

## RADICAL NEW RESEARCH STRATEGY AT THE SMRI: SOME LEARNINGS FROM THE PREPEX PROJECT

By

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### Abstract

IN 2006, the Sugar Milling Research Institute (SMRI) embarked upon an ambitious new research strategy to develop technologies capable of creating step-change opportunities for the South African sugarcane processing industry. In doing this, the SMRI has moved away from incremental improvements to much more innovative research with potentially greater commercial rewards for its members. The first major project to be identified under this new strategy was the 'Prepex' project, which aims to replace the conventional cane preparation equipment with non-wearing components in order to minimise downtime for knife and hammer replacement. Laboratory and small-scale pilot plant research was undertaken, a detailed economic model was developed, and market assessment was conducted to assess the technical and commercial viability of the process. The technology was proven and a patent was lodged. The learnings outlined in this paper include intellectual property management and the role of economic modelling in driving research and development direction and paving the way for commercialisation.

### Introduction

The Sugar Milling Research Institute (SMRI) is a research organisation funded primarily by the southern African sugarcane processing industry and the research arm of the Institute is almost wholly funded from this source. In 2005, the SMRI identified the need to revise its research strategy, in light of a highly competitive marketplace, both domestically and internationally, and the pressure placed on the South African sugarcane industry from diverse factors. The South African sugarcane processing industry already operates at high levels of efficiency and relatively low costs of production by international standards, leaving little scope for using existing technologies to make substantial improvements in efficiencies and costs.

This led the SMRI to embark upon an ambitious new research strategy in 2006 to develop technologies and new products capable of creating step-change opportunities, fully aligned with the strategic objectives and needs of the industry (Dewar and Davis, 2007). In doing this, the SMRI moved away from incremental to much more innovative, high-impact research with potentially greater commercial rewards for its members.

SMRI researchers were encouraged to think laterally and to investigate other industries for technologies that could be used in sugarcane processing, and which could result in significant cost savings or recovery increases.

Cane preparation had been identified as a high cost area of the process, because of the labour and maintenance costs associated with wear of knives and shredder hammers. The first major project to be identified within this new research strategy was to find a way to replace conventional cane preparation equipment with a process that has minimal wearing parts, which it was postulated would reduce maintenance costs and reduce the regular shuts for maintenance.

The nature of this project brought with it a number of challenges which needed to be worked through including, but not limited to, intellectual property (IP) management, economic modelling, and scenario identification and modelling around the potential market for the technology. The development of the process and the learnings that have come with it are discussed in this paper.

### The Prepex idea

The Prepex process was born from a demonstration of high-pressure water jetting, and the idea that it might be used to shred sugarcane. A quick test with suitable portable equipment showed that high-pressure water could indeed shred cane very finely. It was clear that this innovative approach could eliminate the maintenance and labour costs associated with regular replacement and hard-facing of the wearing parts in conventional cane preparation equipment, and could reduce the frequency of factory stops required for this replacement. It was envisaged that as a consequence of its ability to shred the cane finely, the water jetting process could not only replace conventional preparation equipment, but it could perhaps combine preparation and extraction into one unit operation (Figure 1), with obvious cost savings. Hence the name 'Prepex' (**P**reparation/**E**xtraction) was coined.

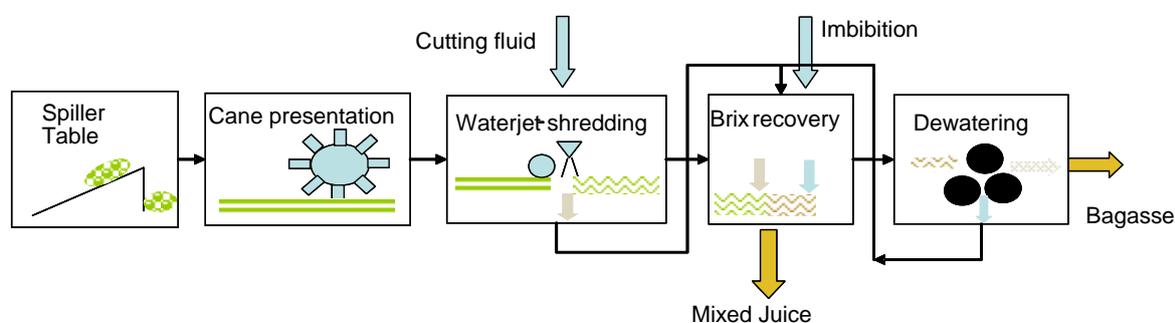


Fig. 1—Outline of Prepex process.

From an early stage it was realised that two of the key factors that would determine the commercial feasibility of Prepex were the amount of water required to shred the cane, and the energy required to do so. The first factor not only influences the energy required directly, but any more water used for the preparation and extraction in excess of current imbibition added would bring an additional energy penalty for evaporation. Hence, it was necessary to develop a test rig to determine the water and energy requirements.

### Need for confidentiality

It was obvious that, should the Prepex technology prove successful, it would need to be exploited appropriately, and that the SMRI members should get the benefit of having funded the development. Thus, protection of the idea and know-how at an early stage was critical to ensure that a formal IP protection route could be followed if deemed appropriate. Confidentiality around the new idea had to be assured. This entailed consideration of:

- **In-house confidentiality.** Scientific researchers are taught to publish their results in journals and at conferences and are keen to share their experiences with other experts in the same field. When working on new, possibly ground-breaking, technologies, this is not always the desired behaviour. It may be necessary to keep the invention, design, project, and the scientific work confidential until the IP has been properly protected. For Prepex, this required a change of behaviour on the part of the researchers, and also required that measures above and beyond the standard Confidentiality Agreements required by the company were put in place. This included frequent reinforcement of the need for confidentiality with employees, not solely the researchers, but every member of staff who assisted with research, documentation, analysis, and any other work to do with the project.

- **Collaborator/Partner/Supplier/Service provider confidentiality.** During the Prepex project, the SMRI team required particular information (for example, the specifications and costs of very high pressure pumps with particular materials). Before revealing any of the process know-how or even the Prepex concept to potential collaborators, suppliers, or service providers, it was necessary to ensure that there was a comprehensive Non-Disclosure Agreement (NDA) in place to protect the potential IP. This led to delays in the research as these NDAs were negotiated and signed. The terms of the NDAs included the requirement that the other party also had agreements in place with their employees to ensure that the NDA was adhered to across the company.
- **Distribution of reports.** The SMRI's Advisory Research Committee (ARC), which comprises industry, scientific and academic representatives, meets twice yearly to guide research direction and to oversee progress of current research areas and to ensure that the SMRI Research Program remains relevant to the industry's needs. In order to keep SMRI member factories, and more specifically the ARC, informed of progress and to retain their support to continue work on Prepex, it was necessary to provide regular progress reports. There was thus a play-off between maintaining confidentiality and providing information each time a report was issued. To reduce the risk of premature leakage of IP, the SMRI was forced to produce reports that contained indications of success, as well as any problems that needed to be overcome, without revealing the intricate details of the IP. It was also necessary to differentiate what information was distributed to the ARC, and what was disclosed to the general membership via monthly reports. Raising awareness with the ARC of the need for confidentiality of the information shared with them was also a new requirement of the SMRI's new research strategy.

### **Techno-economic modelling**

It is well-appreciated at the SMRI that, in order for research to be considered successful, it must be directed towards achieving outcomes, namely the commercial implementation of technologies, processes and products derived from the research. Hence, evaluation of the merits of a research project must be done on the basis of both technical and commercial risks and potential rewards, to both the SMRI and its members.

Consequently, it is necessary at an early stage in the project to develop a techno-economic model that can provide insight into these areas. The detail and accuracy of the information contained in the economic model will likely increase as the project progresses.

Where a technology will replace an existing process, as with Prepex, this allows one to know what the boundaries are relating to costs. For Prepex, rough estimates of costs were used initially, but as the project progressed, the numbers in the model were refined as information was gathered.

Regular updates of the model allowed the research team and the ARC to make informed decisions on the viability of Prepex, as well as decisions on how the perceived costs, or risks, weighed against the perceived rewards should the technology be implemented. An important aspect of such a model is that it should include sensitivity analyses to direct research towards the key elements that have the greatest influence on the economic feasibility of the technology.

The model used for the Prepex technology compared the existing technology costs with those of the Prepex process, and included costs such as:

- Annualised capital costs. These were based on major items, such as knives, shredders, diffusers and mills, with percentages applied for ancillary items.
- Annual maintenance costs;
- Annual labour costs, where savings could be made;
- Energy costs.

Although the first three costs sound simple to determine, it was difficult to get accurate values for existing preparation and extraction installations. Of the three, capital costs should be the most accurate, as data from projects involving new factories, or capacity increases, are fairly readily available. Companies are, however, often reticent to divulge these numbers. Accurate maintenance and labour costs for particular areas of the factory were even more difficult to come by for a number of reasons. This area is one where sugar companies can compete on production costs and, as such, they are often unwilling to divulge information that may assist a competitor. Secondly, factories do not always maintain accurate records of maintenance and/or labour costs for each section of the factory. It was therefore necessary to estimate these costs for the project economic reviews.

At the early stage of development of Prepex there was poor technical definition of the size and nature of the equipment required. As the project progressed, it was possible to refine these costs only slightly as the plant design could not be finalised. Maintenance costs depend on the reliability of equipment and maintenance cycles required. In the case of new technologies, these may need to be estimated for the entire project life cycle, until a demonstration plant is in operation. In the case of Prepex, suppliers of the major equipment could not provide any reliable data on the maintenance or replacement frequency of the equipment, such as nozzles and high pressure pumps and, consequently, estimates had to be used. Conservative ‘worst-case’ estimates are often used, which could affect the viability of the new technology detrimentally, but for Prepex the research team and its industry-appointed advisors used their engineering judgement to estimate realistic values.

## Technical development

### Laboratory experimental work

A small rig (Figure 2) was constructed at the SMRI for testing of the principles and to gain an understanding of the key factors affecting the efficiency of the Prepex process. This rig was capable of processing only a few stalks of cane at a time and for short durations only (2–10 seconds). Nevertheless, it enabled several different types and configurations of nozzles to be tested, and allowed the project team to get an idea of what was possible and what wouldn’t work. However, although the rig enabled the team to shred cane completely and rapidly (Figure 3), it was clear that it would be difficult to optimise the energy and water consumption because of edge and start-stop effects associated with the small rig. At this stage, it was realised that a larger rig would be required, which would be able to generate sufficient shredded cane for initial extraction trials to progress, and a request for such a rig was taken to the ARC for support.



Fig. 2—General layout of first Prepex rig.

However, because of the radical nature of the technology and the conservativeness of the world sugar industry, the ARC guided the SMRI research to focus initially on preparation only, rather than develop the combined Preparation/Extraction technology. This was not entirely in line with the project team's thinking, as the maximum benefit was believed to come from the combination of preparation and a simplified extraction process. Nevertheless, the ARC approved the budget to construct a larger rig that was capable of handling up to 60 kg of cane at a time.



Fig. 3—Cane shredded with Prepex.

This larger rig was built (Figure 4) and testing commenced. One of the factors that was believed to limit the efficiency achieved with the first rig was the pressure of the water. The new rig was designed to handle a higher pressure, but the cost of a pump to supply the pressure and flow-rate was prohibitive, so a suitable pump for testing was borrowed from a commercial high pressure cleaning company. However, the limited availability of the pump meant that an extensive experimental program could not be carried out, and unavoidably delayed the rate of progress.



Fig. 4—Larger Prepex rig.

The trials that were performed showed that the technology certainly had great potential, and that energy requirements were in line with those of current preparation equipment. Some concern was again expressed about the amount of water required, and how this would impact on the extraction achieved in the following step. It was postulated that a way around this would be to use juice instead of water for the shredding. The major problem that was encountered was sourcing

pumps that could pump sugar juice at the flow rates and pressures required. Most pump manufacturers contacted were unwilling to commit to quoting for a unit for this duty, and one pump that was considered suitable was extremely and unrealistically costly because of the uncertainty about the effects of the high pressure juice on the pump internals. This information was fed back into the economic model, and somewhat changed the outlook for the viability of the technology.

### **Upscaling the technology for commercialisation**

In order to get more certainty about the energy and water consumption, and to better define the technical details with a view towards commercialisation, the next stage was to design and build a pilot plant at a factory. The SMRI realised that for the technology to become a success and to be transferred to the marketplace where commercial outcomes could be realised, it was appropriate to engage with a company that would be able to assist the SMRI to scale-up the technology through to commercialisation. It became clear that a simple 'arm's length' transaction with a party was not going to be appropriate, and a partnership would be required. A potential partner would want to be assured of the technical and commercial potential of the technology and share in the subsequent commercial returns from the technology.

The appropriate time to bring a partner on board requires some thought, considering the balance between the increased likelihood of commercial success and the share of the eventual returns. Detailed agreements on IP sharing are required, i.e. what background IP each of the parties possess and how foreground IP developed during the partnership will be shared.

The process to decide on an appropriate partner for Prepex required considerable debate, in that some of the obvious candidates were already involved as SMRI members or were direct competitors in technology development. Thus it became necessary to develop and agree on a set of evaluation criteria that could be used objectively to rate each candidate's suitability, and an expression of interest was called for from the short-listed candidates. In the end, a suitable partner was selected but, by this stage, the time was rapidly approaching for the national patenting applications, and there were still some technical and commercial hurdles to be addressed.

A brainstorming session was held with the chosen partner to agree on the way forward and the appropriate way of developing the technology. The technical success of the technology was recognised, but some peripheral technical hurdles could only be addressed by further expenditure on a pilot plant. However, the cost of pumps to pump juice appeared to be a major factor in the economics, and there was insufficient information available to reduce the uncertainty and risk associated with these costs. It was agreed that, given the current information available to the parties, the commercial risk did not warrant investment in a pilot plant and further work at this stage.

### **IP protection**

#### **Early considerations**

In parallel with the technical development, formal protection of the IP was considered. The first decision to be taken was whether to patent at all. Just because an idea is patentable does not necessarily mean that it should be patented. Issues that need to be considered are the costs of patenting, the chances of being able to exploit the patent, the willingness of the organisation and its stakeholders to protect, enforce and defend the patent, and how the patent would be linked with the technology exploitation plan.

Once it has been decided to patent, the decision as to when to patent must then be made. It is generally advisable to delay the formal IP protection process until sufficient information has been obtained to decide on the likelihood of technical and commercial success, but the decision as to when to patent is not always easy. There is a need to balance the risk of the idea being leaked and thus entering the public domain, which will jeopardise the granting of protection by the relevant authorities, with the risk of someone else developing the idea in parallel and lodging proprietary protection in advance.

Although most countries abide by the 'first to protect' principle, some countries, notably the USA, abide by the 'first to invent' principle. In such cases it may be possible to challenge IP

protection based on dated records kept of meetings, brainstorming sessions, research work, or any other associated ideas. Similarly, such detailed records are important with regards to NDAs signed with collaborators, service providers and the like in terms of establishing background IP. Although it is accepted practice for scientists to document work in a laboratory workbook, it is less common for engineers to do this as engineers tend to be more interested in solving the problems than in recording how. Keeping of detailed dated records of modifications made and new ideas that were tried was a necessary behavioural change that the Prepex research engineers had to embrace.

### **Provisional patent protection**

With regards to the Prepex technology, the SMRI lodged a South African provisional patent in February 2006. This started the clock ticking for development of the technology to the point where a strong and well-defined full patent application could be submitted. However, delays in sourcing and installing some of the equipment meant that time was running out on the provisional patent, and insufficient results were available to be sure of the viability of the technology. One option was to allow the first provisional patent to lapse and to apply for a new one. This carried the risk that anyone who had developed the same technology in parallel and had applied for a provisional patent before the second Prepex provisional patent was taken out would get priority. However, the risk associated with this was considered very small, and the decision was made to buy the extra time with this option, with the follow-up provisional patent being lodged in February 2007.

As work on the project proceeded, the ARC agreed that there was sufficient commercial potential in the technology to apply for a Patent Co-operation Treaty (PCT) provisional patent. Writing this application required considerable debate about what should be included. Considerations included:

- Should the patent cover the process (i.e. the use of high pressure liquid to shred cane) or the product (the details of the equipment to achieve this)?
- Should the patent cover preparation only, or be extended to cover extraction as well?
- Should the patent cover applications beyond preparation of sugarcane to produce sugar to include ethanol as well?
- What are the key elements of the technology that are patentable and protectable?
- What competing technologies were in the public domain, including other patents?

In the end, these questions were resolved, but it was clear that the level of knowledge required to answer them went beyond the experience of the technical project team who had started the project. Other team members with more experience in IP and commercialisation were brought in to assist with these issues. Finally, a PCT patent application was submitted in February 2008 (Loubser and Gooch, 2008). Feedback from the International Preliminary Examination Authority was that all claims were found to be both novel and inventive.

### **National phase patenting**

When considering the appropriate strategy for national phase patenting, several issues come into the picture. It is necessary to identify in what countries the protection is to be sought, as each country requires a separate application, with resultant costs. These costs include legal fees for compiling the patent filings, translation costs where required in non-English speaking countries, the actual filing costs and annual fees for maintaining the patents. Potential costs for enforcing patents also need to be considered.

Identification of the countries in which to patent requires knowledge of the potential markets in order to determine whether the potential returns would cover the protection costs. These could include countries where the technology may be installed, manufactured for use in other countries or further developed. In the case of sugar factory applications, the market size is probably the easiest to ascertain. The number of factories world-wide, and by country, is readily available. More difficult is an estimation of market penetration. Points that need to be considered include:

- Would the technology only be installed in new installations?
- Would the technology be installed to replace worn-out or obsolete equipment?
- Would the technology be installed to replace functional existing equipment?
- Would the technology be installed for capacity increases?

Factors which affect the above decisions are mainly the capital and operating costs and the return on this investment. If the returns are significantly higher than for existing technologies, then there is a case for replacing equipment and reaping the rewards as soon as possible. If the benefits are lower, then the technology may only be used for some of the other scenarios.

Another factor for consideration in the scenario analysis is the industry itself. What barriers to entry exist in the industry with regards to new technologies? The sugar industry has shown itself to be fairly conservative, with the uptake of new technologies (e.g. wholestick shredders and diffusers) to be fairly slow, despite the apparent advantages. This consideration could have a significant effect on the market penetration of a new technology, and should be borne in mind for IP management. Patents have a finite lifespan, and the likely number of installations completed in this time is of significance.

While taking account of the assessed commercial risk when national phase patenting decisions had to be made, the SMRI Board was appreciative of the potential impact of the technology which may be realised should some of the existing constraints change or an opportunity arise to exploit the Prepex technology (for example, together with a simplified extraction technology). The Board therefore approved that the technology be patented in South Africa, being the home country, and in Brazil, being the country of greatest growth and expansions and where suitable applications were most likely to arise.

### **Conclusions and key learnings**

The Prepex project has been the first major project for the SMRI since the implementation of its ambitious new research strategy. As such, the learning curve has been extremely steep. Irrespective of the outcome of this particular project, the information gathered will stand the Institute in good stead going forward in its quest for radical new technologies that will revolutionise the sugar industry. The key lessons learnt are summarised:

- R&D needs to be aligned with industry strategic objectives – i.e. it must be relevant.
- Assess the techno-economic potential of various projects as early as possible and invest in those where there is a higher chance of successful outcomes.
- There is more to a commercial outcome/success than a good idea and a technically proven technology. Commercial issues may be more difficult than the technical ones.
- It is important to develop an economic model early and update it frequently.
  - Include sensitivity analyses.
  - Identify key hurdles and direct R&D efforts to resolve them.
- Understand the importance of collaboration – different skills feature strongly at different phases of the innovation process.
- Realise the importance of good IP management.
  - IP awareness among all stakeholders – researchers, support staff, members/sponsors, collaborators, suppliers – is critical.
  - Need to look at ways of keeping interest/support of members/sponsors without divulging key details (risk of IP leakage).
  - Ensure that membership rights are reserved.
  - Don't waste time innovating in areas where you are already locked out by prior patents/public domain issues – keep abreast of the state-of-the-art.
  - NDAs must be in place before discussions with outside parties and this can slow down the development process.

- It is critical to maintain a detailed paper trail of developments and discussions.
- Patenting decisions are complex.
  - Whether to patent – just because the technology is patentable does not mean that one should patent the technology.
  - When to patent – there is a trade-off between needing sufficient knowledge about the technology to lodge a strong patent and the risk of IP leakage or being pipped at the post by a competitor.
  - Where to protect – this is driven by the exploitation strategy, cost: benefit assessment, potential take-up of the technology, conservativeness of the industry, and so on.
- Learn from your mistakes and successes, and use the lessons the next time.
- If failure seems likely, fail quickly – otherwise it can be VERY expensive.
- Decision-making is required at each stage to upscale the technology.
  - The more certainty required, the more it tends to cost.
  - When the certainty is not there, the decisions tend to come down to the potential of the technology (Prepex: potential = MASSIVE) versus the technical/commercial risks and the investment required.
- Above all, if you do not try, you will never succeed!

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## NOUVELLE STRATEGIE RADICALE DE RECHERCHE AU SMRI: QUELQUES RESULTATS DU PROJET PREPEX

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### Résumé

EN 2006, le Sugar Milling Research Institute (SMRI) a entrepris une nouvelle stratégie de recherche ambitieuse pour développer des technologies capables de créer des opportunités de changement radical pour la transformation dans l'industrie de la canne à sucre sud-africaine. Ce faisant, le SMRI a réduit les projets de moindre importance pour des recherches novatrices, avec un potentiel de gains commerciaux plus importants pour ses membres. Le premier projet majeur à être identifié dans le cadre de cette nouvelle stratégie a été le projet 'Prepex', qui vise à remplacer le matériel de préparation de canne à sucre traditionnelle avec des composants qui résistent à l'usure afin de minimiser les arrêts pour le remplacement des couteaux et des marteaux. Des essais à petite échelle et en laboratoire furent entrepris, et un modèle économique détaillé a été développé afin d'évaluer la viabilité technique et commerciale du projet. La technologie a été prouvée et un brevet a été déposé. Les résultats présentés dans ce document incluent la gestion de la propriété intellectuelle et le rôle de la modélisation économique de la recherche et du développement ouvrant la voie à la commercialisation.

## NUEVA ESTRATEGIA RADICAL DE INVESTIGACIÓN EN EL SMRI: ALGUNOS APRENDIZAJES DEL PROYECTO PREPEX

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### Resumen

EN 2006, el Instituto de Investigación de Molienda de Caña (SMRI) se embarcó en una nueva y ambiciosa estrategia de investigación para desarrollar tecnologías capaces de crear oportunidades de 'cambio de nivel' para la industria procesadora de caña de Sudáfrica. Al hacer esto, el SMRI pasó de realizar mejoras incrementales a una investigación más innovadora con mayores beneficios potenciales para sus miembros. El primer gran proyecto de esta nueva estrategia fue el proyecto 'Prepex', que busca el reemplazo de los equipos convencionales utilizados para la preparación de caña por equipos con componentes que no se gastan, con el propósito de minimizar el tiempo de reemplazo de éstos. Se realizó investigación a pequeña escala en laboratorio y planta piloto, se desarrolló un modelo económico detallado y se realizó un estudio de mercado para determinar la viabilidad técnica y comercial del proceso. La tecnología fue comprobada y patentada. Los conocimientos descritos en este trabajo incluyen el manejo de la propiedad intelectual y el rol del modelamiento económico para conducir la investigación y el desarrollo y construir el camino hacia la comercialización.