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THE NAME-LOCATER GUIDE
A NEW RESOURCE FOR TECHNOLOGY TRANSFER
FINAL REPORT

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INTRODUCTION AND SUMMARY

One of the problems in transferring aerospace technology to nonaerospace industries is adequate communication. Those in such industries will tend to think of aerospace technology in terms of the space missions with which they are familiar. Also the aerospace technology is usually indexed for retrieval by aerospace engineers and scientists. The subject terms used are meaningful to them but not to those working in a nonaerospace industry. Communication is not only a problem in locating relevant technology but is also a problem in transferring it. The reports containing the technology are generally written for the aerospace engineers and scientists. Someone working in a nonaerospace industry can often miss the relevance to their own problem.

This was illustrated in a previous experimental project with the NASA Technology Utilization Office.[1] In that project technology was sought which was applicable to manufacturing problems in the apparel industry. After an analysis of these problems a set of reports was retrieved by manual and machine searching of the literature. The NASA reports were then circulated by the Apparel Research Foundation to key people in the industry that were concerned with these problems. The response was negative. They did not see any relevance between the NASA material and industry problems. Some months after that a series of newsletters was prepared covering the same technology. They were prepared with a style and terminology common in the industry. They focused on the apparel manufacturing problem rather than the aerospace technology. The way in which the latter could contribute to a solution was pointed out. These newsletters were distributed by the Apparel Research Foundation and drew a very positive response from the industry. The potential value of the technology to them was evident.

To overcome this communication problem a new transfer mechanism was proposed with the following sequence of steps. First, the key technical problems in a given industry would be analyzed. This would be done in accordance with the Problem Statement Guidelines that were previously developed for the NASA Technology Utilization Office.[2] The analysis would be such as to define the characteristics which relevant technology would have. Second a limited list of subject terms would be developed using words familiar to those working in the industry. It is these which would be applied in subsequent steps to the NASA technology and used to locate technology relevant to a specific problem in the industry. Third for each RTOP terms applicable to that RTOP would be chosen from this list. Fourth a name-locater guide would be provided to the Regional Dissemination Centers (RDC). This guide would be analogous to an index. The key words would be chosen from the special subject term list for the given industry. Associated with each key word would be a list of individuals involved with technology potentially relevant to the industrial area represented by the key word. The RDC would use this tool when working with a firm in the given industry. The RDC could contact the indicated NASA personnel for guidance in locating relevant technology to the specific problem. Alternatively the RDC could use the information contained in the identified RTOP abstracts in structuring a literature search strategy.

The proposed transfer mechanism has a number of differences from past approaches. One that is quite significant is that nonaerospace terms are used. Indexes to RTOP's have been prepared in the past and used by RDC's. The subject terms, however, were chosen from aerospace terms. These often have little meaning to the engineers or managers in the user industry. In the present case, however, the term set can be used directly by those in the user industry to define their problem for the RDC.

A second significant difference in the new mechanism is that the RDC in its problem analysis and search locates NASA engineers and scientists rather than just reports. These personnel can serve as "windows" to whole areas of technology that would be difficult to locate through other means. By locating people the new tool has much more leverage than an index to reports, even if one existed using the same set of subject terms. The reason for this is that so often relevant technology exists but is indexed in such a way that it is difficult to locate through machine searches of the literature. Several examples of this have been documented in previous experiments.[5] In these several RDC's were simultaneously given the same problem. Each would locate several reports of relevant technology that were located by none of the other RDC's.

Another example was provided by a recent study of transfer of technology to the apparel industry. In this study it was desired to locate technology relevant to the problem of automatically guiding fabric under the sewing head. A specific individual, Mr. M. Huffaker, at Marshall Space Flight Center was identified. He had developed technology relevant to measuring the velocity of moving objects. This was applicable to sensing fabric motion during the sewing process. Through initial discussions held with Mr. Huffaker at Marshall a series of contacts followed at the center and other relevant areas of technology were identified. These involved photocell arrays for sensing fabric during sewing. None of this technology had been identified through an initial RDC literature search or by sending a problem statement to the center. It was only identified through the personal contact.

It is anticipated that the name-locater guide can be used as a marketing aid by the RDC's. It is new and thus provides a basis for gaining the interest of a prospective client. It could serve as the opening point of discussion in presenting the complete package of RDC services to a prospective client. The name-locater guide would be oriented through the descriptor list to the business of the prospective client.

The objective of the present project was to test this mechanism. This was done by first preparing a name-locater guide in a single industry, the home appliance manufacturing industry. The guide was then evaluated with the participation of two RDC's.

The first step in preparing the name-locater guide was to identify the problems in the appliance industry. This was done through interviewing an industry organization and key firms. These problems were then analyzed in a manner similar to that discussed in Problem Statement Guidelines. One purpose of the analysis was to describe that type of aerospace technology which would be relevant to the problem. Means for doing this are included in the Problem Statement Guidelines. A second purpose was to derive a list of subject terms meaningful to the industry. After preparation the list of terms was checked with industry representatives.

In the next step terms from this list were selected for each RTOP. This selection process depended on the problem analysis described above. The RTOP abstract was screened to determine the technologies that it involved. Even though the abstract was only a paragraph in length, it had been demonstrated in past projects that such screening can be done accurately. [3, 4] The previous analysis of industry problems identified the characteristics of technologies relevant to these problems. It was then determined whether any of the technologies involved in the RTOP program had any of these characteristics. Where a match was found, appropriate problem oriented terms from the industry list would be applied to the RTOP. Once terms were assigned to each RTOP in this way the name-locater guide was assembled.

In the final step two RDC's, ARAC and NERAC, participated in the evaluation of the guide that had been prepared. Areas of utility for this new resource within the RDC were identified. Application in both the problem solving and marketing functions was considered. In addition Dr. Clingman and representatives from ARAC visited a group of appliance manufacturing firms. The presentation to these firms included a description of the name-locater guide. From the information obtained in these activities conclusions were drawn on the utility of the guide.

The following sections of this report cover each of these steps. First the analysis of the home appliance manufacturing industry is described. The problem statements prepared during this analysis are collected in Appendix A. Second the means used to prepare the guide itself is described. Following this the evaluation of the guide through discussions with ARAC and NERAC as well as visiting ARAC prospects is covered. In the final section conclusions from the project are presented.

It is concluded that there are two principal areas of utility for the guide. First would be the rapid identification of some technology relevant to a prospective clients' problem. Based on the results of the evaluation activities it is believed that this would contribute significantly to the marketing function. Second would be use of the guide in the RDC interacting with NASA field centers. In this case the guide would complement other resources available such as the Technology Utilization Office at the field center.

ANALYSIS OF THE HOME APPLIANCE MANUFACTURING INDUSTRY

The first step in the project was to conduct an analysis of the home appliance manufacturing industry. This was done through face-to-face interviews with engineering personnel in four manufacturing firms. Chairmen of industry engineering committees were selected for these discussions so that an industry-wide viewpoint would be obtained. Firms in different sectors of the industry were also selected in order to cover as many different technological needs as possible. The technical staff of the Association of Home Appliance Manufacturers was also interviewed. All of these individuals are listed in Table 1.

After the interviews four problem statements were prepared. These are collected in Appendix A of this report. The problem statements represented an identification and analysis of the technological needs in four segments of the home appliance manufacturing industry. These were dishwashers, disposers, room air conditioners, and refrigeratars. A number of common problems were found between these segments, such as the need for plastic or composite materials which can be formed to close tolerance without machining. The statements were prepared using information obtained in a literature search as well as in the interviews described above.

These problem statements along with the journal articles cited in them were next used to generate a set of subject terms relevant to the problems in the home appliance manufacturing industry. This process is described in the next section of the report.

TABLE 1

Individuals Interviewed

Herbert Phillips
Director Technical Department
Association of Home Appliance Manufacturers
20 North Wacker Drive
Chicago, Illinois 60606

Walter H. Blanck, Jr.
Assistant Technical Director
Association of Home Appliance Manufacturers
20 North Wacker Drive
Chicago, Illinois 60606

A. R. Kays
Design and Manufacturing Corporation
Regenstrief Ave.
Connersville, Indiana 47331
(AHAM Dishwasher Engineering Committee)

R. P. Perry
Vice President Engineering
Gibson Products Corporation
515 W. Gibson Drive
Greenville, Michigan 48848
(AHAM Engineering, Standards and Safety Board)

G. C. Smith
Friedrich Refrigerators Inc.
4200 N. Pan American Expressway
San Antonio, Texas 78295
(AHAM Room Air Conditioner Engineering Committee)

T. F. Meyers
Hobart Manufacturing Company
Troy, Ohio 45373
(AHAM Disposer Engineering Committee)

PREPARATION OF THE NAME-LOCATER GUIDE

The name-locater guide prepared for this project contains a set of descriptors which are relevant to the problems within the home appliance manufacturing industry. After each descriptor are listed the NASA projects (RTOP) and responsible individuals that are considered to involve relevant technology. This is technology relevant to the appliance or manufacturing problem associated with the descriptor.

The guide is thus different from an index of RTOP's and should not be confused with such an index. A subject term in the guide is not necessarily descriptive of the technology in the RTOP's listed under it. For example, RTOP W73-70332 is listed under the term "FROST SENSOR". This RTOP under G. B. Graves at Langley Research Center involves the development of new materials and processing techniques for solid state sensors. Included are strain gages, ion detectors, infrared detectors and other electro-optical devices. The RTOP does not involve a frost sensor. It is assumed, however, that G. B. Graves and his associates could provide meaningful assistance in identifying a technical approach to a frost sensor.

The list of subject terms in the guide were first developed. The starting point was the set of four problem statements previously discussed. A list of descriptors was prepared for each of the problem areas. The problem statement and the industry interview on which it was based was the primary source of these descriptors. A secondary source was a collection of technical articles in engineering and industry trade journals. References to these are given in each problem statement. Finally the descriptor list for each problem area was furnished to the chairman of the cognizant technical committee of the Association of Home Appliance Manufacturers for comment. They were given the opportunity to add or delete descriptors from the list. These committee chairmen were the same individuals interviewed in preparing the problem statements. The only recommended changes came from A. R. Kays of the Design and Manufacturing Corporation. He suggested deleting the names of specific plastic materials and using only the generic term, "PLASTICS", in the list.

The next step was to combine the terms in all four lists into a master descriptor list. This was done and duplications were eliminated. An abstract of each RTOP was then studied and appropriate terms from the master descriptor list were assigned to the RTOP. Many RTOP's had no terms assigned to them. A term was assigned to an RTOP only in those cases where one could expect the NASA individuals associated with the RTOP to help solve the appliance problem associated with the subject term. These are the problems defined and discussed in the problem statements.

A computer program was then used to sort the assignments made above and to print the name-locater guide in the format of the enclosed copy. The final list of descriptors used in the guide is given in Table 2.

TABLE 2

DESCRIPTOR LIST

ABS
Acoustic Materials
Acrylic Finishes
Adhesives
Air Flow
Aluminum
Analog Control Circuits
Automatic Check-out
Automatic Control
Automatic Defrosting
Automatic Diagnostics
Bearings
Blowers
Bonding
Bonding Plastics
Boundary Layer
Boundary Layer Effects
Brazing
Coating Processes
Coatings
Coextrusion
Comfort
Components
Composite Materials
Compressor
Computerized Design
Control Mechanism
Control Panel
Control Systems
Cooling
Corrosion
Corrosion Inhibitors
Corrosion Protection
Corrosion Resistance
Curing
Design Flexibility
Design Methods
Diisocyanates
Durability
Dynamic Motor Characteristics
Electric Motor
Epoxy Coating
Fan
Fasteners
Fault Location
Feedback Control
Fiber Glass
Filters
Fire Retardant Materials
Flow Measurement
Fluid Evaporation
Fluidic Control
Fluidic Sensor
Foamed Polymethane
Forming Methods
Frost Sensor
Gaskets
Glass Filled Plastics
Hardened Alloys
Heat Exchamge
Heat Exchanger
Heat Load
Heat Pump
Heat Transfer
Heat Transfer Mechanisms
Heat Transfer Surfaces
Hermetic Seals
Housing
Humidity Control
Humidity Sensor
Impact Resistance
Impeller
Joining Methods
Leaks
Life Support Data
Liner
Liquid-Gas Heat Transfer
Liquid-Solid Boundaries
Long Life
Lubricant
Manufacturability
Manufacturing Cost
Manufacturing Methods
Materials
Material Systems
Metal Coatings
Metal Forming
Metal-Metal Bonding
Motor Control
Multilayer Materials
Nickel Alloys
Noise
Performance Testing
Plastic Coatings
Plastic Forming
Plastic Materials
Plate-Fin Heat Exchangers
Pollution
Polycarbonate
Powder Metallurgy
Prefinished Materials
Protective Coating
Pump Seals
Pumps
Quality Control
Radiant Heat Transfer
Rate Sensors
Reliability
Rotary Compressor
Safety
Sealing
Seals
Sensors
Service Costs
Solid-Gas Heat Transfer
Solid Lubricants
Solid State Control
Sound Absorption
Spine-Fin Heat Exchanger
Stainless Steel
Surface Coatings
Surface Structure
Temperature Sensor
Thermal Conductivity
Thermal Insulation
Thermal Properties
Timer
Timing Mechanisms
Welding
Wet Bulb Temperature

EVALUATION OF THE NAME-LOCATER GUIDE

The next step in the project was to evaluate the utility of the name-locater guide. In particular it was desired to determine alternative uses for the guide within the RDC's. A principal question considered was whether or not similar guides should be developed for other industries.

Two regional dissemination centers, NERAC and ARAC, were involved in this evaluation. The guide and its method of preparation were first discussed with the directors of each center. In these discussions a clear distinction was drawn between the guide and a simple index to NASA programs. As discussed above the format of the guide is a list of descriptors and under each descriptor is a list of NASA programs related to it. In a simple index the descriptor would refer to the content of the NASA program. In the guide the descriptor refers to a problem in the home appliance manufacturing industry. It is forecast that the NASA program will generate technology relevant to that descriptor.

Methods of testing the utility of the guide were also discussed with the RDC directors. Two general areas were considered. First was use of the guide as a problem solving tool. In one mode the individuals associated with the programs located through the guide would be contacted. They would either advise on solving the industry problem or provide further insight on where to locate relevant information. In another mode the names of the individuals as well as the programs located with the guide would be used in structuring a search strategy.

The second area considered was use of the guide as a marketing tool. The existence of this special tool developed with the participation of the home appliance manufacturing industry would be used as a further incentive for members of this industry to become clients of the RDC. This second area was discussed not only with the RDC directors but also with their marketing directors.

There followed two sets of activities contributing to the conclusions presented below on utility of the guide. First, consideration was given to the two above areas by the interanl staff of each RDC. The manner in which they would utilize the guide was noted as well as their opinions on the usefulness of several guides in different industries. In the second set of activities W. H. Clingman, J. DiSalvo, and K. Burdsall visited several potential ARAC customers in home appliance manufacturing. W. H. Clingman is principal investigator of the current project. J. DiSalvo and K. Burdsall are responsible for the marketing function at ARAC. In these discussions particular note was made of the attitudes of the industry representative being interviewed and the relationship of the guide to these attitudes. There were five such interviews in the Chicago area with Sunbeam, the Association of Home Appliance Manufacturers, Sears Roebuck, Cory and Air King.

W. H. Clingman and J. DiSalvo visited Mr. Roger A. Rieckman at Sunbeam. Mr. Rieckman is in a staff position relative to the research director and Dr. DiSalvo had made a previous presentation to him. Sunbeam had put $5, 000 in their budget for an ARAC contract but this decision had been reversed by top management. In our conversation Mr. Rieckman raised some immediate objections. He said that the emphasis in appliance manufacturing was on cost and that NASA solutions to their problems would be too expensive to implement. He also said that they periodically review Tech Briefs and that none of them had ever disclosed technology useful to Sunbeam. From this he had concluded that there was no NASA technology that would be useful to them. Finally he commented that they were dependent on suppliers for much of the new technology incorporated in their products. They were not large enough to carry out an independent research effort on new materials.

We countered these arguments as follows. First, we were able to use the name-locater guide, which we had with us, to determine those areas of interest to Sunbeam in which NASA was doing extensive work. One area was noise, and we could point out that NASA had thirteen active projects that would be relevant to noise reduction through application of acoustic materials. We also pointed out that there are twenty-one projects related to noise reduction through design changes. We emphasized that the first step in preparing the name-locater guide had been an analysis of industry problems with engineers from the industry. We had learned that a principal constraint on any new technology was that it could not increase the cost of the end product even though performance might be improved. In preparing the guide current NASA programs were matched to technological opportunities in the appliance industry. There was no reason to believe that in the selected programs all of the technology would be ruled out because of the cost constraint.

Mr. Rieckman said that they had a definite interest in noise problems. He said that he was going to bring to the attention of some of their engineers that NASA had a number of relevant programs in this area. He also said that the proposed ARAC subscription was back in their budget and that a decision should be forthcoming shortly.

The second group visited by W. Clingman and J. DiSalvo was the Association of Home Appliance Manufacturers (AHAM). There the discussions were with the technical director, Mr. Herbert Phillips. A presentation was made of ARAC capabilities, and the specific project leading to the name-locater guide was reviewed. Mr. Phillips was partially familiar with the latter since AHAM had been one of the organizations contacted in the project. After this there was discussion of possible ways that ARAC could work through AHAM in serving the appliance industry. A significant point made by Mr. Phillips was that the mere distribution of printed material would be unsatisfactory. This would include the periodic distribution of abstracts in a current awareness service. Mr. Phillips said that engineers already get too much material crossing their desk. We did not arrive at a satisfactory alternative during this first discussion. ARAC plans to pursue the matter further. It would seem though that the service would need to focus on specific problem solving activities. A potential function of the name-locater guide in these is proposed below. As a first step Mr. Phillips agreed to distribute general information on the availability of ARAC services.

Drs. DiSalvo, Clingman, and Mr. Burdsall participated in the next two discussions. These were with Cory and Sears Roebuck. At Cory the meeting was with Mr. H. R. Karlin. He is concerned primarily with new technology which will improve their present product line. He works closely with another group involved in new product development. There are about seven engineers engaged in these activities. Their main product line is automatic coffee-making machines. Cory has relied principally on suppliers for their new technology. This has only been partially successful. One of the problems that has been with them for years is the fouling of liquid level sensors with lime deposits. There are two approaches to this problem. One is to prevent the deposit build-up and the other is to use a new kind of sensor. Cory and their suppliers have taken the first approach but without success. The name-locater guide indicates that NASA would have technology relevant to the second approach. Mr. Karlin agreed that solving such a problem would be quite valuable to them. He was not convinced, however, that information from NASA would lead to a problem solution where all other approaches had failed for several years. He did comment that NASA information might well contribute toward a solution. His problem in subscribing to ARAC services was in determining in advance how valuable the information would be so that he could justify the cost.

The meeting at Sears was with Mr. Richard B. Priest, Assistant National Manager of Sears Laboratories. This was the second call on Sears by ARAC in about four months. Sears Laboratories is responsible for approving the product design of their suppliers. They become particularly concerned with performance and safety specifications. Mr. Priest had not been present at the first meeting so the initial discussion reviewed ARAC capabilities. Mr. Priest said that Sears Laboratories had worked with the Manned Spacecraft Center in Houston on fabric flammability problems. It was not clear to him, however, how NASA would be able to contribute in other areas. Using the guide we pointed out two appliance problems where NASA was doing relevant work. First was noise as discussed above. Second was plastic liner coatings for dishwashers. There are a number of potentially relevant NASA projects on both adhesives and coatings for metal surfaces. Mr. Priest could identify with these problems. He then asked what the next step should be toward their working with ARAC. A meeting was set up for April in which ARAC will make a presentation to the engineering staff group leaders.

In the final industry visit K. Burdsall and W. Clingman met with Mr. Farmer at Air King. He was responsible for engineering and product development. Before joining Air King Mr. Farmer was with Collins so he was sympathetic with the concept of upgrading the appliance industry with aerospace technology. His difficulty though is in selling his superiors on this approach. In order to sell any project internally he needs the support of someone in marketing. He can only get this if he has a well defined short term proposal. Any project with ARAC would have to focus on a specific problem rather than a general area of interest. At the present time Mr. Farmer is building an acoustic chamber for testing and analyzing the noise from their air moving appliance components. He expects problems when it is completed and at that time will need help. Using the guide we identified a NASA program at Langley that is involved in both noise and performance testing. ARAC plans to follow up.

These visits served as one source of information on the potential utility of the name-locater guide. Comments were also obtained from NERAC and ARAC after their internal staff considered this same question. In Appendix B is a copy of one letter received in this regard from Paul Hengstenberg at NERAC. He plans to test the utility of the guide in acquiring new customers. They will visit some appliance manufacturers that they have contacted previously but who are not NERAC clients. They will visit others for the first time. Their presentation will include an explanation of the guide as a specific resource tailored to the needs of the appliance manufacturing industry. Also at NERAC the guide has been used as an additional resource in serving clients that are not in the appliance manufacturing industry. The guide is helping them work more closely with the NASA TU Centers in meeting the specific needs of NERAC clients.

At ARAC it is anticipated that the guide would be used as a preliminary tool in structuring search strategies for the appliance manufacturing industry. A principal use for the guide at ARAC will be for cost effective identification of NASA individuals that can contribute to problem solutions.

CONCLUSIONS

There were two principal conclusions drawn from the project. First the feasibility of matching current NASA programs to problems in a specific industry was demonstrated. This matching took the form of a name-locater guide for the home appliance manufacturing industry. The guide contained a list of descriptors of the technological needs of that industry. Associated with each descriptor was a list of current NASA projects (RTOP's) relevant to the need and the responsible NASA individual. First the feasibility was shown of generating a descriptor list acceptable to engineers in the industry. Second it was shown that the NASA program was sufficiently broad that one or more projects could be matched with each descriptor.

The second principal conclusion drawn from the project is that such a guide would have special utility in the rapid identification of some relevant technology. This would be particularly true in talking with potential customers. The first reaction of most of those interviewed in the appliance industry was that aerospace technology would be of little value. This doubt would make it even more difficult for a prospect to judge in advance the value of an RDC. The application of the guide would be to identify at least some technology relevant the prospect's needs. This could be done without a thorough analysis of the prospect because the analysis was done for the entire industry when the guide was prepared. The prospects visited in this experiment had the same major technological needs as the firms interviewed during preparation of the guide. Being able to cite relevant technology to the prospect without his committing the time needed to construct a detailed profile of his interests would be significant in the marketing phase. This would help increase the expectations of the prospect so that he could justify the cost of the RDC service before knowing the exact results of that service. A rapid identification is made possible because NASA projects would have been screened and matched to the technological needs of the client when the guide was prepared. Once identifying a program with the guide one or more phone calls to the field center should produce the desired information.

The guide would also have utility in the RDC working with its present clients. In visiting prospects a need was detected for providing more than retroactive or current awareness searches of the literature. A shift of the RDC's to a problem solving orientation is already under way. The guide is an additional resource for locating individuals within NASA that can advise the RDC on specific problems. The selection of these individuals (RTOP's or projects) would be made by the guide preparer only after a thorough analysis of the technological needs of the industry. The selection in the guide thus complements the selection of individuals through other resources, such as the TU office at the field centers. The TU office would be more knowledgeable of the individual capabilities. The guide preparer would be more knowledgeable of the capabilities required to solve the industry problem. His choice of capabilities is reflected by his selection of relevant NASA projects given in the guide.

It is recommended that additional guides be prepared as a new resource for the RDC's that will assist them in moving toward a problem solving mode of operation. It is further recommended that the industries selected for these guides be those which have significance to the consumer and/or national problems and also be those which are not now served to any degree by the RDC's.

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APPENDIX A

PROBLEM STATEMENTS

PROBLEM STATEMENT

"Home Refrigerators"

What is Needed

There are two principal current needs for new technology in the manufacture of refrigerators. These are energy conservation and reduced manufacturing cost. Both will principally result from the application of new materials.

Background

All home appliances are highly engineered products. Considerable effort has been made to reduce manufacturing cost to a minimum through improved design. Further opportunities for improvement will thus come primarily from the availability of new materials or special components. Opportunities for applying aerospace technology to the industry also arise from new demands that are made. In the case of the home refrigerator there is a current demand for lower energy consumption. This is the most important engineering problem facing the industry.

A typical refrigerator has a power input of three to four kilowatts, so the energy consumption is not trivial. It can be reduced by either increasing the coefficient of performance of the refrigeration cycle or by lowering the heat load. Each approach is discussed below.

The compressor is generally made by the refrigerator manufacturer although compressor companies also supply the industry. The product is well engineered and little opportunity is seen for improving performance. The best opportunities lie in improving heat transfer surfaces. On the high temperature side a wire and tub condensor is used. This has a painted steel surface and operates with natural convection. On the low temperature side a fin and tube coil made of aluminum is used with a forced draft. New designs or surfaces which would have improved heat transfer characteristics over these systems would be relevant.

The second opportunity for reducing energy consumption is in reducing the heat load. Special designs of the box itself have usually had too low a sales volume in the market place to be practical. An example is a box with many separate compartments so that only one compartment at a time is exposed to the room air when the box is opened. Thus the greatest opportunity for reducing heat load is through improved insulation. Foamed polyurethane or fiber glass is used now in the wall of the box.

Another area of need in refrigerator manufacture is reduced manufacturing cost and reducing dependance on materials that are in critical supply. Cast iron is used in the compressor for the crankcase, piston, connecting rod, and crankshaft. It is difficult to machine and an improved material would be of interest. Plastic material systems can often lower manufacturing costs since a larger portion of the final unit can be formed as one piece. This eliminates assembly operations. The inner liner is an example of where this would be desirable. The material systems now being used for the inner liner in order of increasing cost are ABS, painted steel, aluminum, and porcelain coated steel. Both the ABS and steel are in critical supply. A material system of comparable cost to these but giving a higher quality surface would be of interest. Work is now being done in the industry on the coextrusion of plastic sheet for this application. The sheet has a layered structure. An expensive material is used at the surface and an inexpensive material forms the bulk of the sheet and gives it structural strength. The sheet is then vacuum formed into the desired shape for the liner.

One of the trends in the industry is toward the use of prefinished material directly from the mill. This means that the operations involving the joining of this material become a larger component of the value added. Improved joining methods will thus receive increasing attention. These include welding methods and the use of low cost adhesives.

Another component of manufacturing cost is that associated with safety and pollution prevention. These factors are related to the volatile chemicals that are used in finishes and in other parts of the manufacturing process. Replacing acrylic finishes with water based paints would be of interest. Diisocyanates are in one of the components used for foamed polyurethane insulation. It would be desirable to eliminate this by going to another type of insulation.

Another area of opportunity for applying new technology is in reducing service costs. Service is usually associated with the timing and control mechanisms. The timer is used to automatically defrost the refrigerator. The control of defrosting through a frost buildup sensor is an alternative that might have utility. Timing mechanisms with improved reliability would be significant. Another service related factor is to lower the cost of service. One manufacturer has a diagnostic module. The serviceman plugs the refrigerator into this module and it automatically performs a sequence of tests on the electrical system of the refrigerator. Expanding this concept to test both the electrical and mechanical operation would be significant.

Constraints and Specifications

The principal constraint on introduction of new technology is cost. The market is very sensitive to product cost and the latter is sensitive to production volume.

The premium which the consumer will pay for an improved product is limited. Also any premium reduces market volume which in turn increases cost. It is thus imperative that new technology not increase manufacturing cost and preferably decrease it.

Characteristics of Relevant Technology

Any technology involving new heat transfer mechanisms or heat transfer surfaces would be relevant. This would include the effect of surface coatings and surface structure on the heat transfer coefficient at solid-gas boundaries. It would include the thermal insulation and conducting properties of materials. New thermal insulation concepts would be relevant.

Technology that could be associated with manufacturing processes would be relevant. Examples are technologies associated with bonding, fabrication, forming, plastics, coatings, and finishes. Technology applicable to the formation of multilayer materials would also be significant.

A final group of relevant technologies would be associated with the reliability of the mechanisms used in the refrigerator. The principal one in this regard is the timing mechanism. Relevant technologies would include sensors of surface characteristics (for frost), timing mechanisms, and management procedures for increasing the reliability of a manufactured product. Also relevant would be technology used to automatically check out performance of equipment. This would include methods of testing mechanical equipment by observing the dynamic electrical characteristics of motors driving that equipment.

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PROBLEM STATEMENT

"Dishwashers"

What is Needed

Basically what is desired is better performance at a lower cost. Improvements are principally sought in three areas. These are the pump, the interior finish of the dishwasher, and new materials for electrical enclosures. In each of these areas there is a need for material systems which retain their functional properties over a long period of time in contact with detergent and water.

New control systems, new cleaning mechanisms, and more efficient methods of performance testing are also areas of interest.

Background

In using new technology the principal aim of the dishwasher manufacturer is to achieve better performance at lower cost. The pump is the primary item of cost. Closely associated with the pump is the motor and control system. The probability of lowering the cost of the electric motor is considered quite low. Work has been done on the control system, however, replacing mechanical timers and sequencing relays with solid state controls.[3] There are systems now which use feedback control and vary the heater input and washing time with water temperature. The primary emphasis in looking at new control systems is on cost reduction.

In the dishwasher there are two pumps. One pump washes only and the other washes and drains. In pumps the shaft seal and clearances are a problem. Generally a gray iron casting that is porcelain enameled is used for the housing and the impeller is aluminum. Manufacturers are looking at plastic materials and glass filled plastics for cost saving. A plastic part can be held closer dimensionally when being formed and thus require less final machining to achieve the necessary tolerances. The tolerance now on clearances in the pump is $\pm$ 1/32". To achieve this plastic parts are formed with a tolerance of 5 mils and castings with a tolerance of 5-15 mils.

Another problem that is arising with pumps is corrosion. Phosphate detergents have contained inhibitors, whereas the new detergents that have been introduced on the market without phosphate have been corrosive. Long term stability in the presence of detergents and water is also a problem with the inner liner of the dishwasher. The principal coating used now on the liner is porcelain enamel. This is expensive and chips, resulting in corrosion of the underlying metal. A PVC coating has been used to reduce costs but it is cut easily, again resulting in corrosion. The PVC coating is also stained by fruit juices.

New materials for electrical enclosures and the control panel would also be of interest. These used to be limited to nylon and phenolic resisn. Now a whole range of materials is being examined. The need is for nonflammable plastics that are easily formed. In the case of electrical enclosures moisture resistance is also required.

There are two further areas of need in dishwasher manufacturing that may be opportunities for applying aerospace technology. One is related to entrapment. Although entrapment of children in dishwashers is rare, Underwriters Laboratories and the Association of Home Appliance Manufacturers will be starting research on this. Sufficient venting to sustain life will be necessary. The need is for the life support data required to do the engineering design.

The second need is for more cost effective performance testing procedures. This involves sampling procedures as well as establishing measures of performance related to the effectiveness of dish cleaning in a given period of time. In particular methods of rapidly assaying the bacteria left on a plate would be significant.

Constraints and Specifications

The principal constraint on introduction of new technology is cost. The market is very sensitive to product cost and the latter is sensitive to production volume. The premium which the consumer will pay for an improved product is limited. Also any premium reduces market volume which in turn increases cost. It is thus imperative that new technology not increase manufacturing cost and preferably decrease it.

Characteristics of Relevant Technology

Any technology relevant to pumps and new materials for use in pumps would be relevant. Plastic materials or composite materials that can be readily formed would be relevant. Improved forming methods that reduce final machining costs would be significant. Corrosion protection and corrosion resistant alloys are also areas of interest. Components associated with a pump such as gaskets and seals would be relevant.

Another technological area involving primarily materials would be associated with finishes. Ceramic or plastic coatings which are durable and impervious to water would be significant. Methods of applying such coatings on metal surfaces would be relevant as well as bonding between metals and coatings. Another related area would be finishes to provide long term corrosion protection. New materials are also required which can be used in electrical enclosures. These would be characterized by good dielectric properties, ease of forming into the desired shapes, and moisture resistance.

Another class of relevant technology would be solid state components and timing mechanisms associated with controls. Finally there is a class of technology associated with the cleaning mechanism itself. Included in this would be methods of assaying bacteria, sterilization technology, soil removal and cleaning mechanisms, and performance testing.

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PROBLEM STATEMENT

"Disposer"

What is Needed

There are two principal needs for new technology. The first is for a material which can be machined to a cutting edge and used in the blades of the cutter. The second is for corrosion resistant housing materials which can be readily formed without machining.

Background

The principal objective of disposer manufacturers in applying new technology is to reduce manufacturing cost. The largest cost component in the disposer is the motor. The opportunity, however, for reducing motor size and thus cost is limited. In most designs power losses in the bearing and seal are less than ten percent of the available power from the motor. The remaining power is used in the cutting and grinding operations.

The housing for the disposer presents an opportunity for cost reduction if new materials can be applied. There are two problems with present materials. One is corrosion and the other is cost of machining an initial casting.

In the lower housing of the disposer cast iron is now used and this requires more machining than any other part in the unit. An aluminum diecast housing has also been used but corrosion is a problem. Corrosion is important since a lifetime of ten years is desired for the disposer. The first component to wear out in present designs is in fact the housing. An aluminum part is now available for the upper housing, but improved corrosion resistance in this case would also be desirable.

To prevent corrosion some manufacturers have tried coating a diecast housing. One study used a 10 mil epoxy coating. The coating, however, failed to have long term integrity. It chipped and scratched readily. It also flaked off from the metal after time.

Another opportunity for reducing costs is in the manufacture of cutting blades. These are now made from a hardened nickel alloy and the cutting edge must be ground. Manufacturing costs would be less with a material that could be machined to a cutting edge. In any new material used in this application durability would be important. The present blades, however, outlast the other disposer components. Thus there is some room for backing off on durability to achieve machineability of the blade material.

Constraints and Specifications

The principal constraint on introduction of new technology is cost. The market is very sensitive to product cost and the latter is sensitive to production volume. The premium which the consumer will pay for an improved product is limited. Also any premium reduces market volume which in turn increases cost. It is thus imperative that new technology not increase manufacturing cost and preferably decrease it.

Characteristics of Relevant Technology

Relevant technology would be characterized by factors contributing to the corrosion protection of metals. This would include methods of permanently bonding plastics to metals as well as coatings for metal surfaces. Inexpensive forming methods and composite materials with structural strength would be relevant. Methods of forming parts so as to reduce subsequent machining costs would be significant.

Another area of relevant technology is associated with cutting blades. New alloys are required which can be machined to a cutting edge. Alternatively new methods of forming a cutting edge applicable to hardened alloys, which can not be machined, would be relevant.

PROBLEM STATEMENT

"Room Air Conditioners"

What is Needed

The principal opportunities for improving room air conditioners are increasing efficiency, lowering manufacturing cost, and reducing noise. These improvements will primarily come about through the application of new materials and manufacturing methods. Advanced control methods will also be important. What is needed in particular are new heat exchange methods, readily formed plastic materials, and a humidity sensor.

Background

All home appliances are highly engineered products. Considerable effort has been made to reduce manufacturing cost to a minimum through improved design. Further opportunities for improvement will thus come primarily from the availability of new materials or special components. Opportunities for applying aerospace technology to the industry also arise from new demands that are made. In the case of the room air conditioner such demands are for higher efficiency and lower noise. Efficiency is probably the single most significant engineering problem facing the industry as a result of the energy crisis.

The room air conditioner can be considered component by component to determine where the opportunities are for applying new technology. First let us consider the compressor. This is the most expensive component. Typically it is a one or two cylinder reciprocating machine with a two pole motor. The units are internally spring mounted and hermetically sealed in a drawn steel housing. Performance of the compressor, of course, is significant in determining the overall efficiency of the air conditioner. Very few air conditioner manufacturers, however, produce their own compressors. The reason lies in the economies of volume manufacture of compressors. The unit volume needs to be of the order of one million per year before a company can afford to tool for compressor production. Thus compressors are manufactured by just a few firms that specialize in this business. The air conditioner manufacturer designs his product around the compressors that are available from such firms.

Opportunities for applying new technology which would make minor improvements in compressors are limited because of the high tooling cost. Major improvements are always a possibility but are less likely to be found.

A significant area which is under the control of the air conditioner manufacturer involves the heat exchange components, which are the evaporator fan, the evaporator, the condenser fan, and the condenser. Little opportunity is seen for improving the fans. New heat exchange concepts applicable to either or both the evaporator and condenser, however, would be very relevant. A past example was the introduction of stamped aluminum plates punched with holes for the coils.

Heat exchange is the major design area available to the manufacturer for improving the efficiency of the unit. The latter is becoming an increasingly important problem. Legislation establishing a minimum BTU/hr/watt is expected in New York. Efficiency is increased by increasing the heat exchange area for a given compressor size. This causes a problem in high capacity units (e.g. 30,000 BTU/hr) where the space available for heat exchange is limited by the size of the window.

Another problem that is related to efficiency is control of the unit. It is desired to maximize comfort in the room with minimum operation of the compressor. Comfort depends on both temperature and humidity. It is standard practice to sense the dry bulb temperature but a satisfactory sensor for wet bulb temperature is not available. If temperature and humidity are not independently controlled, then extra energy is often used to reduce one below a level that is really necessary in order to reduce the other. At least one manufacturer has achieved better humidity control by having both automatic fan and compressor control. Automatic fan control requires sensing not only the temperature but also the rate of rise of temperature in the room. Development of the latter sensor made this type of control possible.

Solid state controls have not been used extensively. One of the problems here is that any unsymmetrical wave forms produced by such controls in the power supplied to the motors causes noise. Noise is a very important criteria in design and any materials with special acoustical properties would be of interest.

The final component where new technology would be applicable is the cabinet. This is an area where new material systems that improve ease of manufacture have been introduced in the past. Strong, fire-retardant materials are required that can be readily formed into complex parts. New manufacturing methods would also be applicable.

Constraints and Specifications

The principal constraint on introduction of new technology is cost. The market is very sensitive to product cost and the latter is sensitive to production volume. The premium which the consumer will pay for an improved product is limited. Also any premium reduces market volume which in turn increases cost. It is thus imperative that new technology not increase manufacturing cost and preferably decrease it.

Characteristics of Relevant Technology

Any technology on new methods of heat exchange would be relevant. This includes design concepts, boundary layer effects at heat transfer surfaces, and thermally conducting materials. Other technology which might be applicable to the problem would include the effect of surface coatings on radiant heat transfer and processes involving the evaporation and condensation of fluids. For example, technology which would allow the economical cooling of the condenser with condensate water would be relevant.

Coatings or conditioning of heat exchange surfaces can be significant. It is known, for example, that a small amount of frost on a surface increases the heat transfer coefficient.[1] If there were a coating that was not wet by water and had a good heat transfer coefficient, the frost buildup on the evaporator might be prevented. This might give greater design flexibility in optimising efficiency where the physical space for the unit is limited. It would also help prevent rehumidification of the room during the part of the cycle that the compressor is off. If there is frost or condensate on the evaporator coils then rehumidification occurs through evaporation of the frost or condensate when the compressor is off.

Any technology which can lead to inexpensive control systems would be relevant. An example would be inexpensive analog circuits that would be used in controlling to a comfort index rather than temperature. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) has developed such an index.[2] In a space with temperature and humidity as coordinates there is a region of satisfactory comfort. For any given load conditions it would be desireable for the air conditioner to bring the room air to the comfort region with a minimum expenditure of energy. The room air temperature at this optimum point will vary with the amount of moisture being introduced into the air and the thermal load. A more sophisticated control system would thus be required than is now currently used.

Any components useful in a control system would be relevant. In particular this would include temperature and humidity sensors and solid state power switching components that were competitive with mechanical relays.

Another area of relevant technology is that which would lower the cost of manufacturing. Joining techniques, adhesives, welding, forming of metals and plastics, and new fabrication methods are all examples. Plastic materials which are flame retardant or easily formed would be relevant. Another area would be acoustic materials for either absorbing sound or dampening vibrations which produce sound.

References

The references listed below supplement the material in the problem statement. Some illustrate through examples major areas where new technology has been applied to room air conditioners.

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APPENDIX B

NERAC COMMENTARY

New England Research Application
Center
Mansfield Professional Park
Storrs, Connecticut 06268
March 12, 1974

Mr. William Clingman
W. H. Clingman and Company
2001 Bryan Street
Dallas, Texas 75201

Dear Bill:

The study which you prepared, concerning how space technology could be applied to the development and manufacture of major home appliances, might help us in our R. D. C. mission of trying to match the documentations of many varied technical investments to specific industrial technical needs.

Several major appliance manufacturers whom we have been up to now unable to persuade to participate in our program, will be re-visited, and given a new presentation which will include an enthusiastic explanation of your study. Hopefully, this additional more specific resource, tailored to their industry's needs, will help persuade them to reconsider their participation in our own R. D. C. services.

In addition, we plan to incorporate an explanation of your study, in some initial presentations to prospects whom we have not previously visited, with the hope that this additional resource might make participation in our program more attractive.

Our presently successful style of matching documented technical investments to specific industrial needs, incorporates the procedure of first having our participant technologists thoroughly identify and discuss their technical needs with appropriately matched University and/or Government professionals, and only then, effectively and efficiently guiding the access of the enormous and varied manual and mechanized information resources available.

The study which you have prepared seems to follow a reverse procedure. It suggests that an intensive effort is first made to identify a large and varied generic resource. Only then is an attempt made to find a matching need. Traditional economic enterprise procedures are usually more successful when a greater emphasis is placed on matching resources to needs than on matching needs to resources.

You should be pleased to know that your "name-locater guide" is being used with increasing frequency and effectiveness as a well categorized resource for the needs of many of our participants who are not necessarily in the major appliance industry. The 125 technical topics are an important help to our expanding program of working more closely with the eleven NASA TU Centers in order to make their resources more available to the specific needs of our participants.

We look forward to reporting to you soon on the effectiveness of testing the value of your study in our field sales activities.

Best wishes and regards,

Sincerely yours,

Paul Hengstenberg
Regional Manager

PH:sjw