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Small Hermetic Compressors

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R & D

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INTRODUCTION

The industrial manufacture of hermetic refrigeration machinery has existed for about 50 years. The origins of this particular branch of industry go back to 1926 when the American firm, General Electric, brought out the first viable design especially for use in household refrigerators.

Since then a tremendous development has occurred which is of course due to the growth of applications for hermetic compressors for household appliances and in air conditioning.

Production of hermetic compressors in 1974 has been assessed at 64 million, distributed as shown in the table below.

WORLD PRODUCTION OF HERMETIC COMPRESSORS (1974)

Compressors for the household and similar sectors		Independent production approx.
Western Europe	24 million	75%
USA	11 "	50%
Japan	5 "	16%
USSR	5 "	0%
Others	3 "	
	48 million	50%
Compressors for air conditioning plant		
USA	9 million	70%
Japan	3 "	
Europe	0.3 "	
Others	0.5 "	
	13 million	60%
Compressors for commercial refrigeration		
	2-3 million	100%
Total	63-64 million	55%

The table also gives totals for that part of production reckoned to have come from independent compressor manufacturers as opposed to manufacturers who supply compressors to their own refrigerator and air conditioning factories.

The structure of the compressor market can also be seen from the table. By far the biggest numbers lie in the household sector where the requirement is for "small" compressors (up to 1/3 hp). Here, Western Europe has a dominating position.

Within air conditioning the USA has a clear dominance. Not only this, but the centre of gravity of world trade in hermetic compressor production lies in the USA.

American influence stretches further. The main part of world production of hermetic compressors is dependent on American groups, i.e. on licensing agreements or other forms of co-operation. This situation is most marked as far as the "independent" compressor producers are concerned, but it can also be seen to some extent with refrigerator manufacturers who produce compressors for their own use.

This situation is not unnatural when taking into consideration the traditional American position within the field of compressor and air conditioning unit production.

Looking at the "independent" European manufacturers of hermetic compressors, the situation is that six groups dominate. Of these, five have licensing agreements with two American groups. Only one European manufacturer can be considered as independent (Danfoss).

All this is not to say that all further developments on hermetic compressors will be concentrated in the USA for much technical progress in recent years has been made in Europe. However, it is clear that with such a market structure, technical progress occurs in a

relatively few centres of development.

PREVIOUS MARKET DEMANDS

To remain in the market, the compressor manufacturer must of course keep in line with the demands of the refrigeration and air conditioning industries. Although the compressor manufacturer remains largely anonymous to the end user - as long as the compressor works well - he will soon come into the limelight if this is not the case.

The demands which the hermetic compressor had to meet, and which were taken for granted, were:

- High production quality
- Reliability
- Competitive price
- Low noise

REVIEW OF TECHNICAL PROGRESS

Production quality

"High production quality" can be said to mean a quality that will satisfy a series of conditions important in mass production. These include uniformity, a reasonable range within significant function parameters as regards, for example, capacity, power consumption, noise level, start characteristics, as well as keeping the degree of dryness and cleanliness within prescribed limits. Problem-free installation on the production line also assumes that the production and inspection functions at the compressor manufacturers' will ensure a low level of rejects for the end user (e.g. refrigerator manufacturer). In the refrigerator sector it is normal that line rejects significantly greater than 0.5% are unacceptable. On the other hand, it is understood that line rejects are unavoidable since to ensure 100% acceptability on all parameters would be an economic impossibility for compressor manufacturers.

Basic design

It is natural that all progress in development, design and production has as its object the fulfilment of one or several of the current qualitive main requirements.

Hermetic compressors of the '30s and '40s had 4-pole motors. A great step was taken in the 1950s when compressors with 2-pole motors were introduced.

In the beginning of the 1950s the European refrigeration industry stood before a fantastic growth based on small refrigerators suitable for the European market. Compressor design had to suit the limited space available in refrigerators and this requirement was met when in 1955 the 2-pole motor was introduced (Danfoss).

Insulation materials

The biggest progress in the 1960s was the adoption of synthetic insulation materials for motors. Previously, insulation materials were paper, Prespan, and cotton, which give off significant amounts of water at temperatures over 120°C. Motor overheating was therefore critical.

The enamelled wire used in the 1960s was polyvinylacetal (Formvar) which was modified to a greater or lesser extent with phenol-melamine, etc., to reduce refrigerant extract.

A breakthrough occurred with polyester enamels, but the real improvement came with the so-called THEIC modified Polyesterimid enamel.

This gave designers new possibilities of minimizing the overall dimensions of the compressor while at the same time refrigerant extraction had been reduced. The situation today is that extraction from correctly hardened enamel is insignificant. The newest enamels of the ester-imide type are also blister-free in R 502 and R 22 and give off no microparticles in solvents.

Progress in insulation materials has also meant corresponding progress with regard to lubricants. Because of improved refining techniques there has been a movement away from the strongly aromatic naptha oils towards oils with greater thermal stability. The latest oil is hydrogenated and is extremely good for use with R 12.

For the difficult mixable refrigerants like R 22, R 502, and R 131B1 there are now the alkyl-benzenes which are thermally stable and lubricate well. Oil return problems have disappeared with the use of these oils, even in evaporating temperatures in the range -70°C to -90°C.

Electrical system

Defects arising in the electrical system can, under unfavourable circumstances, make the refrigerator cabinet live.

About ten years ago this led Danfoss to work on an idea that would make the electrical system safer.

The new idea was that the electro-magnetic relay be replaced by a PTC (semi-conductor element) and that the current/temp. sensitive element be placed in the motor itself. In this way the winding temperature would be directly sensed, whereas with the previous external device sensing was indirect.

In electrical systems with a PTC starting device the auxiliary winding will always be cut out a few seconds after a starting attempt.

Furthermore, the PTC system offers other advantages since the starting device contains no contacts. This is advantageous as regards working life and it also makes the system suitable for use where there are stringent requirements regarding radio noise level.

The built-in motor protector still contains a moving bimetal with contacts, but since this senses direct on the winding it has to protect it will only operate when required and not because of high loads on an otherwise cold motor. Therefore, a more correct function ensures no unnecessary wear.

Even under extremely low supply voltage (brown out) this system will protect the motor effectively.

We introduced the new system in one of our product lines in 1970 and extended its use to a second product line in the beginning of 1974. Based on 300,000 units on the market, we can safely say that the idea has been a success.

Besides the new technologies just mentioned, a consistent series of smaller improvements in material and design has occurred. In addition there has been a rationalization in production leading towards the desired goals.

EXTENDED DEMANDS

The outside world today not only expects continued improvements of the already good characteristics achieved, it also expects the producers and sub-suppliers to meet a much broader spectrum of requirements and demands, for example:

- Lower energy consumption.
- More versatility in the use of raw materials and less dependence on raw material sources and prices.
- Extended demands on the compressor and refrigeration systems.
- Extended demands on the production plant.

An examination of previous and new demands will reveal what R & D tasks must be taken up.

Reliability is in the main a question of being able to control the production process - not least at the refrigeration manufactueres.

In connection with reliability, an important factor is thermal protection and an expansion of the use of the new electrical system with the PTC/winding protector is expected.

Lifetime is already wholly satisfactory in that a compressor will, as a rule, outlive a refrigerator.

Low prices can only be maintained if a continued rationalization of production can balance increases in wages, and if increases in the costs of raw materials (especially as regards cast iron and copper) can be balanced by savings of material - perhaps by changing to aluminium wire, which up to now has not been significantly exploited in Europe.

Low noise generation is customary from small hermetic compressors, but even so, in Scandinavia and the European Common Market work is taking place to draw up standards of noise output from household refrigeration appliances. These standards will make stricter the requirements on noise, vibration, and pulsation.

The energy crisis caused the industrial world to make a series of reassessments, especially of the way in which we use energy. One of the areas to come under close scrutiny was household appliances; among these, refrigerators and freezers.

There is a great difference in how the various countries tackle the energy problem. In the USA a directive was issued in the beginning of 1975 to the effect that all household appliances in a certain category were to be stamped with the amount of current they used per 24 hours. This enabled users to make appropriate assessments as to type, cabinet size and make when choosing a refrigerator.

Discussions have taken place in the EEC on certain laws and parallel with this activity, consumer organisations in the Scandinavian countries have been considering legislation in line with the American pattern.

In France, for many years there have been standards on max. current consumption declaratuons. However, these have been such generous limits that, practically speaking, all refrigerators sold there fulfil the stipulated conditions. In Germany, standards similar to those in France are being looked at, but in this case with significantly lower values for permissible current consumption.

Technically, the problem can be tackled with better refrigerator insulation and condensers, and evaporators can be altered to give greater efficiency. In future, the choice of defrosting systems will also be given a higher priority, with the least possible power consumption in view.

But it is clear that the market will be enquiring about compressors with high specific output as a parameter of the highest priority.

There are three main areas to be tackled:

1. Mechanical losses
2. Electrical losses
3. Gas circulation losses

With an estimated improvement potential of 15% in specific output, the annual European compressor production could reduce its energy

consumption by $3.6 \cdot 10^5$ kW.

The question of raw materials has already been touched on in the section dealing with prices, but the supply of raw materials to our sub-suppliers is also vital for us. Here, it must be said that we are completely dependent on a number of critical raw materials.

Extended demands on compressor and refrigeration systems will include standards on noise output. But also, in several countries, attention is being given to what extent R 12 can damage the ozone layer. The result could be the laying down of certain rules for the handling of R 12.

Extended demands on production plant will cover the relationship between the factory and the outside world and will involve waste fluids from wet processes and air pollution especially from casting and enamel wire production.

Another important question on the production side is better personnel protection. Auxiliary materials such as cutting oils can, for example, cause eczema. Not only this, working tempo in connection with the short cycle times in mass production must be assessed to ensure the greatest possible degree of personnel protection.

These problems are of course general throughout industry, but I name them because the R & D department in many circumstances is the best equipped to assess the possibilities of changing the production process and because the difficulties which crop up in the factory should influence the the choice of technology for future products.

CONCLUSION

Gradually, as the R & D department tackles the jobs arising from the new outside requirements, it will be possible to provide some solutions in the form of changes within current production. However, it is clear that not all requirements will be met by the present compressor concept and the question of whether a new concept can be created to do this should be raised.

The investment necessary to completely change production for a new generation of compressors is enormous and would under any circumstances be made over a fair number of years.

That is not all. The European market has been in recession so that only 75% capacity was used in 1975 and as yet there is no sign of any significant improvement.

The reaction to this situation will probably vary from manufacturer to manufacturer, but our opinion is that the fundamentals of a new compressor concept should be in our thoughts now.

CTC I and CTC II formed an important foundation and we look forward to CTC III in the expectation of gaining further knowledge about compressors. Knowledge which will be necessary to enable us to create a new and successful compressor concept.