EXECUTIVE SUMMARY

0.1 THE PRODUCT

This study concerns motors of power less than 1 Horse Power (HP) suitably designed for *electronics - based application.* Their primary functions include positioning controlling, timing, sensing in addition to light driving of electronic apparatus. Designs of such motors are aimed towards lightness. miniturization. precision and controllability rather than efficient power output. The term *micromotors* is aptly coined for these types of motors.

As electronics pervades more and more areas of activity, micromotors are being used in audio/video recording, still and movie cameras, husehold goods, electronic toys and games, computer peripherals, office electronics, industrial automation and increasigly in electronic for automobiles. Categories under the term micromotors are DC, AC, Synchronous, Servo and Stepper motors. Principally, this classification is on the basis of the type of current used to drive them to perform the particular function.

The sub-parts of micromotors are nominally the same as those of the larger electrical motors but are quite different in design and performance terms. Micromotors use increasingly powerful permanent magnets instead of field coils: functinons of the rotor electornic communication : their shape is moving from the traditional cylindrical to a compact pancake structure.

The crux of the micromotor is the innovativeness in the disign and development of its key parts. These are generally procured to specific requirements from other industries powerful magnets, special permanently lubricated bearings, high permeability laminations, custom IC, ultrafine but high conductivity wire. Manufacturing process generally comprises minor mechanical processing, high density winding followed by accurately jigged and aligned assembly and testing.

0.2 INTERNATIONAL SCENE

Japanese technology end-uses and their corresponding micromotor designs dominate worldwide. Most of these products were perfected and produced in mass in Japan and then fanned out into Korea.

Taiwan, Singapore, Malaysia as far as the lower cost items are concerned. Currently, Japanese production of high grade micromotors seems to have stabilised at Yen 130 Billion or US$ 1 Billion at the rate prevailing in 1992.

However, about an equel value (US$ 1 Billion) is produced in the other ASEAN countries. Since these are at lower cost level, the quantity produced in other ASEAN countries is more than double of the quantities of advanced motors produced in Japan. Production in Western countries is only of highly professional grade motors where cost is a secondary consideration.

International applications of micromotors are aimed at 40% in Audio & Video, 20% in Home Applications, 15% in Automobiles, 10% in Office Automation and the rest in all other applications. As applications in the digital area proliferate, the product variety is expected to move in favour of Stepper Motors. They are expected to rise from 5% in 1991 to 35% by 2000 in quantity terms.

Variety is on the increases in international markets for various reasons:

(a) Electronic end use equipment is proliferating miniaturising, digitising and providing better designs of motors. Typical example being the Hard Disc Drive (HDD) which has shrunk from 20.32 cm (8") to 13.34 cm (5.1/4" to 3.1/2") to 6.35 cm (2.1/2") while at the same time providing more storage at lower cost.

(b) New end use products are entering the market requiring variations in design of the micromotors. Examples are Digital Tape. Laser Disc, Automatic Cameras, CD-ROM, Robotics, Laptop, etc.

(c) Improvements in materials are enabling, more advanced parts of micromotors. Rare earth magnets (Neoymium Boron), special micro bearing, multilayer PCB Coils, high permeability amorphous iron enable greater precision and torque in tiny, flat "nano-motors" not more than 10 mm in diameter.

(d) Since motors are small enough to be incorporated within any apparatus, motor designs are available for adverse environments. vacuum, explosive, submerged, vibrational, and others.

Driven by the onset of miniaturisation and the profitable proliferation of new applications, the technology of micromotors has met the challenge of change. A variety of technologies and materials have been successfully used.

(a) Powerful magnetic materials (Neodymium "hard" magnets and morphous "Soft" iron) enable superb performance through innovation designs.

(b) Improved fine wires with special treatment enable motors to be made "coreless". This enables lower weight, less inertion, quick response, negligible losses.

(c) Brushless motors are designed with a magnet (with multiple poles) as the rotor and the field coil as the stator. This enables elimination of commutator, slip-ring or brushes by performing commutation through electronic switching.

(d) Disc type or "pancake" motors are a combination of powerful ring magnets and coreless flat coils.

(e) Flatness can be further enhanced by fabrication of the coil by use of multi-layer PCB in which the coil configuraion is attached on the copper layers of the PCB and connected by "vias" which are plated through.

(f) The use of Surface Mount Technologies (SMT) and "chips" components allow the commutation circuits to be mounted within the motor configuration.

(g) New phenomena (other than magnetic) are being explored for creating special types of motors, Piezo-electric effect is employed to propagate an ultrasonic wave round a ring which is turn pushes around a rotor. The rotational speed is determined by the frequency of the wave.

0.3 LEADING INTERNATIONAL MANUFACTURERS

Multi-national and multi-product corporations like Canon. Masushita, JVC, Toshiba, Sanyo, Goldstar, have their own subsidiaries or divisions making micromotors for captive use. Using their own high volume requirements as a base, these divisions also offer their products in the general market through their worldwide trading houses.

However, there are large companies, who specialise in electro mechanical products produce even higher volumes. Most well known names among them are Mabuchi Sankyo-Sieki, Sayama-Precision, Japan Servo, Mitsumi. These specilists have joint-ventures in ASEAN countries who have become large in their own countries as their own electronics industries have grown. These joint ventures now have taken over the low end production from Japan in view of their lower costs.

Special mention needs to made of Mabuchi Motor Co. Ltd. which started in 1926 and has stuck to specialisation in micromotors., They claim a productin of 700 million pieces (about US$ 350 million) from China. Tiwan, Malysia, Hongkong. Of this only 1% of the motors are made in Japan. Share of world market in numerical terms is 55%. They also offer kits of parts and manufacturing equipments to industries in developing countries. The low average ex-factory cost i.e US$ 0.50 of Janpanese manufactures which no one is able to match due to bulk production and automation : bulk of Mabuchi products are at the low end meant for toys, games, mass protables, car windows and spray and so on.

The leadership of Japan in the area of micromotors can be attributed to their strategic position :-

(a) The leadership in designing and popularising end products rest in Japan. Thus the motors built into these products find an automatic market.

(b) The continuing change of models, features, techniques results in a continuous need for R&D where Japan lays great emphasis.

(c) Advancement in materials is now taking place more and more in Japan (viz. leadership in magnetic materials by Sumitomo and Tokoku Industries). These are quickly converted into improved components and products. The control of materials always leaves the trump card in Japanese hands.

(d) Excellence in tool design and fabrication is an enormous advantage where miniature and high precision products are concerned.

(e) Having hold over a large share of the market, Japanese companies automate and robotise their production of main parts and move the more manual assembly work to lower cost countries.

0.4 INDIAN USAGE

Demand for micromotors is entirely dependent on local assembly of the relevant end use equipments. Here, India is behind not only in overall volume of end equipment production but also in variety of items where micromotors are used. The level of activity in India for audio recorders, some other products like toys, games are picking up volume, This is the area of demand of DC micromotors.

Other areas for new types of motors are computer peripherals, office apparatus, telecom instruments and household applicnces. Here, local production is presently moving from old designs to new designs and picking up volume. Production of equipments is just tramoiting from SKD and CKD stages of assembly. The real demand for these micromotors can broadly be summarised at about 5.8 billion DC micro motors, 4.6 million universal motors, 1.7 million household AC motors. In these areas local suppliers can be said to be capable of meeting the demand as far as traditional and older designs are concerned. However, the end use proudcts are moving to modern motor designs and these are being imported increasingly due to liberalising policies. Indian makers are finding it difficult to bring in new designs and to compete in costs with the better imported products.

In case of Stepper Servo Motors, about half a million of each would be the usage. The larger rated stepper/servo motors for industrial automation are partly supplied by techno-entrepreneurs into surrounding niche markets by way of reverse engineering (without collaboration). However, the volume requirement for office automation and computer peripherals is still met through import of kits.

If the area of the part and components are to be looked for all micromotors the position is even more discouraging. This simpler and routine parts like stampings, mouldings, routing bearings shafts are locally supplied by going to sub-contractors. The more advanced parts like powerful magnet microbearings, super smooth shaft, special fine wire, precision brushes, control IC are generally imported and that too from the collaborators.

Forecast for the next few years indicate that in 1996, India will need approx. 18.6 million DC micromotors, 9.25 milliion universal motors, 3.3 million household AC motors. This provides a chance for existing organised units to better utilise their capacity, introduce advanced

types and employ scale of productions to reduce costs. In this manner imports could be curtailed.

Volume of stepper motors is expected to rise to 1.74 million pieces and servo motors to over a million. This should enable the organised manufacturers to add new designs of these motors to augment their output.

0.5 INDIAN MICROMOTOR INDUSTRY

The manufacture of larger rated and traditional motors (espacially of the AC type) has been established in India for many years. Fractional horse power (FHP) AC Induction motors down to 1/4 HP have been made in volume. However, these were mainly for industrial motive power supplied by the electrical engineering industry.

The newer and smaller micromotors meant for the electronics industry commenced production in India only a decade ago. For the organised sector, 8 industrial licenses were issued for DC micromotors prior to the liberalisation of industrial policy. In addition. 34 letters of Intent/registration were issued including. 13 for stepper motors and 12 for the other motors such as servo, synchro and special types.

Approved capacity of almost 95 million DC micromotors in the organised sector has resulted in an installed capacity of only 13 million by 1991. In case of stepper motor a capacity of 2.27 million motors was installed by 1990.

Similarly, for other small motors, out of about 12 million. only 20% was reported installed by 1991.

Actual capacities of small scale units cannot be estimated since motors are generally made manually and for specific niche markets, on order to order basis.

Mention may be made of M/s. Micro Accessories India Ltd. who have established a 50% export oriented project in joint venture with Tokyo Parts industrial Co. Ltd, of Japan. An investment of Rs. 50 million has enabled an annual capacity of 3.6 million DC micromotors. In 1991, they produced 1.2 million motors for domestic and an equal number was exported to their collaborators. They claim to have achieved 80% indigenisation. Now, they are planning to add brushless DC micromotors and instrument fans to their line and expand the

capacity to 8 million per year. Their ability to indiginise and in turn export them seems to be the crux of their strategy for success.

While the organised units focused mostly on quantity production of DC micromotors, the SSUs have moved to making somewhat higher ratings of stepper/servo/synchro motors. These are made in small quantities on order basis and generally by reverse engineering of imported prototypes. Parts and materials are locally procured as far as possible though some critical items are required to be imported,. These units are content to tackle such high margin niche markets with customers around their location. Major investments and aggressive marketing are not their strategy. Notaworthy however, is that they atleast make developmental efforts on their own while the organised sector relies mostly on their collaborators.

The contribution of the "informal sector"around Coimbatore and Delhi should be recognised as makers and suppliers of more routine FHP motors of fair quality at low prices. These are clusters of small parts makers, winders and assemblers who work informally and symbiotically to provide small motors for use in mixies, grinders, juicers and small home appliances.

0.6 CONSTRAINTS

The organised units are noted to be operating under a number of constraints :-

— The more advanced applications are at kit assembly stage thus obviating local procurement of more modern micromotors.

— Even in case of the highest demand DC Micromotors, the requirement of 5 to 6 million in the near future would be just 2 to 3 days output of certain factories in Japan & other countries.

— Fractionation of capacities among numerous aspirants have resulted in low utilization (around 30%) for each.

— Until recently, these units have been almost entirely dependent on collaborators for parts and materials. Collaborators margins, exchange rate and others have resulted in high cost inputs.

The SSUs have been satisfied to remain small, specialised and confined to local niche markets where imports do not bother to attack. Even here, getting their parts made in small quantities leads to delays and thus constriction of their contribution to the overall industry.

With the new exchange rate of the rupee one would expect the possibility of exports to increase. This in turn should provide the necessary volumes required to lower costs. The issues in this regard are :

— Where collaborators agree for buy back from the Indian unit, exports can be enhanced.

— Indian units have not put in sufficient direct export marketing efforts.

— Local added value needs to be maximised through indeganisation of parts and materials. Here the limited infrastructure of tool making and precision large quantity production are a hurdle.

— Concentration of capacity in a few units would enable proper backward integration leading to economies of scale and higher plant value addition.

0.7 TECHNOLOGY ABSORPTION

For the limited range of micromotors taken up in India, the aspects of stacking, winding, assembling, testing such motors can be considered as absorbed by organised small and informal units, to the level of quality accepted by customers. However, true absorption of technology is lackng in numerous respects ;-

— Even for the limited range manufactured, the quality, efficiency and yield is not upto international standards.

— The aspects of fresh designs (except minor modifications) and development has not yet been established. Hence requirements deviating substantially from what the collaborators have given, continue to be imported.

— Technology of the modern miniature type of micromotors has not yet been developed or procured nor research and development initiated.

Much of the technology is built into the parts. As far as routine mechanical parts are concerned, some progress has been made by way of imported tooling to make them locally. However the important parts like high performance magnets, miniature self lubricatitng bearings, super smooth shaft, high permeability laminations and so on are in the domain of other larger industries. Such industries find the quantities of such special needs too small to justify their own technological upgradation.

There are no programmes of R&D specifically aimed at developing advanced types of micromotors at any one institution. Because at the parts level several technologies are involved a multi disciplinary and cross intitutional effort would be needed but has not been organised.

At the level of education and training the emphasis seems to be on traditional high rating motors. Institutions are also not taking course-work or post-graduate specialisation aimed at this new area of motor technology. Attention seems to be mainly in using them as components in control circuits but not in the inwards of the motor itself or its parts and materials.

0.8 CONCLUSION

0.8.1 International Scenario

Motors for may years, were doing the function of prime movers to industrial plants. It is in the last 28 years that the small motor has become a component widely used in electronic equipments. Motors are becoming smaller, more sensitive, more precise for use in electronic goods such as cameras, taparecorders, VCR, home appliances, cars, data peripherals, automation, professional instruments, meditronics and so on.

Under pressure of use as an electronic component, the basic function of the motor as providing motive force is changing. It is being used for positioning, timing, providing constant speeds, etc. Under the overall thrust of miniaturization - which is a relentless pressure on all of electronics - motors, while performing a wide variety of functions are changing shape, becaming smaller, consuming less power, generating less heat and noise, having less vibration, etc.

The worldwide changes that are taking place in motors used in electronics is so varied and so drastic that there is little similarity between the micromotor of today and the traditional electric motor. Of course, motors used as prime movers continue to do their function even today in the electrical industry. Micromotors have become an entirely different product, serving a different market and employing exciting new technologies and materials.

To fulfill the ever widening uses of motors in electronics and under pressures as described above, micromotors are undergoing certain fundamental changes. It is important that :

(i) Because micromotors are of low power (as compared to regular motors) use of magnets, which provides a permanent magnetic field, is wide spread.

(ii) To pack more power into even smaller sizes, magnets with more and more field strength are sought, the latest being Nd-B-Fe material.

(iii) In order to perform complex tasks and at the same time make manufacturing easier and cheaper, complex shapes of magnets - multipole, sectoral etc., are required. For this, composite magnets with plane matrix have been developed.

(iv) Better ways of commutation or doing away with commutation altogether, have been developed. One other way is to use the magnet as the rotor, another is to do electronic switching of the stator coils to sarve as commutation.

(v) Complex electronic signal crossing to make the motor do complex tasks is made easier by use of dedicated integrated circuits.

(vi) To make motors fit into ever decreasing space, motors are changing shape flatter, longer, thinner etc, the limit of this is a silicon motor developed using photolithography which is small enough to pass through the eye of a needle.

(vii) Use of special materials which give the motors improved performance is increasing. Neodemium magnets, high permeability amorphous steel PCB coils and so on, are a few examples.

(viii) Entirely new types of motors are being developed i.e. stepper,

brushless, coreless, etc. Though all may not find widespread application today, they may have in the future.

(ix) Having become an electronic component, the common features of components - standardised specifications, low cost, volume production - are becoming applicable for micromotors also.

(x) Motors are adapted to use in portable batter if operated equipments like automatic cameras camcorders, laptop and notebook computers, etc. by consuming less and less power to do the same function while at the same time becoming lighter in weight.

(ix) International companies are going for high degree of automation to reduce costs and variability in mass production.

Motor manufacture is becoming an interlinked industry with performance of the motor inextrically linked to the materials used in its construction. Since the materials and components used in manufacture of micromotors are manufactured by other industries, close interaction between motor user, motor manufacturer and component/materials suppliers is well established abroad.

Because low price motors are only achieved through mass production, micromotor manufacturers should address global markets. An example will highlight this point. All companies put together made 5 million DC permanent magnet motors in India in whole of 1991. the Japanese company Mabuchi produces 2.5 million motors per day. If the generally accepted norm (in electronics) of 5% reduction in cost with every doubling of production is used. the price advantage of the Japanese company can be imagined.

Micromotor production internationally continues to be dominated by the Far East. Japan is the dominant force. However, though main Japanese companies continue to cater to the market, manufacture is increasingly shifting to low cost areas abroad. To give an example Mabuchi, which dominates the DC micromotor market world wide with 55% market share, produces only 1% of its motors in Japan. There is a steady shift toward low cost areas, like Korea to Taiwan to Singapore. Preferred locations for new plants are China, Malaysia and Thailand. China has 30 factories producing micromotors, with many being large ones.

0.8.2 Indian Scenario

Considering the variety of motors available internationally, the range used in India is limited. Many of the end use applications are not yet introduced in India. and even if there are, the volumes are not present. End use products are made in collaboration with a variety of foreign principals : thus indian market is fragmented with low volumes for most types and models.

The only motor with reasonable demand is the DC permanent magnet used in audio cassette recorder applications. These are being made in the country. Manufacture of printers and typewriters started some years ago and demand for Stepper motors for these applications has started generating. Floppy and Hard Disc drives have also begun to be manufactured in Inda. Volumes are yet to pick up and motors for such drives are not made in the country.

Technology for motors has several aspects : -

— Design of the motor
— Component parts of materials
— Mass manufacturing

India has only limited knowledge of these since certian popular types of micromotors are being assembled from parts purchased from foreign companies. Variations within the basic design are being done in India to cater to different ratings. Design capability does not exist to develop new types of motors i.e. coreless, stepper, etc, in particular the know-why as distinct from knowhows is often lacking.

Components, parts and materials are crucial to the performance of micromotors. Most of these componets are not made in the country. Items like micromachined shaft, fine winding wire, self lubricating bearings, precision brushes, IICs magnets etc. are by and large imported, India is not in a position to develop many of these components for newer types of motors. Motors also need special materials like beryllium copper, phosphor bronze, special silicon steels, etc. Availability of these are severely limited in India. Consumption by the nascent micromotor industry is too small to interest indigenous manufacturers, who have to make additional investments in many cases.

Mass production on semi-automatic lines, if not automatic line, is almost essential to achieve consistency of specification, volume of production and low costs. Mass manufacture of micromotors is a technology in itself. Extensive use of automatic asembly machines, robots, jigs and fixtures are made abroad.

With limited markets, and limited availibility of technology, the development of the industry presents formidable difficulties. If motor manufacture is linked only to the domestic user market, technology could be acquired on a need basis, as and when the country needs them. As it is the present market scenario does not justify investment in a strong R&D effort required to develope new types of motors.

The Indian market is plagued by clandestine imports which artificially reduce prices. This takes place only for those motors which enjoy a wide customer base. Imports also exist for micromotor components which are then assembled in India by SSUs. Since international volumes are very high, the imports tend to depress Indian prices.

0.9 RECOMMENDATIONS

0.9.1 The Indian micromotors industry must compete at global level. Indian markets are not sufficient to sustain an internationally competitive industry in the liberal policy scenario. The industry needs inputs with minimum cost to be competitive with imports as well as in international markets.

0.9.2 An International survey of micromotor manufacturers can be undertaken to try and identify companies who are looking for off shore facilities to locate their plants. Such a survey will also give an insight to the kinds of policies which will attract these investments.

0.9.3 Incentives by way of excise rebate and import duty rebate can be considered to units setting up manufacture with indigenously developed technology.

0.9.4 The problems of motor manufacturers, endusers and component manufacturers can be reviewed by them by sitting together or by arranging an interaction meeting. Many useful suggestions can emerge from interaction meet and on the basis of the suggestions emerging out from the meet, actions can be initiated.

0.9.5 Comperensive standards for the most popular types of motors may be drawn. Standardization will help tremendously in reducing variety and in increasing volumes of individual models

0.9.6 Selected ERTLS and ETDC should be equipped to test a range of micromotors. These laboratory centres can also evaluate and test components and materials used by the motor manufacturers. This will be a direct help to motor manufacturers and this will also enhance exports. These laboratories/centres can also be considered for certification of micromotors, components and materials.