Technology Transfer
Experience at Philips/VALVO

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Abstract

Used as RF sources feeding a particle accelerator, a klystron itself represents a small accelerator as well. Hence, many of the advanced accelerator technologies developed and used at the accelerator laboratories are applicable. The paper outlines the constraints of an industrial firm, why technology transfer is needed and how technology transfer from research laboratories should appear. Some results out of cooperations with laboratories such as DESY, CERN, KfK and KEK leading to a variety of klystron improvements, are briefly presented. A most recently established transfer of state-of-the-art computer codes from the BINP at Novosibirsk to Philips in Hamburg and the reasons why this transfer has been that successful will be discussed in detail. An outlook is given how technology transfer, e.g. from Russia, could be further improved.

Introduction

Philips/VALVO has beeing active in the field of high power high frequency tubes for more than 40 years. Since 1979, at that time still under the brand name VALVO, Philips added super klystrons for scientific applications into their scope of production. In a close cooperation with DESY in Hamburg the first 500 kW continuous wave klystrons for 500 MHz were developed for the PETRA ring. The very narrow time target of less than 2 years from the very beginning to a first tube in operation was possible because of an intensive transfer of application and operation know-how between both parties. During the designing and installation phase the inputs of DESY rf and accelerator experts were of inevitable support.
Although normally used for feeding the particle accelerators with rf, a klystron itself represents a small accelerator. In general the technology used in a klystron is very similar to that in a particle accelerator. This common understanding between the scientific customers and Philips as manufacturer has given a firm basis for this successful scientific and research activities at Philips.
This is only to mention a few:

DESY, Hamburg	PETRA, DORIS, HERA
CERN, Geneva	LEP, LPI, SPS
KEK, Tsukuba	TRISTAN
KfK, Karlsruhe	Gyrotron cooperation

Each cooperation in a accelerator project already is a transfer of know-how and technology.

Industrial Constraints

Any customer,who buys products from an industrial firm expect at least some items of the following list:

- Assured delivery
- Product specification fulfilled
- Products reproduceable
- Sufficient documentation
- Environmental and safety conformity
- Service and replacement
- Application Support
- Warranted lifetime

- Low prices

For reasons above the industry is forced to offer products based on evolution. In other words industrial companies have to introduce new technologies and design approaches into their products very carefully. Neither the customer would accept a failing of the product on his expenses nor could the manufacturer afford the resulting technical and financial risks. Klystron know-how is based on a long-lasting experience. The knowledge standing behind a klystron design is very complex. One of the main requirements to a klystron is the longevity in operation. Each supplier has its special experience how to fulfill these expectations. However, any change in the technology has an influence on the life expectation, which is difficult to predict. Typical klystron life times are 20,000 hours. Unfortunately klystrons cannot be tested for that long time period because of the excessive costs. For that reason a change in technology is an extremely risky affair.
Unfortunately excessive research and development efforts are hardly to reearn in the days of shrinking budgets worldwide. It has taken into account that the share of costs directly influenced by salaries and wages in a product like a klystron is already above 80%.
Hence the industry more and more will loose the capability to prepare state-of-the-art products on its own expenses but will need financial or other external support. This situation is especially valid for large accelerator projects in the future, which are scheduled far into the next century but already requiring investments today for products not yet available.
Technology transfer might be one way to enable the industry

keeping in touch with latest results of accelerator technology. But how should technology transfer look like?
Technology basically is know-how, either manifested in designing or production expertise. Any "imported" technology should either extend or improve the available in-house possibilities. This implements, that a foreign technology must be able to get transferred into the current production with a lowest level of disturbances possible. For that reason the exact conditions have to be clearified in a very early state. Otherwise the introduction and follow-up costs could be much higher than expected and tolerable.
The basic principle of a successful technology transfer is quite simple:
Extend the capabilities required for the future whilst safeguarding the current business with the premises available today.

Practical Experience

In 1985 KEK started the installation of klystrons to the TRISTAN ring, for which Philips delivered klystron types derived from earlier tubes for the PETRA ring at DESY. In the course of TRISTAN operation at KEK a lot of improvements in general klystron technology have been investigated and tested. Philips brought in their long-term production and application experience KEK worked systematically on technological aspects. In this phase already very intensive investigations were running on high power rf windows. As KEK tested the results in its own klystrons the reliabilty and behaviour could be observed for a long time. Based on this field results Philips could introduce the improvements in its own klystrons now at a low risk.
Whereas Philips is very reluctant in introducing foreign technologies due to reasons mentioned above, one spin-off of the KEK klystron design activity has found immediate acceptance: the large signal klystron computer simulation. Together with peripheral computer codes like EGUN for gun design, PE2D for magnet field calculation and SUPERFISH for cavity design the Field Charge Interaction code (FCI) developed by Dr. Shintake at KEK permitted a very accurate large signal klystron simulation running on a workstation. A close interaction between KEK assured a implementation and adaption to the Philips CAE system. The simulation results are very close to practical measurements on existing tubes. This for the first time opened the possibility to reduce the quantity of hardware trials to an absolute minimum. The development time and costs could be decreased respectively to a remarkable extent.
Encouraged by this CAE experience Philips came in touch to the Budker Institute of Nuclear Physics (BINP) in Novosibirsk. BINP offered a set of state-of-the-art computer codes running on a PC instead of a workstation. These codes covered the whole peripheral calculations needed for the FCI code, namely for gun injection, magnet field and cavity data. The results and the simulation speed were impressing. But even more than the pure results the support by the BINP experts during the introduction phase were outstanding. In this phase the advantage of technology transfer by "software" against hardware became very obvious. Unlike a "hardware" technology transfer a lot of items could be handled much easier:

- No standardization problem
- No logistical requirements
- No transfer of materials
- Easier documentation
- Easier communication

The later point has shown as very sensitive one, because the normal communication links into Russia like mail, telephone and facsimile have been very vulnerable. The only very reliable link was found to be the scientific InterNet system. For that reason Philips decided to get interlinked into the InterNet communication network. Besides normal correspondence also file transfer of any kind of information then was possible. Upon this basis within recent years a lot of new very effective computer codes have been developed at BINP and introduced at Philips. In summary following reasons are dominant for this successful technology transfer cooperation:

- Highly skilled pysicist
- High motivation
- Large fundus of institute experience
- Excellent response time
- Very flexible
- Extraordinary good teamwork
- Confidence

It has shown that very frequent correspondence is inevitable to define the work to be done very carefully. If this is handled very consequently alignment visits could be reduced to a minimum.

Outlook

Technology transfer has to be beneficial for the receiving as for the transfering counterpart. As each company and laboratory has its own constraints one have to accept that very flexible commercial and administrative handling is requested. Besides the normal money back-flow arangement, which commits the industrial firm to pay back an amount or share of money after these products could be commercially used, also alternatives should be discussed like counter business, transfering hardware equivalents etc.
One major thing to overcome is however the virtual barrier between industry on the one and science and research laboratories on the other side. As long as making profit by an industrial company has a negative smell in some areas of the scientific community a transfer of know-how to the industry is mentaly burdened. It has to made plain to all sceptics that making profit in the industry is the one and only way to maintain know-how but also the interest for future challenges. This will need common continuous efforts.