# PART E—PROJECT DESCRIPTION

## E1 Title:

**Nonlinear modelling, analysis and prediction of optimal conditions for the cold roll forming process.**

*The proposed project investigates fundamental analytical and experimental aspects of the highly nonlinear process of cold roll forming of flat strip to shaped product in order to gain predictive understanding and determine the optimal process conditions. The primary outcome will be an innovative software based setup system that will permit operators to balance and optimise mill productivity, energy consumption, mill downtime, product change-over times and facilitate the development of new products.*

## E2 Aims and Background

Roll forming is a general term used to describe a large class of continuous manufacturing processes. These processes utilise a rotating rolls to progressively deform continuous lengths of sheet metal for mass production of shaped metal product. Typical products of roll forming include welded steel pipes and tubing for structural, mechanical and low pressure reticulation applications. These are subsequently used in a universal field of end user applications ranging from medical equipment to office furniture. A significant advantage of this forming process is that the length of the tubes or pipes are limited only by the amount of materials supplied from coiled stock. The mass production of large quantities of tubing and pipe is performed most economically by means of a continuous process in which a number of driven or undriven profiled forming rolls are arranged in series or tandem. The long series of individually designed profiled rolls progressively form the flat steel into a shaped section (as illustrated in Figure 1) or pipe with a welded seam along the length. At present, Australia is one of the world premier producers of these products. Australia's leading manufacturer in this area, Smorgon (formerly Palmer) Tube Mills, utilise a cold roll forming process, in which the steel is not heated. This gradual cold forming process, provides superior product, by enhancing the strength of the steel and allowing very tight dimensional tolerances to be achieved.

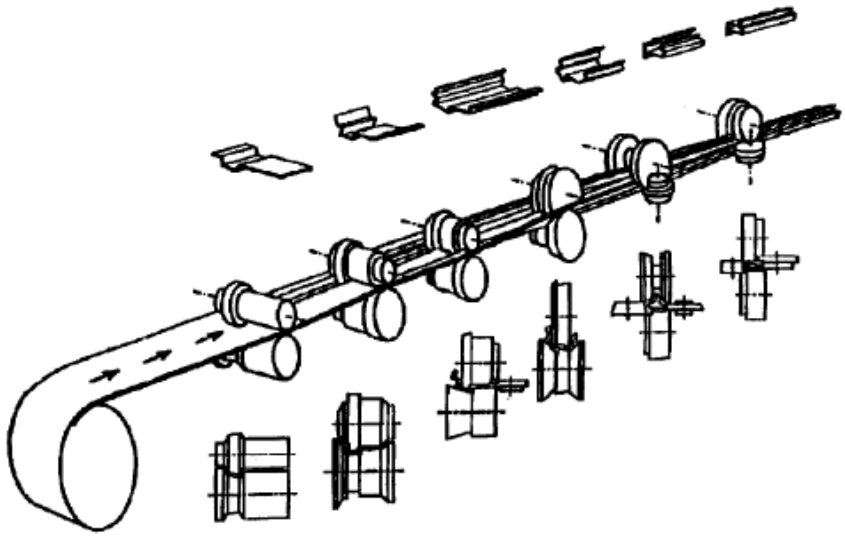

Fig. 1. Schematic of the roll forming process [2]

Although the process has been utilised for many years, at present significant new increases in productivity and efficiency appear to be hampered by a number of complexities. The forming process mechanics itself is highly nonlinear involving high levels of plastic deformation and geometrical complexity. Also the progressive tandem configuration of the roll forming process, although significantly increasing productivity, adds complexity due to interactions and flow on

effects occurring between each roll forming stand. At present, this means, proper design and sequencing of the forming rolls requires considerable experience from operators. In fact the design procedure for cold roll forming products, roll pass sequences and forming rolls remains more an art than a science[1]. Maintaining tolerances, minimising springback due to residual stresses, and tearing and buckling of strip are also typical and difficult problems to address. The effect of lubricants on improving roll life and surface finish of the strip is also significant but not well understood. All these parameters interact in a highly nonlinear fashion. In practice this means that although over time, experienced operators may be able to setup the process adequately for one product there may be significant delays involved in tuning the process for any new product. For example, each new size pipe diameter requires a different shaped tool and setup for the tandem rolls. At present, tool design for roll forming machines is more of an art than a well founded science. No definite rules have been established that can apply to a large variety of sections in the roll contours as a given section may vary considerably depending on the designer. It thus appears the future profitability of the process is over dependent upon highly experienced operators that are diminishing in number and training skills.

It is proposed that complete insight into the process of cold roll forming has not been achieved due to the lack of fundamental analysis that encapsulates the physics of the interactions occurring between the most critical parameters. As such, experimentally validated predictions of the system behaviour and optimal setup configurations have not been achieved.

The main purpose of this project is to develop the fundamental theoretical and numerical groundwork for predictive understanding of the cold roll forming process in order to identify the critical process parameters and determine optimal setup operating conditions. Based on this critical insight, a model-based optimal process setup system will be developed to balance and optimise mill productivity, product quality, energy consumption, mill downtime, product change over times and facilitate the development of new products.

*In particular, the primary aims of this project are to:*

- *Develop nonlinear analytical and finite element numerical models for the cold roll forming process taking into account previously neglected influences of rolling contact conditions, interstand interactions, lubrication.*
- *Determine the critical parameters associated with the strain and residual stress distribution in the product in order to minimise defects and enhance mechanical properties,*
- *Validate models experimentally via extensive online measurements on a full scale mill*
- *Develop a cold roll forming setup module.*

It is perceived that this strategic basic research project will provide the foundations, via fundamental theory, tools and understanding of limitations, required for optimizing the production of existing products as well as facilitating the development of new products.

It is noted that the motivation for this strategic basic research arises uniquely from the combined fundamental and practical insight into rolling processes in the rail transportation and steel production of the chief investigators. This critical fundamental research experience and insight will be well supported by the practical experience of the direct industry support from Smorgon ensuring successful achievement of the outcomes.