE

J. F. Krstulic

Published January 2000

Final Report/CRADA Project Accomplishments Summary

CRADA Number 98KCP1072

Diamond Measuring Machine

Project Accomplishments Summary

CRADA Number 98KCP1072

Date: 12/6/1999 Revision: 0

A. Parties

The project is a relationship between

Honeywell FM&T

2000 E 95th Street

PO Box 419159

Kansas City, MO 64141-6159

AccuGem Corporation

2121 Inverness Drive

Lawrence, KS 66047

B. Background

Certification of diamond characteristics is conducted by highly trained and skilled technicians using manual instruments. It takes months of training to be able to analyze a

stone for defects and properly measure the stone's physical dimensions. Diamond dealers and manufacturers employ hundreds of these skilled technicians to review stones during the grading process. The process to grade a single stone is both time-consuming and not consistent from technician to technician. Thus grading diamonds is a high subjective process.

AccuGem Corporation developed the idea of removing the human subjectivity from the diamond grading process. In 1997, Federal Manufacturing & Technologies (FM&T) was contracted through a Work-for-Others agreement to provide AccuGem technical engineering support to develop a proof of concept diamond measuring prototype (Phase 1). The results of the proof of concept machine clearly showed the proposed technology could achieve accurate and more consistent measurements as compared to conventional measuring methods.

This project is Phase 2 in the development cycle of the diamond measuring machine. For a commercial product, the device needs to be more automated, be less susceptible to light, and be able to plot defects on a standardized report. FM&T technical capabilities in electronic systems engineering and image processing together with AccuGem expertise in diamond grading, analysis, and 3D modeling will combine to develop this next-generation diamond measuring machine.

C. Description

The fundamental goal of this project was to develop additional capabilities to the diamond measuring prototype, work out technical difficulties associated with the original device, and perform automated measurements which are accurate and repeatable. For this project, FM&T was responsible for the overall system design, edge extraction, and defect extraction and identification. AccuGem provided a lab and computer equipment in Lawrence, 3D modeling, industry expertise, and sets of diamonds for testing.

The system executive software which controls stone positioning, lighting, focusing, report generation, and data acquisition was written in Microsoft Visual Basic 6, while data analysis and modeling were compiled in C/C++ DLLs. All scanning parameters and extracted data are stored in a central database and available for automated analysis and reporting.

The Phase 1 study showed that data can be extracted and measured from diamond scans, but most of the information had to be manually extracted. In this Phase 2 project, all data required for geometric modeling and defect identification were automatically extracted and passed to a 3D modeling module for analysis. Algorithms were developed which automatically adjusted both light levels and stone focus positioning for each diamond-under-test.

After a diamond is analyzed and measurements are completed, a report is printed for the customer which shows carat weight, summarizes stone geometry information, lists

defects and their size, displays a picture of the diamond, and shows a plot of defects on a top view drawing of the stone. Initial emphasis of defect extraction was on identification of feathers, pinpoints, and crystals. Defects were plotted color-coded by industry standards for inclusions (red), blemishes (green), and unknown defects (blue).

Diamonds with a wide variety of cut quality, size, and number of defects were tested in the machine. Edge extraction, defect extraction, and modeling code were tested for multiple runs of each stone. Although there were problems with a few stones, the machine automatically completed measurements on a majority of the stones tested. A demo was performed in Lawrence for AccuGem stockholders and potential investors. The demo successfully demonstrated our technology on a random stone brought by an attendee.

In conclusion, the project was successful in development of the basic technology required for a diamond measuring machine. Continued improvements in lighting control, edge and defect extraction, and an increased image depth-of-field will increase the reliability and consistency of measurements. Although additional work is needed to make the machine a commercial product, there are no foreseeable technical roadblocks in that process.

D. Expected Economic Impact

A diamond measuring machine capable of geometric modeling and plotting defects will be the first of its kind and will start an entire new industry of diamond registration. AccuGem believes this technology will both revolutionize and standardize the diamond industry. There will not be any immediate economic impact since the machine is still not ready to be a commercial product, but if AccuGem can secure funding for continued development, it may be ready within 2 years. The diamond industry will benefit from consistent, objective measurements to aid in the grading process. Customers/taxpayers will also benefit in having both reliable diamond information on products as well as certified measurements for insurance purposes. Since AccuGem is a small company at this point, successful commercialization would add manufacturing jobs for system assembly and computer skilled jobs for programming, security, and maintenance of the software.

E. Benefits to DOE

The major benefit to DOE from this project was the development of image processing techniques and algorithms for defect detection. These techniques may be used in non-destructive weapons evaluation and tomographic inspection of weapons hardware. Test equipment engineering gains additional experience in system executive & DLL software development, database driven testing, manipulating large waveform data sets, and computer interfacing to positioning sensors.

The overall project also enhances the skills of a variety of engineering disciplines. It involved electrical and mechanical engineering, application software development, DLL library generation, 3D modeling interface, Visual Basic programming, C++ programming,

and system integration. With an increase of concurrent engineering activity between FM&T and Sandia National Laboratories, this project gave valuable experience in cross-company teamwork since system design was performed at FM&T, image processing at FM&T/New Mexico, vendor testing at AccuGem in Lawrence, and industry requirements from parties across the country.

This technology was developed because of the match between AccuGem industry knowledge and FM&T engineering and image processing expertise.

F. Industry Area

The diamond measuring machine will substantially increase reliability and consistency to the diamond grading process, a process currently highly dependent on human subjectivity. This new technology will reduce costs at diamond grading labs and, most importantly, protect the consumer from fraudulent certifications.

G. Project Status

The project was completed and a demonstration presented in September 1999.

H. Point of Contact for Project Information

Ken Bauer	Joe Krstulic
US Department of Energy	Honeywell FM&T
Kansas City Area Office	PO Box 419159
PO Box 410202	Kansas City, MO 64141-6159
Kansas City, MO 64141-0202	Telephone: (816) 997-3644
Telephone: (816) 997-3917	Fax (816) 997-7169
Fax: (816) 997-5059	Email: jkrstulic@kcp.com

I. Company Size and Point of Contact

Larry Sliker

AccuGem Corporation

2121 Inverness Drive

Lawrence, KS 66047

Telephone: (785) 842-1761

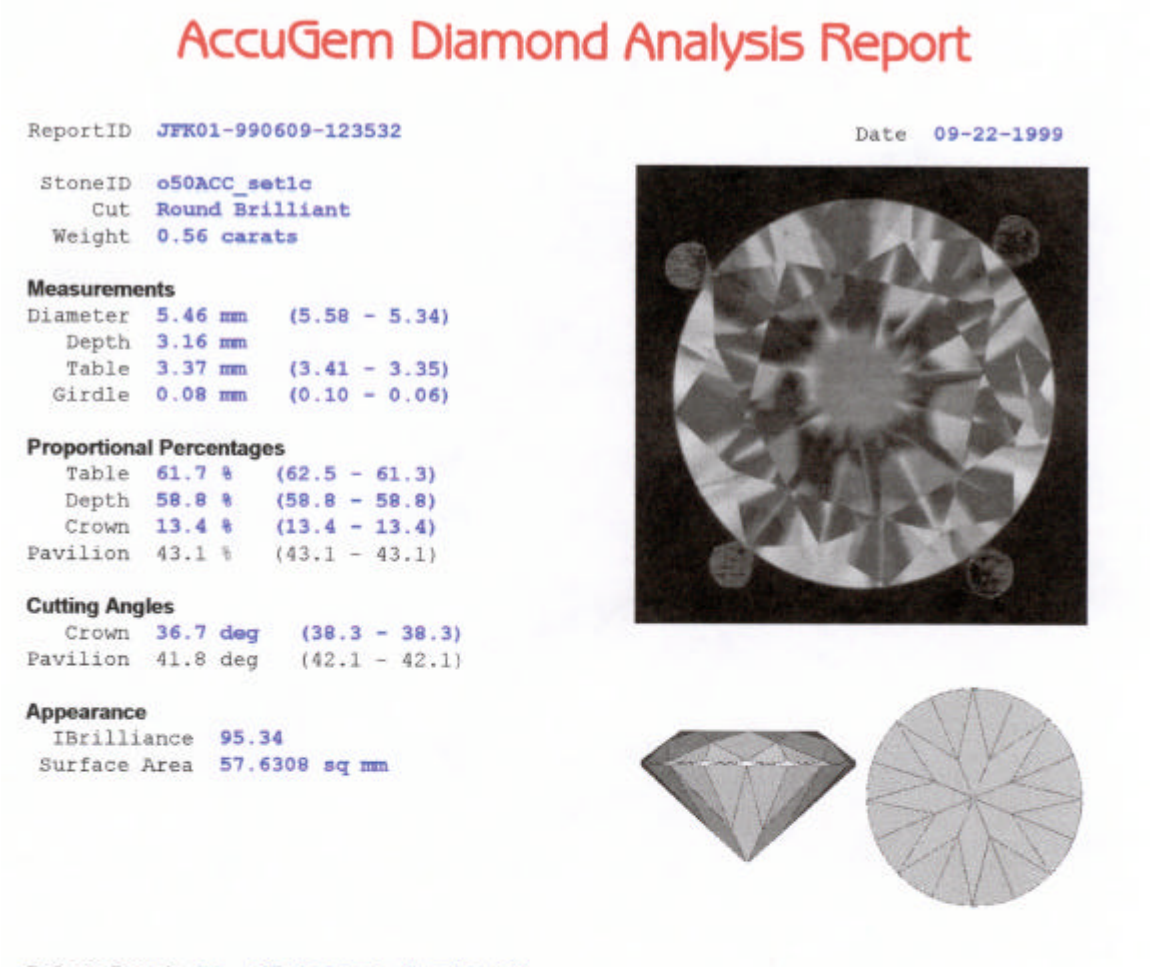
Email: larry_s@usa.com

J. Project Examples

Attached is a copy of a typical report generated by the diamond measuring machine developed by this project.

K. Technology Commercialization

AccuGem plans to develop a commercial product out of the diamond measuring machine in the next 2 years. Once the measurement machine is on the market, AccuGem plans to start development of a diamond grading machine which uses the same technology with additional color analysis and artificial intelligence.



AccuGem Diamond Analysis Report

ReportID JFK01-990609-123532

Date 09-22-1999

StoneID o50ACC_set1c
Cut Round Brilliant
Weight 0.56 carats

Measurements

Diameter	5.46 mm	(5.58 - 5.34)
Depth	3.16 mm	
Table	3.37 mm	(3.41 - 3.35)
Girdle	0.08 mm	(0.10 - 0.06)

Proportional Percentages

Table	61.7 %	(62.5 - 61.3)
Depth	58.8 %	(58.8 - 58.8)
Crown	13.4 %	(13.4 - 13.4)
Pavilion	43.1 %	(43.1 - 43.1)

Cutting Angles

Crown	36.7 deg	(38.3 - 38.3)
Pavilion	41.8 deg	(42.1 - 42.1)

Appearance

IBrilliance 95.34
Surface Area 57.6308 sq mm

Typical Report from Diamond Measuring Machine

L. Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Honeywell FM&T and agree that the information about our CRADA may be released for external distribution.

Original signed by 1-18-00

Name: Clyde Engert Date

Organization: AccuGem

Title: President