TECHNOLOGICAL PRACTICE CASE STUDY			SEPTEMBER 2008
HARD MATERIALS TECHNOLOGY	YEARS	7-10	11-13

ADEPT – DESIGN THAT MATTERS

Auckland plastics manufacturer Murray Fenton designed an easy-to-use, accurate intravenous (IV) infusion device for use in developing countries. The device costs around $6 to produce compared with the US$2,000 high-tech versions used in first-world hospitals. With billions of IV sets used every year in the developing world, this device is saving many lives. This case study overviews the issue and aspects of a design process, including the designers comments on working with a client, form and function, and choosing the right materials.

FOCUS POINTS INCLUDE:

Nature of Technology:

- Characteristics of Technology: Socio-cultural influences
- Characteristics of Technological Outcomes: The role of the industrial designer

Technological Knowledge:

- Functional Modelling

Technological Practice:

- Components: Materials selection
- Outcome Development and Evaluation: Fitness for Purpose

ADDITIONAL SUPPORT MATERIAL

- TV3 News video February 2008
- NZ Herald article January 2010: www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=10619420

WEBSITES

- Design that Matters http://designthatmatters.org
- Adept Medical Ltd www.adeptmedical.co.nz
- Medicine Mondiale www.medicinemondiale.org

ADEPT: DESIGN THAT MATTERS

The issue

The administration of medicines and rehydration fluids by intravenous infusion (IV) is a common medical procedure employed worldwide. In first-world hospitals, microprocessor-controlled syringe pumps – which cost at least US$2,000 – are used to ensure safe and accurate drug delivery.

In the developing world, however, a 50-cent plastic roller clamp is typically used to control IV flow rates. These clamps have no markings to permit flow rates to be accurately set or reproducibly controlled or even to indicate if the clamp is open or shut. Its highly sensitive adjustment mechanism mean that even trained medical staff have difficulty setting and maintaining accurate and safe infusion rates. When administering potent drugs such as anaesthetics or HIV and chemotherapy drugs, a 3mm (the width of the 'm' on this page) movement of the roller clamp may be the difference between life and death. Children have such limited tolerances, it is almost impossible to accurately control low IV infusion rates required to safely treat them.

In the developing world, particularly in crisis situations, patients are commonly left to treat themselves, often with fatal results. Roller clamps 'creep', resulting in highly variable flow rates, and movement of the patient or IV line can change the roller clamp setting resulting in under- or over-administration of fluids. This is a big problem – about 2.5 billion IV sets are used in the developing world every year.

A few years ago, an American not-for-profit organisation Design that Matters (DtM) studied the problem and decided to do something about it. DtM is a collaborative network of volunteers in academia and industry who donate their skills and expertise to create breakthrough solutions for communities in need. They approached Auckland inventor Ray Avery with some ideas and asked if he could turn them into reality.

Ray knows a thing or two about using appropriate technology to solve third-world problems: he is the founder of Medicine Mondiale, an independent development organisation that provides medicines and equipment for those in need. He worked with humanitarian eye specialist Fred Hollow, and set up factories in Eritrea and Nepal to produce cost-effective Perspex lenses for the sight-impaired – factories which today make 10% of the world's supply of artificial lenses and return healthy profits used for blindness prevention.

▲ *Above: IV drip treatment of cholera victims at a refugee camp in Mozambique. [Medecins Sans Frontiers/Doctors Without Borders]*
◀ *Left: A child being treated on a cholera cot at a clinic in Bangladesh. [Medecins Sans Frontiers/Doctors Without Borders]*
From http://designthatmatters.org/portfolio/projects/iv-drip

Ray approached Adept Medical, a spin-off company of specialist plastics-forming company Adept Ltd based in Auckland. Founded originally as a custom injection moulder, Adept has evolved into a turnkey solutions provider with a fully-fledged design house, tooling shop, and production capabilities. The company is headed by Murray Fenton.

Ray explained that a simple rugged device was needed to be used by relatively untrained operators to control flows of IV fluids with greater accuracy than the conventional roller clips. DtM had proposed a solution for development, but Murray could see that, for a variety of reasons, it wouldn't deliver the fine control they wanted. The issue intrigued him. The device had the potential to save millions of lives throughout the developing world, so he agreed to develop the controller free of charge.

Design and prototyping

Murray Fenton pondered the issue. He describes design as an “off and on” process, that proceeds “in bursts of success and periods of despair”. He uses terms like intuition, inspiration, epiphany. “It’s not a conscious thing. You can go off track and most of the time it doesn’t work.”

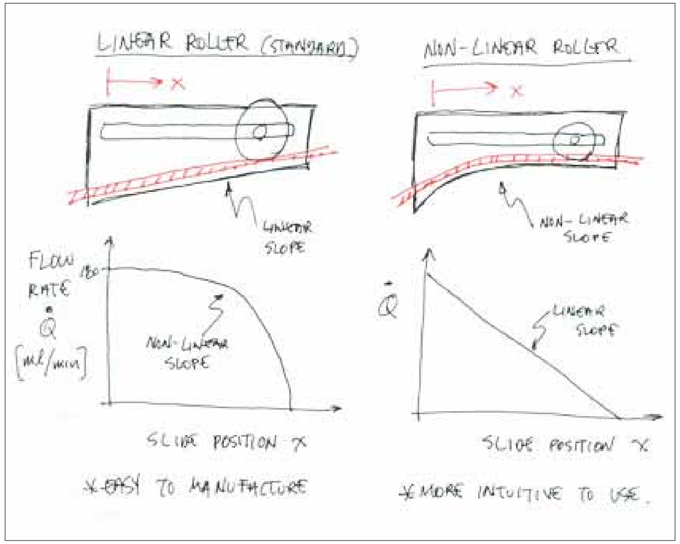
“A long time ago I saw a device that the Israelis had made to help control the flow of irrigation fluids to hillside vines in the desert.” Their solution was to use a very fine capillary system that could be manipulated to create pressure differences through the system. Murray Fenton reasoned he could use a variation of the same approach.

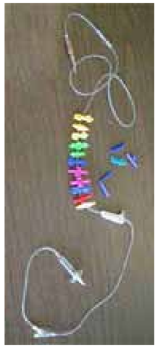
“I tried to compress the tube [on the IV line] in such a way to create a capillary tube over a length to get better control.” A number of prototypes, based on variations of the roller-clamp, were tried but nothing worked.

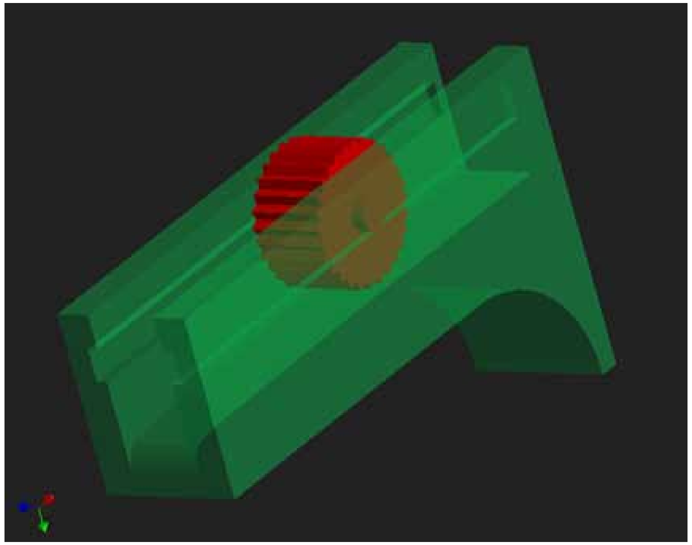
After mulling things over for a while, Murray came up with an alternative approach. Rather than design a control system that was built into an IV line, why not make a reusable line-compressing unit that attaches to the outside of the line? The up-front cost of such a device was higher than a disposable one, but it was reusable, and therefore would save money in the end. And because it attached to the outside of an IV line, rather than being built into it, the device could be larger, simplifying the engineering involved. Adept employed a young designer to develop the idea and model different approaches.

“She tried all different things to compress a tube over a bigger length. For the best part of a year she made all these little prototypes and measured pressures, and finally came up with a curved shape that worked better than a flat shape and all the other options.”

The new and improved IV drip clamp: Early sketches (below), early functional models (right, top) and CAD drawing (right, below)







Modelling a key part of any design process, Murray believes. He remembers a client who ‘’played with bits of wire and springs” and made 51 variations of an idea before presenting the refined prototype for development.

“The big secret is to make a bunch of rough prototypes. The rougher the better. If you make a rough prototype, it will probably teach you something. Or lead you into another prototype. But if you make a really good version you become wedded to it. It’s hard to let go of something that you have put a lot of time and effort into. Whereas if you just make a cardboard model, you can let go. You have to be prepared to abandon things. When you start getting close to what appears to work, increase the accuracy. Home in on it.”

“It was the same with this. We weren’t very careful about sizes or dimensions. Some models were just bits of plastic pinched together in a vice.”

WORKING with a CLIENT

CLIENTS/END-USERS INFLUENCE THE DESIGN PROCESS: from beginning of a project to its completion, when they may file reports on the performance of the finished product.

According to Murray, the quality of most initial input varies wildly. “Some clients come in with an almost complete design. Others come into the factory with, say, a vacuum cleaner connected to a spray gun, wave their hands around, and say the finished product has to be about yea big.”

Quite often an expert in their field will have a very clear view of what they want, but this is no guarantee the idea will be commercially successful. Very few ideas he is presented with are commercially viable, he says.

The inventor often has a very biased view of the value of his product. One in ten ideas are probably worth pursuing further and one in ten of those will be successful.”

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After deciding they were on the right track, the Adept team produced more refined models in steel, a material that was easily machined to the very fine tolerances required by the capillary system. Finally, after deciding the design offered sufficient control, Murray and his team used a rapid prototyping machine to pre-produce a working model out of plastic.

"It looked pretty promising. We improved the design and got an engineer to refine the shapes on CAD, then we gave the full CAD design to Ray and said we reckon this will work."

At this stage, TradeMe founder Sam Morgan became involved and offered to fund the die-making required to produce the units on a commercial scale.

CHOOSING the RIGHT materials

MATERIALS INFLUENCE DESIGN. In the case of the flow controller, Murray and his team had to very carefully consider the properties of the plastics they used; besides being able to be worked to tolerances measured in microns, the plastic(s) chosen had to resist creeping under load.

"The selection of plastics was critical. We had to try and make something strong enough not to creep, very accurately, which is very, very hard to do with plastics. It was very important to use materials that gave us the properties we wanted. To get the efficiency of production and to get the strength, we had to use much thicker sections than we would have liked. Mechanically we stepped out on a limb."

Hands-on experience counts for a lot when deciding on materials. Murray Fenton remembers on another project discovering, after "playing around", that two particular plastics had an unexpectedly low friction against each other. A lot of alternative choices would have squeaked or bound. "They had a particular feel. It was just like magic, yet I've never seen anywhere else these two materials run together."

The final product

The Acuset™ IV Flow Controller has the potential to save millions of lives and improve the quality of clinical care in almost every clinical discipline throughout the developing world. It costs US$6 to produce, and is designed to last 10 years. Its patented dial-a-flow mechanism enables flow rates to be set with a high degree of accuracy and precision similar to the high-tech US$2,000 equivalent. It is intuitive to use even by relatively untrained operators.

To summarise the improvements of the the Acuset™ IV Flow Controller over the traditional roller clamp:

- The Acuset™ IV Flow Controller:
  - enables superior accuracy and precision;
  - has a linear flow rate control that provides faster and more accurate flow rate settings;
  - is intuitive to adjust and use by untrained operators and novices.
- The traditional roller clamp:
  - has flow rates that cannot be preset or reset, and must be adjusted manually for each administration;
  - 'creeps' resulting in highly variable flow rates over time;
  - requires clinical training and expertise to operate with reasonable degree of accuracy.

The device is being evaluated in a study at Auckland Hospital and in field trials in Nepal. It was one of ten finalists in the prestigious $100,000 Saatchi and Saatchi Award for World Changing Ideas for 2007/2008.

The Acuset™ IV Flow Controller will be sold by Ray Avery's development agency Medicine Mondiale. Central to Medicine Mondiale's ethos of sustainable practices is the development of products and technologies that have applications in both the developing and developed world markets. The Acuset™ Intravenous Flow Controller is an ideal product for them, as it can also be used to control the flow of chlorine in swimming pools in the first-world market.

FORM and FUNCTION

FORM SHOULD FOLLOW FUNCTION – Murray is a great believer in this maxim but, he says, good design involves more than that. Because industrial designers design products for the real world, they need to focus on user-centred designs that will also be profitable. They have to know why they are designing the 'thing' and its target market. They must design the product so it can be manufactured in a timely, cost-effective way, and ideally, in an environmentally sustainable way. And, Murray says, designers must build-in the intangible quality of desirability.

"To me, there's two parts to it: engineers make things work, industrial designers add that touch of magic and desirability. To make something commercial, you have to create a good first impression in the eyes of the end-user. It's not decoration – it's something that creates an instant appeal. You have to come up with a shape that does everything you want it to but you also have to convey on first sight, in a second or two, a desirability."

Even for a piece of medical equipment? "Yes. It could look fantastic in pink or be transparent but it's got to look like a sound medical part with a history behind it."