EXECUTIVE SUMMARY

1.0 INTRODUCTION

Molecules such as water with positive and negative charges behave as dipole magnets and respond to the rapidly changing field caused by 2450 MHz or 915 MHz alternations in the cavity of the microwave oven. This causes friction and thus generates heat. The industrial microwave oven preceded its domestic counter part. In recent years, the industrial microwave power applications have grown considerably, apart from the usage of domestic microwave ovens. Extensive work has been done in the areas of microwave ovens, magnetrons and microwave heating/ drying processes since mid 1940's, resulting in a number of commercially exploitable processes/products.

2.0 DOMESTIC MICROWAVE OVENS

Microwave cooking brings speed, energy saving and economy while retaining the nutritional value of food. The major components of a microwave oven include magnetron, wave guide, mode-stirrer/ turntable, cavity door and door seals, power supply etc. A typical microwave oven magnetron operates at a frequency of 2450 MHz with a power output of 600-800 watts with a conversion efficiency of 50% and require 3.5-4 KV of anode voltage. The main manufacturing processes consist of pressing, welding, coating, PCB assembling soldering, main assembly and inspection.

Modern microwave ovens must comply with the standards of safety and reliability as established by various standard institutions in different countries. Indicative SKD prices (in 1989) of domestic microwave ovens of 0.6 cu. ft., 1.0 cu. ft. and 1.4 cu. ft. cavity capacity were $ 105, $ 138 and $ 165 respectively for typical models. These indicative prices. show the highly competitive international prices. Many of the containers used in conventional cookery can not be used in microwave cookery because of the basic difference in the source of heat energy. The ideal container for heating food in the microwave oven is one that transmits the microwaves but does not absorb, reflect or refract them. The energy saving in terms of cost is of the order of 25 to 50%.

3.0 INDUSTRIAL MICROWAVE OVENS/ SYSTEMS

i) Advantages

Some of the well established advantages of microwave energy for industrial applications over conventional techniques are as follows:

* Microwave processing saves 25 to 50% energy as heating is focused and dissipation losses are minimum.
* The microwave processing system is more efficient in drying and reduces running costs.
* It offers reduction in drying times, thereby increasing throughputs. Typical reduction in processing time is between 70-80%
* The system is more compact than conventional systems (1/5th to 1/10th of floor space).
* The system offers clean transfer of energy.
* Selective energy absorption by product constituents results in moisture leveling.
* Puffing of material such as tobacco, doughnuts and food products is achieved by internal pressure.
* Heat transfer in the microwave processing system is independent of air stream whenever combination hot air-microwave heating is applied. High velocity air flows are not required, which may result in fan power energy savings.
* Deeper penetration and energy dissipation is achieved rapidly throughout the volume of the material.
* The system avoids overdrying.
* Substitution of an expensive raw material with a cheaper one sometimes is possible in the system which reduces raw materials costs.
* The system has relatively low maintenance costs.

ii) Industrial Microwave Processing Frequencies

Microwave heating/ drying equipment mainly makes use of magnetron frequencies of 2450 MHz ± 50 MHz, 896 MHz ± 10 MHz in the UK and 915 MHz ± 13 MHz in the USA.

iii) Industrial Applications of Microwave Power

Microwave energy has to be cost effective for acceptance by an

industrial concern by one or more of the following:

* reduced running cost
* saving of labour hours
* improving existing efficiencies i.e., enabling greater productivity

Some of the applications of microwave power in the food industry are as follows:

* tempering of frozen products
* thawing
* blanching
* baking
* drying/ dehydration/ vacuum drying/ freeze drying
* pasteurization and sterilisation
* cooking

Some of the application of microwave power in the rubber industry are as follows:

* pre-heating of rubber bales
* pre-heating of blocks and small parts
* pre-heating of solid rubber tyres
* extrusion curing
* rubber moulding
* post curing

Some of the applications of microwave power in the ceramic industry are as follows:

* process control
* plasma processing
* liquid state processing
* solid state processing

In addition, there are a large number of commercially successful microwave processing applications in different sectors of industry.

4.0 TYPICAL SPECIFICATIONS AND STANDARDS OF MICROWAVE OVENS/SYSTEMS

Domestic

The specifications of indigenously manufactured domestic micro-

wave ovens are generally in line with international Specifications. However, there are a number of advanced features available abroad which are at present not available in India. There are a number of tests for construction and performance of domestic microwave ovens specified by various standard institutions in different countries.The emission and exposure standards are among the crucial standard parameters which ensure that safe levels are maintained. Electronic Test and Development Centre, Jaipur has been designated to carryout these tests in India. The Indian standard for domestic microwave ovens is IS:11676-1986.

Industrial

Industrial microwave oven/systems have not taken root in India. Small microwave generators for industrial applications have power output generally ranging from 0-2.5 KW. The standard industrial microwave ovens available abroad have variable power control from 1.5 KW - 60 KW. A number of industrial microwave equipment are tailor-made depending on the exact processing requirements.

5.0 STRUCTURE AND STATUS OF INDIAN INDUSTRY

Domestic

Out of 10 organisations licensed to indigenously manufacture domestic microwave ovens, only 4 units are in actual production viz., Microtronics (India) Ltd, Microwave Products (India) Ltd, Microwin Electronix Ltd and Kelvinator of India Ltd.

One party has abandoned the project. One unit viz., BPL Appliances & Utilities Ltd is presently implementing the project and other 4 parties have not implemented their projects. The indigenous production of the industry is estimated at about 2,500 ovens in 1992. Negligible exports of about 200 ovens have been made by one unit in 1991-92 to Dubai and Russia. Imports of microwave ovens are insignificant as consumer goods are not freely allowed into the country.

Industrial

The production of industrial microwave ovens in the country has not picked up, due to reasons explained later in the text. Some important ones are lack of knowledge regarding its energy and time saving capability. Microwave Product (I) Ltd is the only unit to manufacture industrial microwave heating equipment valued Rs 7.95 lacs in 1989-90. Since only two industrial microwave heating equipments

were manufactured in the past and no trend of its usage is available at present, any projection towards demand estimation is difficult. However, to have a conservative estimate for providing initial planning for demand of industrial microwave ovens in 1994, the figure of 100 systems seems to be realistic.

6.0 MAJOR PROBLEMS OF THE INDIGENOUS MICROWAVE OVEN INDUSTRY

Major problems of the indigenous industry are as follows:

- High import duties on components.
- Reduced level of import duty @ 100% on finished products as part of economic liberalisation.
- Dietary habits of population which is largely not based on instant, microwavable foods as in the west.
- Inadequate user awareness of microwave cooking.
- Inadequate indigenous vendor base for quality components for manufacture of microwave ovens.
- Inability to allocate sufficient funds for in-house research & development.
- Lack of R & D support by leading national R & D laboratories/ academic institutions.
- Non availability of proper microwave cavity design suited for Indian/Chinese cooking. The market of domestic microwave ovens is directly related to the adaption of the microwave cooking by the consumer and will have significant impact in its usage.
- Lack of availability of microwave oven associated utensils, containers, wrapping, covering etc.
- The scales of operation of indigenous manufacturers are far below the levels of the leading international manufacturers who have annual production capacities of a few million ovens.

7.0 SOURCES OF TECHNOLOGY

Out of 5 foreign collaborations approved in this industry, only 3 units viz., Kelvinator Of India Ltd and Microtronics (P) Ltd and Microwave Products (I) Ltd are in production. Microwin is the only unit manufacturing microwave ovens based on indigenous technology.

Number of Licensees are 10. As per Dept. of Electronics, total indigenous production in 1991-92 was 4,548 domestic microwave

ovens valued at Rs 3.45 crores and out of these 200 were exported. The indigenous production in 1992-93 was 2,878 Nos. valued at Rs 0.25 crores.

8.0 INTERNATIONAL COMPETITIVENESS OF INDIGENOUS MICROWAVE OVEN INDUSTRY

The international competitiveness of Indian industry in the field of domestic microwave ovens is determined by several factors as given below:

* The reliance on imported kits for local assembly will not make Indian manufacturers internationally competitive. The major manufacturers have established overseas operations in U.S.A and Europe etc to cater to the world demand in a bid to overcome the quota system restrictions which is dependent on the country of origin. Indian microwave oven as on today is more than twice as costly as the one available abroad.

* The critical components like magnetron, oven door, mode-stirrer, ferrite absorber, etc are not being manufactured in India at present. Thus, the cost-effectiveness of the finished product is a problem area since these are sourced from abroad. However indigensation of large number of components, expecting magnetron is expected in the near future.

* The present level of operation of individual units in India and the performance of microwave oven industry as a whole is inconsequential compared to the mass production operations (of the magnitude of few million ovens per annum) of major international manufacturers. For example, annual production of ovens by Sharp Corpn in 1990 was 3 million numbers.

* The indigenous R & D is practically non-existent except for some effort on indigensation in contrast to the R & D investments of leading manufacturers abroad.

* Consumer electronic items including domestic microwave ovens were under banned list for import as per the Government policy. As such, a threat to the domestic manufacturers did not exist. However, with the reduced imports tariffs from the present level of 100% duty on finished microwave ovens the prices will crash and Indian industry will have to be ready for the same.

* Indigenous manufacturers have a possibility in direct exports to major international retail chain stores since they are open to new

sources of procurement. However, the procurement prices offered are not lucrative. Further, they also need to approve the models based on individual country-specific standards and regulations as well as their own checks for quality and performance.

* As yet, no Indian manufacturer has even obtained the BIS standard approval. The international standards are extremely stringent. ISO-9000 requirement must also be built in to make Indian microwave ovens acceptable in international market.
* Manufacturers should ensure that the provision given in IEC Publication 705 Method for Measuring Performance of Microwave Cooking Appliances for house-hold and similar purposes should be made.
* The competitiveness of indigenously manufactured microwave ovens can be strengthened through export-oriented ventures with prestigious manufacturers in the international scenario. Some of the countries with sizeable Asian population where the Indian exports may be targetted include Bangladesh , Srilanka, Mauritius, Kenya, Pakistan, Nepal etc.
* There is a spectrum of high-end sophisticated microwave ovens with advanced features and this is an area of technology strength to established foreign manufacturers.
* Some exports have been made, although very small, despite the above factors.
* Except for Microwave Products (India) Ltd, who have made a humble beginning in the area of industrial microwave heating equipment, there is hardly any activity in this area by other domestic microwave oven manufacturers. The technology transfer in this are is difficult because of specific designs required to meet the user applications. The competitiveness of the Indian industry in this case depends largely on the wide spread use of such systems in India.

9.0 STATE-OF-ART INTERNATIONAL SCENARIO

9.1 LEADING INTERNATIONAL MANUFACTURERS OF DOMESTIC MICROWAVE OVENS

The leading intentional domestic microwave oven/magnetron manufacturers are listed here after.

Europe	*Japan*	*Korea*	*U.S.A.*
AEG	Matsushita	Gold Star	Litton
Thomson	Toshiba	Samsung	Tappan
Electrolux	Hitachi	Daewoo	Whirlpool*
	Sony		
	Sharp		
	Brothers Industries		
	Imaflex		
	Sanyo		

* NV Philips Eindhoven is presently not involved in the field of microwave ovens as this activity has been sold to Whirlpool. U.S.A.

9.2 MAJOR INTERNATIONAL MANUFACTURERS OF INDUSTRIAL MICROWAVE SYSTEMS

Major manufacturers of industrial microwave systems are as below:

Microdry Corporation, USA
Cober Electronics, USA
Amana Refrigerator Inc, USA
Varian Associates, USA
Calorex AB, Sweden

9.3 GLOBAL DEMAND

Global demand for microwave ovens in 1990 is given below:

Country/Region	Demand for domestic microwave ovens in 1990
U.S.A	8.8 Million Nos.
Europe	7.0 Million Nos.
Asia & Oceania	2.1 Million Nos.
Canada	0.8 Million Nos.
Japan	3.6 Million Nos.
Total:	22.3 Million Nos.

Source: Japanese Engineering Industry (JEI) (November, 1990 issue)

9.4 A summary of recent imports, exports of microwave ovens/magnetrons by USA, Japan & South Korea are given below:

Summary of Recent Imports & Exports of Microwave Ovens & Magnetrons (U.S.A. Japan & South Korea)

Country	Imports (M. Nos)		Exports (M. Nos)	
	Microwave ovens	Magnetrons	Microwave Ovens	Magnetrons
U.S.A (1989)	6.386	4.498		
Japan (1990)	0.152	0.013	2.075	7.949
South Korea (1990)	0.007	2.490	5.509	0.486

Source: Compiled from Annexure 15

The current capital costs of industrial microwave equipment are $2500 - $3000 per Kw based on reliable modular designs with parallel arrays of low-power magnetrons.The magnetron typically has an operating life of more than 5000 hours. R&D in industrial microwave systems is being done in several countries including USA,UK, Japan, Germany, Sweden, Switzerland, China, South Korea, Russia, Egypt, Italy and Yugoslavia.

9.5 DEVELOPMENTS IN DOMESTIC MICROWAVE OVENS

A recent study by Amana Refrigeration, Inc., comparing energy consumption of conventional and microwave ovens suggested a minium energy savings of 63% in 57 of 77 home-microwave-cooked food items. thus study reported energy savings in microwave heating of 50-75%. However, conventional ovens are advantageous for preparation of several items together in a shorter period of time.

Improvements in the design of home ovens are expected for control of heating rates and product "doneness". These may include feedback systems with computerized algorithms of "cookbooks" that can automatically set power levels and process times by product weight and moisture and by oven cavity environmental conditions (gas, humidity, temperature, infrared, and electromagnetic conditions) measured by field sensors. Electronic timers are now used in the more sophisticated home ovens, in conjunction with microprocessors and electronic circuitry for continuously variable power control. The significant advantages of home microwave/convection combination ovens for browning/crisping and for inactivating microbial

contaminants at product surfaces should also increase their use.

The international market has already witnessed the arrival of ovens incorporating artificial intelligence known as "fuzzy logic" to simplify complicated cooking procedures and provide desirable finishing touches to dishes.Artificial intelligence has potential in automating microwave oven system design, modeling, simulation, real time control, tests and diagnostics. Fuzzy logic, unlike the crispy logic in Boolean theory, deals with the uncertain or imprecise situations.

Cooking software for incorporation in the new generation microwave ovens is being developed to suit local culinary culture. Features such as stew timer, synthetic voice guides, food-drying functions etc. are being incorporated in sophisticated models. Boom-rang turntable which places the dish handles towards the user for easy removal has been introduced. Humidity sensors are available in some models for optimum heating. Similarly, air circulation fans are also being used to enhance uniform heating.

Differential overheating effects are seen in food with regions of different dielectric activity, wherein one region of the food absorbs more or less energy than another and consequently heats at a different rate. Such effects are being overcome by new package designs using susceptor materials which absorb energy more strongly and thereby provide localized heating.

Compact microwave ovens with 500 W, 0.4 cu.ft capacity are also available in the international market (example, NN-4208A Panasonic). These are aimed as space savers as they occupy only about 40% space compared to most full-size microwave ovens and are aimed for use in offices, small apartments, etc.

The combination ovens and domestic microwave ovens are tested as per IEC 705-88 test procedure. The magnetron is provided with a limited warranty on parts and labor for five years.

9.6 FUTURE DEVELOPMENTS IN DOMESTIC MICROWAVE OVENS

* **Food**

  Home microwave applications are expected to grow in the coming decade as a result of the increasing consumer demand for convenient and safe food products of high nutritional value and organoleptic quality.Combination ovens are likely to be used increasingly for browning and crisping of surfaces and for reducing surface bacteria. Product development will continue to

emphasize new food formulation and packaging techniques.

Development of convenience foods for those suffering from certain gastrointestinal diseases such as peptic or duodenal ulcers, diabetes, gall bladder distress and colon problems is being addressed. Some attention is being focused in this direction, in view of present supply of suitable convenience food.

* **Vending Systems**

Development of automatic-vending systems with microwave oven integrated into the overall system having loading, refrigeration, transfer and coin functions is anticipated in the future. Two thirds of food-vending in U.S.A consists of hot canned food and 1/3rd includes other items.

Some specific features being planned into the vending system include number of personnel, schedule for food service, number and placement of push-button microwave ovens which have operating instructions of panels, specific heating instructions for each type of food, adequate frozen food, storage space, varied and nutritionally adequate food that are prepared and/or frozen, disposable containers and placement of self-service condiments.

Large-quantity conveyorized microwave oven systems with multimagnetrons have been experimented. The conveyorized microwave oven system consists of a number of magnetrons mounted over a moving conveyor belt with flexible microwave sealing devices at each end. The refrigerated food placed on plastic trays goes in one end and comes out hot at the other end. The development of these systems is anticipated in future for schools, commercial food service kitchens etc.

* **Combination Ovens & Sophisticated Features**

The development of a combination hot air oven with 240°C recirculating hot air and 700 W of microwave power are also being envisaged for future development. Some systems are already in the field. For example, Model NN-8550 of Panasonic provides for four cooking methods in the oven viz., microwave cooking; browning and baking with convection heat utilising the constant circulation of dry, heated air in the oven for cakes, bread, pastries etc; roasting of combination microwave/convection cooking to prepare meat which are tender inside and evenly browned on the outside; and broiling of steaks, chops, hamburgers etc; thorough convection is done with different boiling

temperatures to suit the thickness and type of food. A turbo defrost which uses weight pads is provided to quickly defrost meat, fish and poultry according to the food weight automatically. With turbo defrost feature, there is no need to change power levels or calculate cooking or defrosting times. Also, an automatic turbo reheat feature with memory function for upto 4 servings enables to quickly reheat food. An auto start program allows programming the oven to start cooking up to 12 hours in advance. A doneness control is provided for greater flexibility within the preset auto sensor program. The doneness control enables the cooking time to be increased or decreased for any recipe to tailor-make the cooking programme.Over-the-range microwave/convection ovens are also being marketed. These can be installed over the range with the bottom panel of the range equipped to operate as a two-speed exhaust fan for the range. A special rotating wave guide beneath the oven floor helps to distribute microwaves evenly throughout the oven cavity. A 3-way ventilation system is incorporated to let the air out of the top exhaust duct, the back of the oven and for houses without an exhaust duct, recirculation from front of filtered air. An auto sensor is provided which utilises a humidity sensor to detect the escaping moisture of food cooking in the oven. This provides the oven's microprocessor the information necessary to calculate and program the appropriate power and time settings for a variety of food. An auto weight combination cooking enables cooking of meat and poultry according to their weight without the need for manual setting. Furhter,additional features such as snack menu keys provide in-built settings for specified snacks. Similarly, frozen food keys enable automatic cooking of dinners, frozen entrees and vegetables. Multifunction digital display is also provided to indicate cooking program and time and the readout automatically converts to a digital clock when cooking stages are completed. A three stage memory feature enables presetting up to three separate cooking commands (defrost-cook-keep warm) in a row and enables programming the oven to complete the entire cooking process from start to finish. A stand timer allows setting the oven to count down stand time between or after cooking programmes.

Bread bakery microwave/combination ovens have also been introduced (example family size 1.1 cu.ft Model NN-3659 of Panasonic) which feature a dual flat heater/convection fan heating system to assure excellent cooking and baking results.

The partially microwave cooked food such as meat can be finished off with browning by baking from outside. The built-in bread bakery enables baking of basic bread by utilizing the loaf setting on the panel. To operate, flour, water and yeast in bread container are placed inside the oven and loaf button is pressed. It also incorporates a dough setting to allow preparation bread, rolls etc. Using this setting will stop the bread-making process at the dough stage so that it can be removed and shaped as desired and baked further. It also has a special broil setting.

There are also combination ovens which consist of conventional oven with microwave oven alongwith traditional thermal cooking. There are seven distinct modes in these combination ovens, viz.,microwave, bake, broil, microbake, microbroil, convection bake and convection microbake. These combinations feature external exhaust system, temperature probe to alert when the food is done, gasketless doors, pyrolytic, self-cleaning, programmed sequential cooking, etc.

* **Browning**

For certain food products, a browned surface is necessary and an infrared black body radiator can be incorporated into the top of the oven to grill the exterior surface of the food product at the same time as heating with microwave energy. For example, Model NN-6880 of Panasonic (800W, 1.1 cu.ft family size microwave oven) incorporates a quartz heater to add a finishing brown touch through emission of infrared light. It also is equipped with a touch pad, a convenience feature for automatic browning of specific food in the menu pad.The piezo-electric sensor detects steam from the food and then determines the appropriate microwave and browning time for food. In manual quartz browning, flexibility is provided for inputting individual browning times.

In the past few years, halogen heating elements have been used in domestic appliances as these give rapid source of heat energy at a high infrared frequency. The halogen element can be incorporated into the microwave oven and can be used for particular food products requiring a baked or frilled appearances.

* **Magnetron**

The current method of obtaining the EHT voltage for the magnetron is to use a variable reactance transformer with a

capacitor and a voltage doubler circuit. Much work is currently being undertaken to produce a switched mode power supply which will use a solid state device to chop the incoming 50 Hz waveform in to a 20-50 KHz wave form, which can then be passed to a small ferrite cube core supply the EHT for the magnetron. This is anticipated to simplify the electronic control package and the microwave oven will be considerably lighter.

The magnetron has changed considerably since its invention. The future generation magnetrons are envisaged to be smaller, having greater efficiency with built-in harmonic suppression.

* **Sensors**

Much work is currently being undertaken for the development of sensors for improvements in the cooking of products within microwave ovens. Some of these sensors are already in the market.

- ***Bar Code Sensors***

  Most food-stuffs bought in the super markets abroad have bar codes which designate the stock number and price of the product. With a small modification, this bar code could be made to give the heating time and microwave power required, which could result in an equipment where the user passes the bar code sensor over the bar code of the food to be cooked and the oven then programmes the correct cooking cycle.

- ***Temperature Sensors***

  These are normally used where, a turntable is not, and they comprise in general of a thermistor head carried in a stainless steel sheath. The stainless steel sheath interferes with the microwave energy distribution and gives only a conducted heat reading. New developments are the fibre optic sensors which do not interfere with microwave energy distribution. However, they are prohibitively costly at present, but if the cost reduces significantly, they may be considered in the new generation ovens.

- ***Humidity Sensors***

  These sensors are placed at the point where the cavity air leaves the cavity i.e. in the outlet duct and they control the cooking, measuring the moisture content of the off gases.

* **Weight**

  This technique is used in industry particularly when drying a product. A load cell is used to record the weight of the product during the drying cycle and this information is used to control the programme. The advantage of this technique is to use the weight input to set the time and power settings for a given domestic food product and this would to a large extent make the operation easier for users. If the cost of weighing scales which presently are high are brought down, this feature may be incorporated in domestic microwave ovens.

9.7 INDIGENOUS RESEARCH & DEVELOPMENT

There is little evidence of R&D activity at national level in the field of industrial microwave systems. The present R & D activity of indigenous manufacturers of microwave ovens is aimed at development of components/parts locally.

9.8 TECHNOLOGY GAPS

There are a number of technology gaps which are evident in the area of domestic microwave oven industry in the country. These are discussed below.

* **Component Base** Critical components like magnetron, oven door, door seal, mode stirrer, turntable, cavity, electronic components such as sensors, opto-couplers, LCDs, high-voltage capacitor etc are not being manufactured in India and the requirement is being met through imports. There is a need for promotion of indigenisation of these components by industry. Some of these components like oven door, mode stirrer, turntable, cavity, HV capacitor etc. are under indigenous development. Bharat Electronic Ltd, Bangalore are producing magnetrons for defence applications but magnetrons for domestic microwave ovens are yet to be manufactured by them. CEERI, Pilani is reported to have done some R&D work on development of ASICs for use in the controller of microwave oven.
* **Features** A number of advanced features are available in the domestic microwave ovens abroad such as boom-rang turntable, humidity sensors, infrared sensors, LSI based controllers, artificial intelligence (fuzzy logic), automatic menus for dietary patients etc. Further, although a small percentage of the microwave oven market, commercial ovens and combination ovens (infrared/microwave-hot air/gas) which are available abroad, are not yet available in India.

* **Cooking Software** Most major manufacturers abroad have their own food laboratories and are strengthening strategies for development of cooking software to match the local culinary culture in specific markets. In India, although some effort has been made by manufacturers to prepare microwave recipe books to suit Indian conditions, there is a considerable scope for institutional support for the same.

* **Microwavable Foods** There is on-going development activity in relation to microwavable food and packaging internationally. Because of the small market size in India, no effort has so far been made in this direction.

* **Containers & Utensils for Microwave Ovens** Different types of containers and utensils specifically for microwave oven use have been developed abroad. In India, development effort is yet to be made.

* **Production Volumes** Present industry production level in India is extremely small to be compared with international production levels. The annual production of a single manufacturer (Sharp Corporation) in Japan in 1990, for example, was 3 million nos. The domestic market potential is constrained due to the high prices of finished products and specialised Indian Culinary culture. There is also relative absence of convenience/fast food consumption as in the developed countries.

* **Manufacturing Technology** The manufacturing technology is primarily based on modest investments on in-house equipment for assembly & quality control. Major investments are made by manufacturers in Japan and South Korea etc. for mass production of microwave ovens and magnetrons on automated plants. The typical production capacity of magnetrons in South Korea for example is 7,000 tubes per day.

* **Certification & Standards** No indigenous manufacturer has so far obtained BIS certification. Most countries abroad require certification of microwave ovens and compliance to stringent standards before being introduced into the market. In India, there is a need for a mechanism to ensure the standards of performance and safety. Also, the Indian standards need to be updated to bring at par with intentional certification standards like Underwriters' Laboratories (U.L.).

* **Industrial Microwave Processing Technology** Industrial microwave ovens/systems have been introduced abroad and mil-

lions of dollars have been spent during the last 50 years in Research & Development in this area. Although the industrial market internationally lags behind domestic microwave oven market, there are a number of processing technologies which are commercially proven. In India, there is practically no induction of these systems so far.

* **Research & Development** R & D in the field of microwave ovens is considered as low priority area by national laboratories and the industry is not equipped to invest in in-house R & D, operating in a low-volume market.

9.9 RECOMMENDATIONS FOR DOMESTIC MICROWAVE OVENS

* There is a high-end sophisticated microwave oven/combination oven with advanced features available abroad. These include stew timers, infrared functions, hot-air-circulating ovens, infrared sensors, synthetic voice guides, food drying functions, just-hot sensors, artificial logic to simplify complicated cooking procedures and to provide desirable finishing touches to dishes, automatic menus for heating, melting and cooking for dietary patients, humidity sensors, combination ovens which consist of conventional oven with microwave oven alongwith traditional thermal cooking, computerized algorithms for automatically setting power levels and process times byproduct weight and moisture, over-the-range and compact microwave ovens, etc. There is a need to incorporate some of these advanced features depending on the specific market requirements in India and particularly for enabling exports to advanced countries. There is a need to design battery operated microwave oven as it will be very useful for railway etc. The microwave ovens need to be designed to operate from 90-250 V supply and preferably use Switch Mode Power Supply (SMPS). There is also a need to develop low cost radiation monitor which could be supplied alongwith the oven to the user. The reliability of microwave ovens can be improved and cost significantly reduced if the turntable and the mode-stirrer are completely removed. Future ovens may be based on the concept of generating rotating field in the oven cavity. The rotating magnetic field is not being employed in most of the current commercial models abroad. Uniform wave distribution inside the cavity through this technique requires special design.

  Specific cost implications vis-a-vis traditional oven design depend on several factors including volume of production.

* Commercial microwave ovens for restaurants have not yet been introduced in the Indian market. Since the culinary culture differs from country to country, the Appliance System Groups of major international manufacturers undertake Research and development of cooking software in cooperation with staff, home economists and food technologists in each target country. The indigenous industry needs to consider inter-linkages with hotel/ catering establishments and food research organisations/institutions to develop microwave menus suitable for local tastes and cooking conditions.

  Indian hardware technologists and Indian food technologists may work together to evolve appropriate design of microwave oven cavity suitable for cooking Indian/Chinese. ASIC design by CEERI may be taken as base.

* There is a need for the development of microwave oven compatible containers and utensils. Microwave oven cooking recipes must address preparation of commonly consumed courses/ snacks in the Indian households as well as special microwavable recipes which may be difficult/time consuming to cook by other means of kitchen appliances like electric oven, LPG oven/grillers etc. There is minimal availability at the present time for total meal management including cooking sequences using microwave oven in India. The necessary R&D needs to be taken up by the industry through appropriate linkages with Institutions of Food Technology.

* Food that have formerly been packed for conventional preparation abroad are now appearing in containers for use in both conventional and microwave ovens. An even more rapidly growing segment of the market is food designed specifically for use in the microwave ovens. The development of microwavable food needs to be closely followed by heat resistant plastic packaging for use with microwave oven. Efforts are therefore required to be made in the development of packaging of microwavable food. The industry should get it developed may be through existing R&D/ academic institutions in India.

* The food habits vary from country to country. The software used, should match the culinary culture of that country. Presently this aspect is not being given proper attention by the Indian industry. It is essential that the software development should be done to suit the culinary culture of India.

General Recommendations

* There is a need to develop a common vendor base to the extent possible so that economies of scale for the vendors are achieved, thus benefiting the industry as a whole and helping to reduce the oven price. The domestic manufacturers need to formulate an effective common plan in this regard.
* Convenience food are available in the market but a greater quantity of microwavable food for domestic and institutional use is required. Food that can be recommended in a microwave oven will need a simple, well-known symbol on their packages as well as a listing of their nutritional properties. People on special salt-free, fat-free and sugar-free diets should be able to find microwavable food suitable to them.
* Compared with the international status, the Indian microwave industry is in a nascent stage. This product is in a low priority area and minimal government assistance is expected unless there is a possibility of earning foreign exchange. In order to tap the vast Indian market and to become competitive in the world market, the following thrust areas emerge:
    a) Specifications, standards and norms compatible with ISO - 9000 may be adopted.
    b) Indigenise components keeping in view the financial viability. In this sector considerable development has taken place and it has been confirmed by the manufacturers that but for magnetron and semiconductors all components used will be indigenous very shortly.
    c) Develop microwavable Indian food since this is also a potential foreign exchange earner from Indians living abroad.
    d) Enter into collaborations/joint ventures, specifically with buy-back arrangements in order to enter international markets.
    e) The aim should be to create a niche in the world market rather than competing with Mega Corporations.
* The major international manufacturers have established overseas operations to overcome the quota system restrictions and have large financial resources, reach and established infrastructural support in their international operations. There is a need to develop tie-ups with leading international retail chain stores, joint ventures and explore buy-back possibilities by the indigenous industry in an effort to tap export markets.

There is a need to develop oven models based on individual country-specific standards and regulations for quality and performance to meet the highly competitive international environment.

* There is a need for a regulatory mechanism to enhance the standards of performance and safety. Also the Indian standards need to be updated to bring at par with international certification standards like U.L. It should be mandatory to obtain BIS approval for indigenously produced microwave ovens which should also take into account ISO - 9000 for acceptability in international market.

* There is a need to standardise the information to be provided for the consumer on the microwave oven name plate to include manufacturer's name and address, model and serial nos., size and capacity, seals of approval, electrical specifications, wattage applied to the oven and available cooking wattage within the oven. At present, all this information as well as seals of approval by authorized bodies are not present. The consumer Councils have a role to play in ensuring that the basic product information is available.

9.10 RECOMMENDATIONS FOR INDUSTRIAL MICROWAVE OVENS

Technical Recommendations

* As brought out earlier the cost of energy saved by using microwave ovens is of the order of 25 to 50%. This gives a sizeable saving in terms of money in case of industrial applications of microwave ovens. The cost of saving will further increase as the cost of energy is increasing.

  It is further recommended that the use and development of industrial microwave ovens may be given priority.

General Recommendations

* In India, only Microwave Products (India) Ltd are manufacturing industrial microwave ovens at a modest level. Government may extend special fiscal benefits for users of industrial microwave equipment at par with the benefits extended for energy conservation and pollution control equipment. The manufacturers may also be encouraged through special incentives etc to enable indigenous production to take off.

* There is a need to focus R&D work in India towards particularly for food and rubber industry. There is a need to promote the adoption of commercially exploitable microwave processes in baking, cooking, curing/hardening, dye fixation, sterilisation/ mould inhibition/ purification/ disinfection/ sanitation/ tempering/ thawing, vulcanisation/ curing, etc.