Press Shop Machine Analysis and Trending

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ABSTRACT

Historically downtime data collection and reporting systems in many automotive body panel press shops has been somewhat adhoc. The impetus for this study stems from frustration in respect of how this data is collected, assessed for trends and presented. Ideally this data should be used to identify costly repetitious faults for actioning of maintenance work and for feedback to tool design for consideration when designing new parts.

Presently this data is stored largely in the form of tacit knowledge by press shop operators; the encumbrance of transferring such information being that there is very often only limited channels to quantify it into something more tangible. Findings show that there tend to be two related obstacles to plant data recording. The first is that automation of down time data collection alone cannot determine fault causes as the majority of press shop events are initiated primarily from operator observation. The second is that excessive subjective operator input can often result in confusion and end up taking greater time in recording than remedying the actual fault.

This Paper presents the development of a system that through press mounted touchscreens encourages basic subjective operator input and relates this with basic objective data such as timekeeping. In this way all responses for a given press line become valuable and can be trended and placed in a hierarchy based on their percentage contribution to downtime or statistical importance. This then is capable of statistically alerting maintenance, lineflow and/or toolbuild areas as to what issues require their most urgent attention.

Keywords: Data driven manufacturing; Quality Assurance; Downtime Issue.

INTRODUCTION

Much work has been done in the areas of Quality Assurance (QA), operations research and plant optimisation techniques, as they pertain to Automotive Stamping Plants. While nearly all auto manufacturers have, through their QA systems attempted to implement a number these concepts and theories, an observation has been that at times they are plagued with low acceptance when or even before being placed into practice. In many cases this low acceptance is due to a lack of accurate input data. The result is little or no confidence in the system output [1]. By way of demonstration, such a case is presented in this paper.

It should be noted that this case does not appear to be isolated in the automotive stamping world and moreover, it is this author's view that while there are many sub-issues, there is one major cause. Manual recording, as used by many stamping plants, is time consuming for the operator and any perceived benefit is so far removed from the operator's day to day activities that it is easily overlooked or neglected, especially at a time when the operator is already under pressure to remedy a fault situation.

Demming [2] identifies that some companies are notorious for not collecting enough information about their processes, but alternatively, he suggests, there are companies that collect too much. A condition often referred to as "paralysis" develops, coming about due to excessive and largely unnecessary data collection.

For a collection system to be effective there needs to be a mid point found, where cost of collection and processing does not outweigh cost savings. This is often a difficult point to find; usually only coming about through considerable tuning of the system.

Of recent years, there has been a concerted effort toward "data driven manufacturing". The concept promotes consistent high quality output through placement of customer satisfying limits on process variation. Measurements and decisions should only be made using accurate data – never approximations or "experience" [3].

To use the 6 sigma vernacular, Design Measure Analyse Improve Control (DMAIC), this paper relates to the Design and initial Measurement phase of the overall problem of raising the level of data control in an automotive stamping plant. There are many Analyse

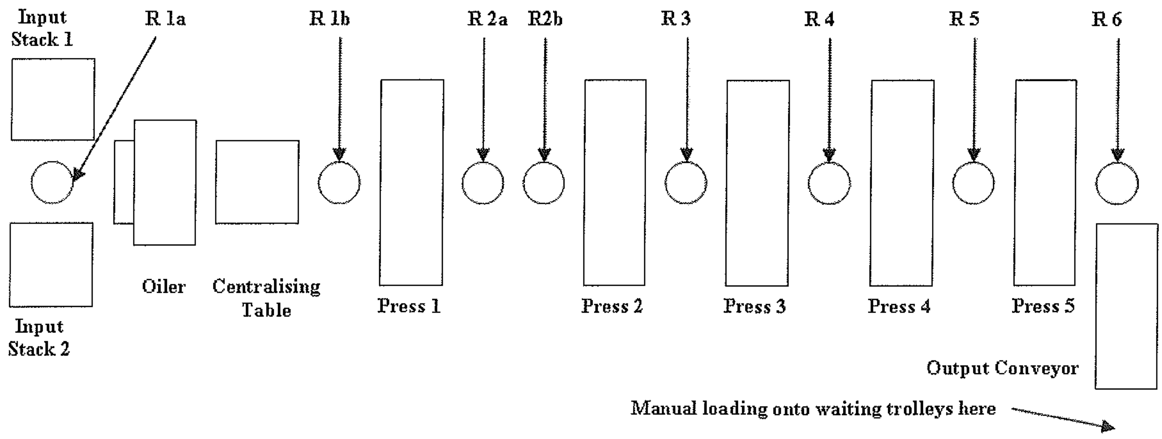

Figure 1. Machine Layout

Improve Control loops that could be considered in the future.

Finally, in recording production "events", an Automotive Press Shop seeks to fulfill a Quality Assurance objective, which in theory should result in the shop operating in an optimal manner.

DESCRIPTION OF ANALYSIS

The analysis presented relates to a case study conducted at an Australian stamping plant. One of its 1200 ton press-lines, currently carrying 18 different part runs was considered. Line features include 5 press stages (Press 1 - draw press) and robotic panel transfer between presses. Blanks are automatically fed to Press 1, and finished panels (from Press 5) are automatically unloaded onto a table where they are manually loaded onto waiting trolleys (see diagram below). Other lines, and indeed other plants may exhibit slightly different results, although it is thought that the results and trends presented would be indicative of Australian plants generally.

The purpose of this study is to statistically assess the nature of stoppages, and what aspects of these stops can and cannot accurately be recorded by operators on the shop floor. As operators are generally the only people that actually witness stoppages, the ability to accurately record their perspective becomes paramount in addressing major issues [4].

As a rule, under the current assurance system at this plant an operator should record an event if its duration exceeds 5 minutes. In this, the plant makes an assumption that faults exceeding 5 minutes make up the vast majority of the stoppages by contribution to overall time lost, thereby limiting the operators written work both during and after the shift. By recording a fault, a fairly normal industry practice is followed whereby a sheet of "codes" with up to 100 options on it are provided for the operator to choose from based on their appraisal of the situation. In addition to the recorded code, the operator also records the fault duration and time.

It will be shown that there are shortcomings in the above procedure, and this study aims to provide an alternative to the current system which allows for increased data confidence and usability.

Since the introduction of mass factory automation systems, considerable effort has been put into devising ways to eliminate operator subjectivity through automation of fault recording systems. Whilst theoretically sensible from a data accuracy perspective, this action has the added effect of virtually eliminating operator input all together. Early in this work however, it was observed that only approximately 40% of stoppages were actually machine initiated, although this varies significantly from part to part. This means that in 60% of events at the test plant, the operator has observed a QA issue or failure and stopped production in order to curtail undesirable operation. Experience shows that automatic detection of many stamping problems (eg. QA issues) is beyond the domain of affordable plant automation systems. In any case, as automation increases so too does the need for human intervention [5 6].

In order to reduce recording variation, quality assurance systems such as Six Sigma encourage automated recording where possible but also acknowledge the need for accurate recording, so the

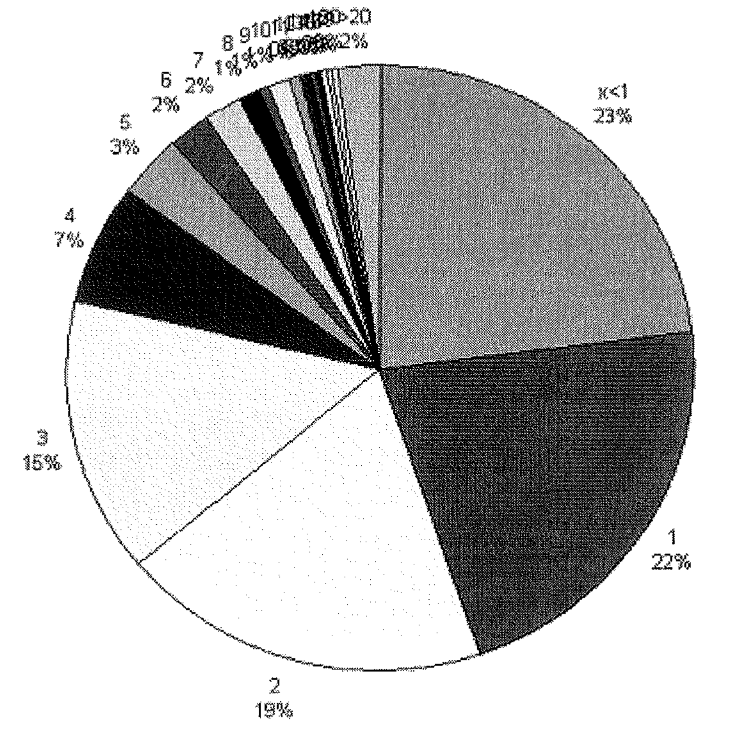

Figure 2. Distribution of stops by percentage of total stoppage number.

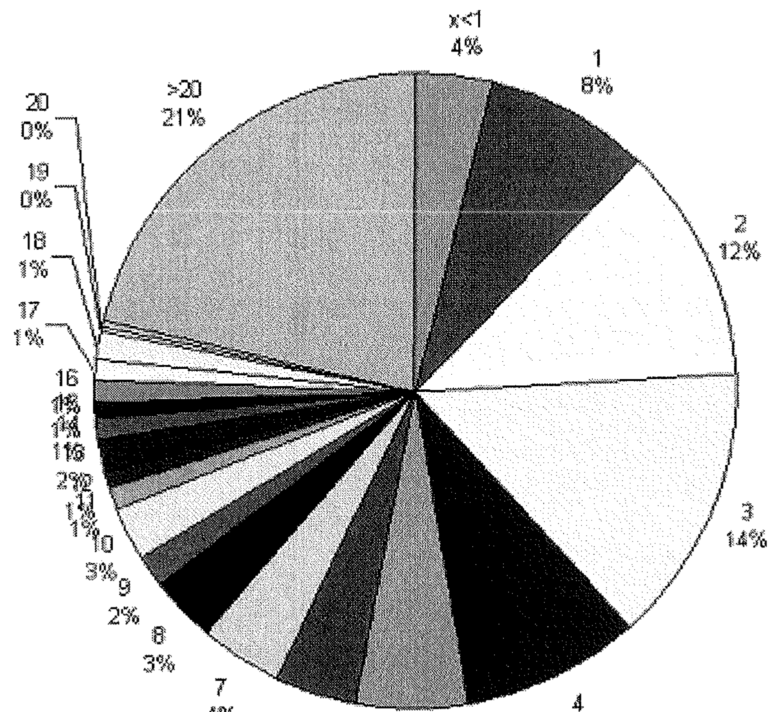

Figure 3. Overall Distribution by percentage contribution.

need for a balance between automation and human interaction is imperative [7 8].

Analysis:

The first stage of this investigation related to the measurement of effectiveness and accuracy of the current stoppage recording system. Operators kept recording data as they normally would, and in addition a logger was set up to automatically record stoppage times and durations, but not stoppage causes. This allowed 4 months of data to be collected covering all parts and shifts and provided an insight into two important aspects, these being:

- An accurate view of overall stoppage distribution.
- An assessment of whether the current operators reports in connections with the 5 minute rule were in fact able to capture the majority of events.

It should be noted that the diligence of operators in recording stoppages has been seen to vary widely. Consecutive shifts running the same part (where the logger suggests little difference in machine behavior) can exhibit wide operator reporting discrepancies. The variable X will hence be defined as the downtime duration of an event. Depending on the operator, data can be relatively accurate for X>5 minutes, but for the next shift almost no information, so uniformity of recording is presently a big problem. In either case, the X<5 min data is not currently being considered. Fault reasoning is another significant issue with 46% of recorded stops presently being designated "miscellaneous"; this type of input offering little or no assistance in the diagnosis plant problems.

On the previous page is Figures 2 and 3; Figure 2 showing stop length as a percentage of all stops, and Figure 3the percentage contribution of stops by length to overall time off. Meal breaks, meetings, non-production related stoppages and shift changes have been excluded from this analysis. What is immediately apparent is that X<5min stops contributes to 53% of overall time losses, indicating that in general, the plant rule of only recording X>5min stops excludes just over half the data before any analysis is done. Over the test period, 270866 panels were made with at an average of one 2 minute stop every 44 panels, totaling 6180 events.

Based on Figure 3, there are 3 major regions that manifest themselves.

- The 1st is the section from 25sec - 4 minutes (Short Stops) where the segments are increasing in size. For the sake of sensibility, stops of less than 25 seconds duration are excluded as they are infrequent and time taken in recording (say 5-10 seconds) would clearly outweigh any benefit.
- The 2nd is from 5 - 13 minutes (Medium Stops) where the segments are decreasing in size.
- The 3rd segment (X>13 mins) is relatively uniform from 14 - 20 minutes (Long Stops). The X>20min segment is made up of 140 events that are spread from 20 - 120mins. In the absence of significant detailed information about stoppage causes, this is the most logical breakdown of events.

Of interest, the majority of long stops are related to major issues like part splintering, tool repair work and occasionally a machine failure. These issues are generally well understood and are handled under current plant maintenance regimes. Analysis of Figure 4 suggests that they tend to become manifest either early or late in a run – at times resulting in completion of a run being postponed due to the length of the repair or modification required. An objective is to look at whether certain categories of parts are more susceptible to specific large faults than others.

Medium length stops tend to relate more to larger transfer issues, small mechanical or setup issues – these again tend to come up at the start or end of a run, but are also quite frequent during production. While these problems are usually addressed during production, there tends to be little done outside of production in order to mitigate future occurrences. The objective here is to eventually build up an optimized maintenance regime for areas causing the greatest ongoing interruption.

Short stops are by far the greatest group and are probably the least understood from a plant operation perspective. These problems have been observed to be largely transfer related, either in terms of robot automation adjustment or in the organization of resources and personnel around the machine loading and unloading areas. These issues appear to have uniform distribution for almost all runs assessed. Of all downtime issues that could be addressed in the plant, these issues would very likely yield the highest increase in runtime per maintenance dollar spent – although in some cases changes to personnel activity would also be required. The objective with these stops is to show where problems are most prevalent so that resources can be better coordinated.

In order to show this data more clearly a series of charts (Figure 4) have been produced. These charts show how Short, Medium and Long stops contribute to downtime over the course of a number of runs of the same part. Runtime for the considered part is generally 10-15 hours, and production in the order of 2000 parts.

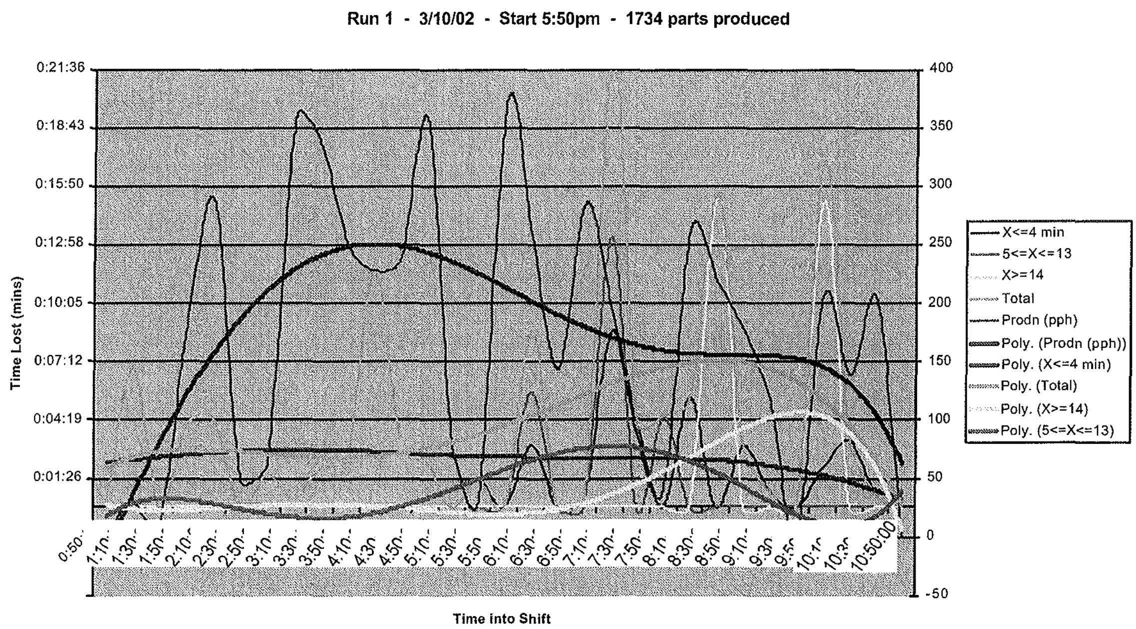

Figure 4a

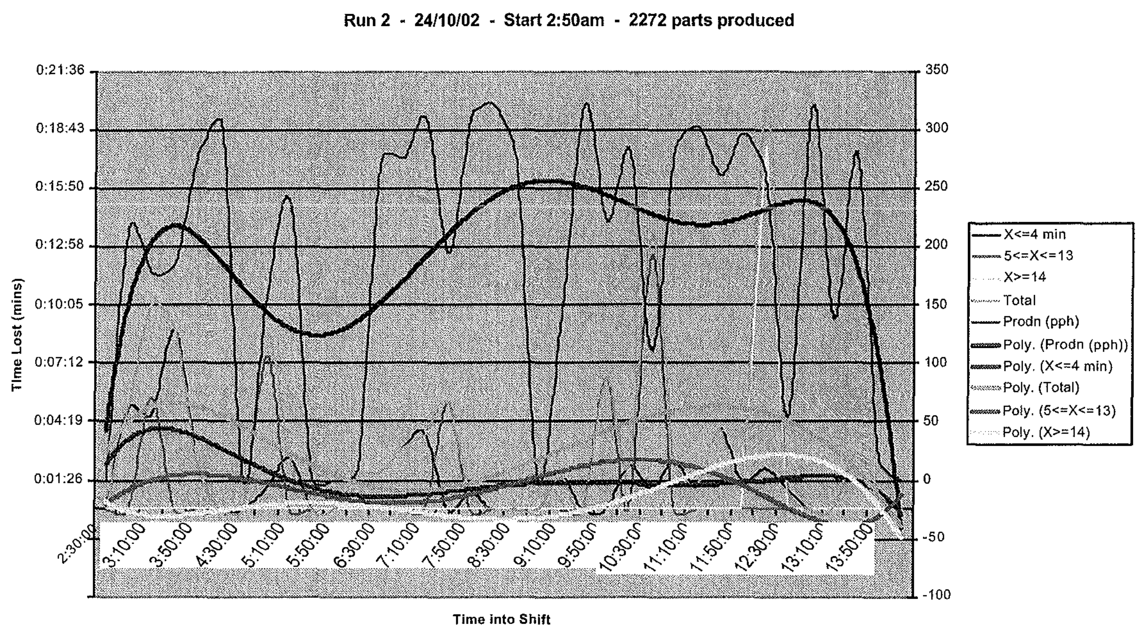

Figure 4b

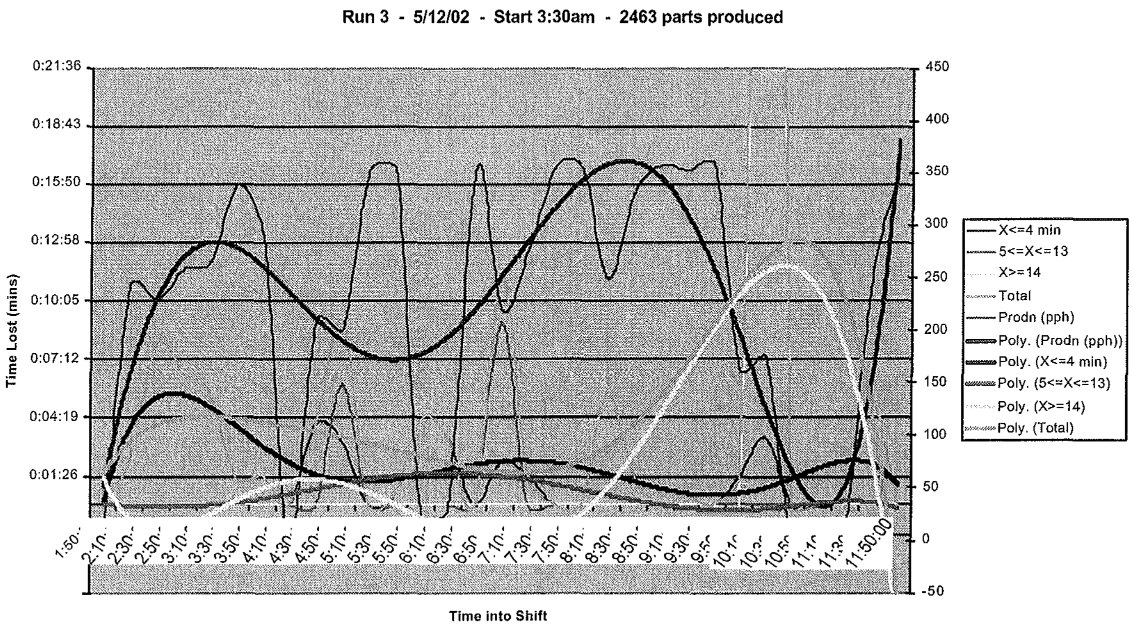

Figure 4c

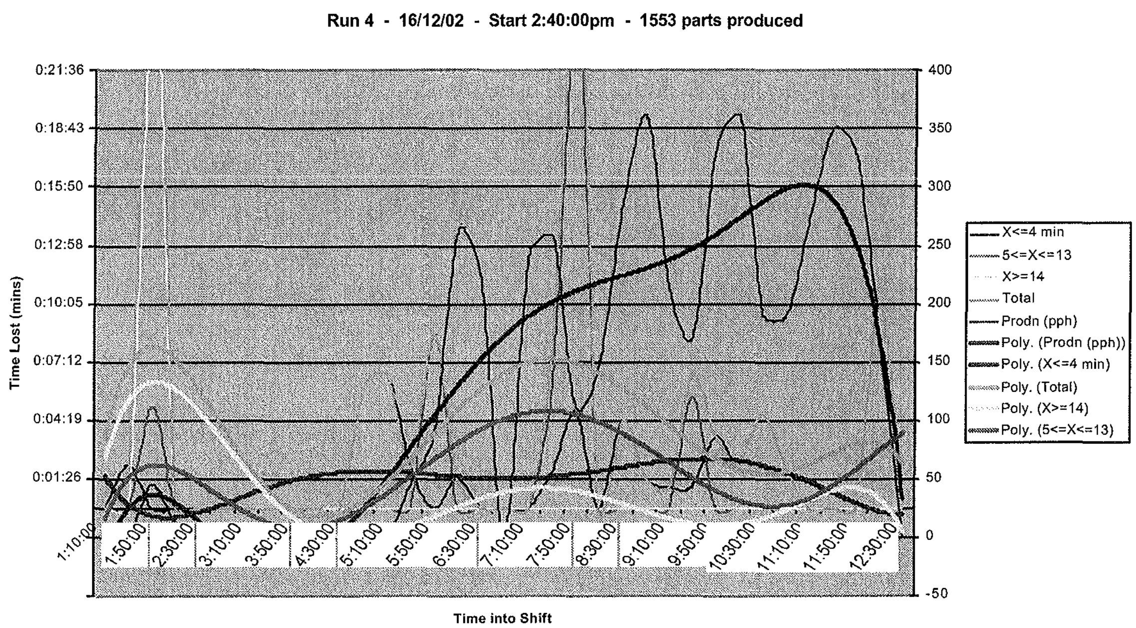

Figure 4d.

By way of explanation, the Figure 4 charts are segregated into 20 minute blocks on the "x" axis. While finer resolution may offer greater clarity, 20 minutes is considered adequate given the interest period is 10-15 hours. Accumulation of loss per 20 minute segment (blue, pink, yellow and cyan coloured curves) is indicated on the lefthand "y" axis, where as hourly production (purple coloured curve) is indicated on the right. Thicker trendlines (6 order polynomial) have been added to the charts to show the overall nature of the actual data.

While these charts show stops broken up based on length, it is not reasonable to say that a stop taking 5 minutes to rectify is the same as, or even similar to, one that takes 13 minutes. Plant observation suggests that there are likely to be hundreds of potential issues contributing to each of these curves, generally all being rectified only as they occur. It is plausible that the many issues that make up particularly small and medium stop downtime curves are of a fairly sporadic nature. In other words, there are a number of small issues contributing to unknown levels to make up the overall curve. The reasons behind longer stops tend to be a little more clear as they are known about and in many part runs expected. This being said, there is a probability that any type of fault can occur at any time, although one could argue the occurrence of infrequent faults are almost impossible to predict due to the largely non-robust nature of panel stamping.

DISCUSSION

Ideally if the location and particulars of faults were known, it would be possible to build up a much better understanding of the problem areas. The issue is that where there are so many faults occurring (average 1 fault every 44 panels), operators in general do not have the time or possibly the inclination to record large amounts of detail; the currently used recording sheets making this point abundantly clear. However, bearing in mind that it is X<5 min stops that make up over 50% of time lost, information about all stops, both long and short, is crucial. The focus therefore must be on the transfer of operator perspective for all stops, not just stops of specific type or duration. If recording could be made sufficiently quick and straightforward, that is, taking only a few seconds to complete, with the removal of post-shift data entry, then it is thought many of the current problems with data collection and handling could be eliminated. In theory as problem areas are addressed the amount of required recording should decrease.

One of the easiest ways of meeting the objective raised above would be to employ a touchscreen system whereby the operator could enter data and have it automatically logged into a database. This allows for the automatic collection of objective data such as time, date, part in production, and duration of stop. At the beginning of the run the operator would need to indicate some particulars such as the part being made, beginning of setup time, beginning of run time, end time, and whether the run was terminated prematurely (this could be determined from expected production – actual production).

An area of research where similar objectives and participant mindsets are encountered may be consumer surveys. It has been found that people are in the main more motivated to quickly and truthfully answer a questionnaire when presented with a pictorial representation of a question (multiple choice etc.) rather than a question requiring detailed reading or written response per se [9]. It has also been recognized that people when presented with excessive options are more likely to choose a generic option, even in cases where a more suitable option may exist [9], such as the "miscellaneous" option in the current system.

During runtime, an overview of the line could be shown on the screen and in the event of a stoppage the operator would press on the area that is the subject of the stop. Based on the area of the machine indicated, the screen could then present a list of 5-10 major issues that may affect that area. In nearly all observed instances the operator was aware of the area of the machine that had caused the stop, so accuracy of this is not considered to be an issue. Operators were also found to be aware of why the machine had stopped, although their opinion as to the root cause was noted to vary substantially at times. From this it could be assumed that fault reasoning information would be somewhat subjective, however, the following recommendations would alleviate part of the problem:

- Minimising the number of available options to include broad aspects of the area only.
- Removal of "miscellaneous" or "planned stoppage" options, except where required, ie. Meal breaks, Shift Change, Tool Tryout, Maintenance etc.

FURTHER DISCUSSION

Implemented, such a system would provide accurate information on time, duration, and location of problem areas. Further information would be available through the 5-10 major issues section of the system and could be used to add colour to location data. Due to the presently high number of stops, and therefore amount of data to be entered, it is thought that a 23 level decision system such as that described would allow for the most expedient knowledge capture from already busy operation staff. Confidence in the identification of top time loss issues would be greatly assisted. Trending to see whether certain problems were increasing over time, or studies into specific aspects of the process would be possible. An example of a recording system

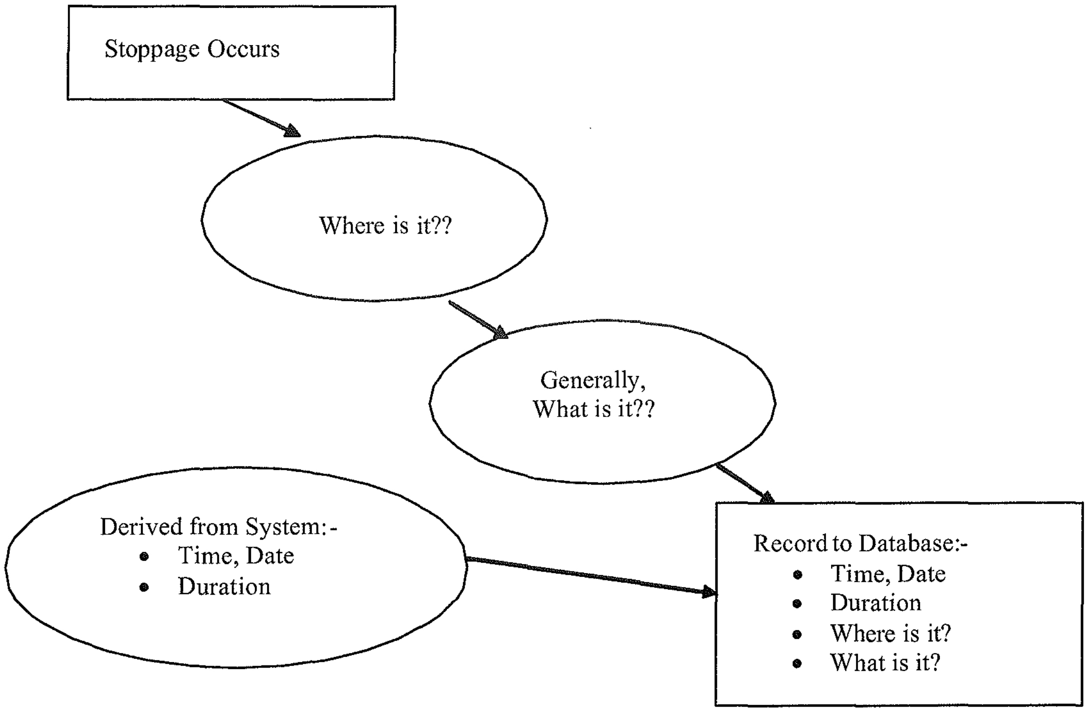

Figure 5: Example of Decision Tree

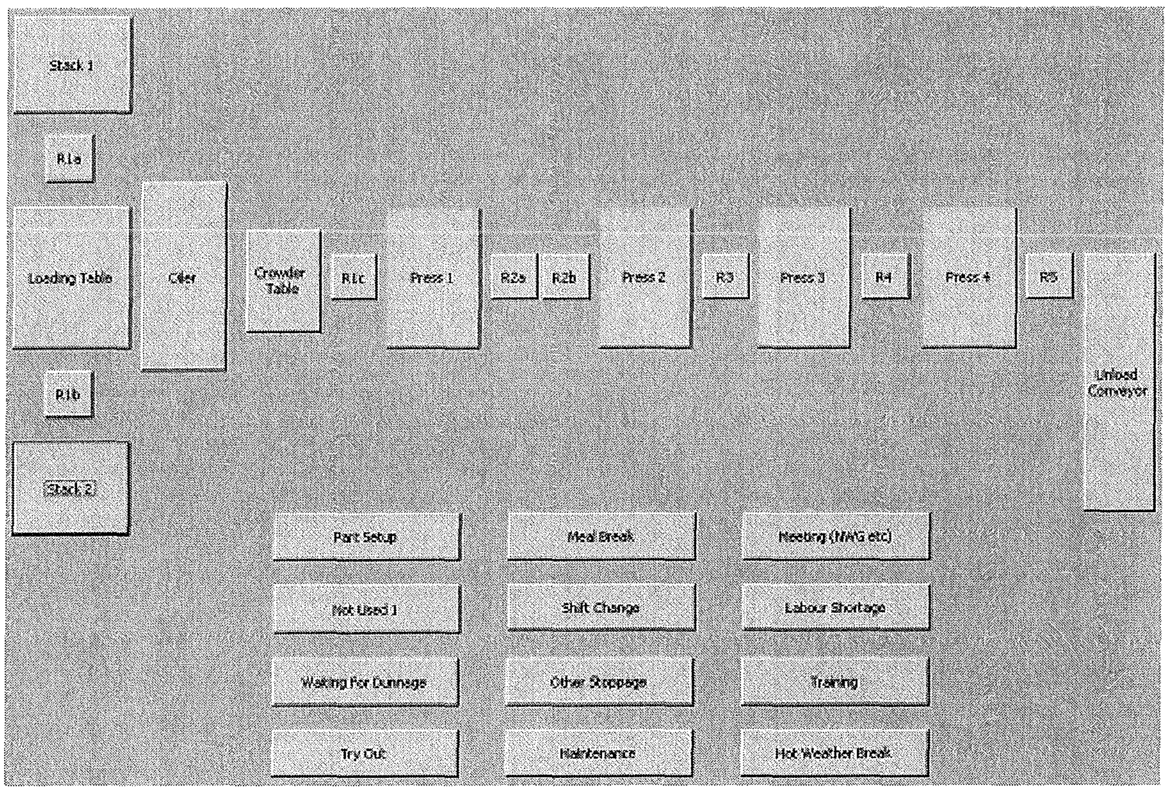

Figure 6: Example of Recording System Front End

tree structure ought not be any more involved than that shown in Figure 5. A typical front end might look as simple as Figure 6.

As a final note, this system is not intended to replace communication. The intention is to provide a method for maintenance and management personnel to identify major problem areas requiring closer inspection and action. Further detail from operations staff should always be sought due to the very underlying reasons that make this system plausible.

CONCLUSION

Findings at the investigated plant indicate that the current stoppage and event recording system is inadequate for its intended purpose due to 2 reasons:-

- 53% of time loss data is largely ignored due to plant determination that only X>5 minute stops are significant.
- Records with "miscellaneous" designation presently make up 46% of all recorded time lost. In addition, the remaining 54% of more substantive data is weak in determination of problem areas, frequency, duration, or cause, rendering it largely unusable.

While the existing system makes immediate further analysis almost impossible, results to date indicate that this could be improved considerably through the simplicity of a touchscreen system. This system would need to cover all stoppages. As there is presently very little consideration given to the importance of X<5 minute stops, short stops and to some extent medium stops stands to benefit greatly through better resource coordination and optimization of equipment. A better understanding of longer stops should also result. Time should see many of the repetitious problems being addressed through increased data driven decision making.

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