Design analysis of distributed control system (DCS) room with curved monitor

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Abstract. This paper presents the design analysis of distributed control system room with curved monitor. The objective of this research is to seek the possibility of replacement current monitor using eye ergonomic and human factor analysis. The research are backed up with three theories of Fitts’s Law, Horopter Theory, and Westheimer’s Saccadic Eye Movement Model. Fitts Law used to illustrate the general powers and faults of humans and machines. Horopter used to match another distinctive of our visual ergonomic: the placement of surfaces of monitors. Saccadic eye movements used to describe the express movements of eyes with monitor shape. The survey was conducted to operators seeking possibility to use curved monitor to replace the flat monitor. The researcher used simulator for Boiling Water Reactor (BWR) and its training movies and asking the participant doing the experiment then filling up questionnaires. Participants will be selected from the panel DCS operator doing their job in oil, gas and petrochemical manufacturing plants. The questionnaires are analysed by Rasch Model Analysis, to seek the benefit of curved monitor than flat monitor. Rasch analysis to find internal test reliability and conclusion out the each item analysis on visual ergonomic and human factor interaction.

Keywords: Design, Analysis, Distributed Control System (DCS), Curved, Monitor

1. Introduction
Curved design has been widely discussed among the researchers due to increase the performance of employee and productivity. Shupp et al (2001) recommended that as the display gets larger curving the display will allow performance improvements. The authors found that curving with large high-resolution monitors, taking all the pixels into visual array, provides the subsequent effects [1]. Three concepts are arranged to back up this research about substituting of flat monitor with curved monitor, the Fitts Law, Horopter Theory and Saccadic Eye Movement Model. The potentials are open for curved monitor. Deeper research is required in the future particularly the resolution from panel screen manufactures for industry to discover and provide the curved display which fit with the condition for panel DCS based on ergonomic and human factor.

Another study described the automation becomes more refined, the nature of its boundary with people will need to adjustment in intense ways [2]. In non-unimportant connection of this sort, the fact is not to contemplate which assignments are best performed by people via monitor but instead how errands can finest be collective by the both humans and automation working in the show, which
highlights how the capabilities of humans and machines can be enhanced through suitable forms of mutual interaction between DCS operator and curved monitor.

A study was presented of positive tasks, such as those requiring sophisticated decision, could not be lifted to machines, and other tasks, such as those demanding ultra-precise movement, and could not be done by humans [3]. Vertical and horizontal horopter were explained as part of this study [4]. A vital, the typical of the visual method is the vertical horopter.

Recent study presented the visual fatigue from curved monitor [5]. They found that curved screen getting less visual fatigue than the flat screen. These days, most of the people work at monitors for significant quantities of time, and plenty of activities can be finished without shifting from monitors. Working at visible display terminals has been shown numerous health complains. Of those, eye issues are the single most not unusual grievance. Making use of idea of useful field of view (UFOV) research [6] to provide the benefit of the stare factor on the central may be defined how curved reveal better than flat. UFOV is described as the component that the visual evidence can be pull out at a short test without head or eye motion. Assuming the UFOV is constant, it covers more place on a display whilst the remark point is at the central. Thus, it is able to be inferred that the tendency of participants staring at the centre of curved display is better useful in inspecting as whole without shifting different body parts.

The usability of curved display substituting flat monitor in Distributed Control System (DCS) or control room panel will be in line with vision advantages for operators [7]. Difficulties with focusing and eye alignment can result in eyestrain, neck pain and headaches during computer work. Numerous vision problems associated with using computer display as computer vision syndrome (CVS) was studied in the journal [8]. The foremost symptoms of CVS are diplopia, eyestrain, headaches, ocular discomfort, dry eye or blurred vision. Because of the visual discomfort, CVS has imposed economic influence for manufacturing company with the health complaint of their workers.

The project of planning control room is on the point of presenting the most recent technology with the importance of Human Factor. With technology racing to the lead of personnel development, many new technologies are being utilized. While training and direct interfaces are being improved as fast as possible, we believe that the values of other key components are underestimated. For example, focusing on workplace ergonomics and efficiency based on actual needs and future adaptations to process and technology evolution will create successful control room designs that are built to last. The objective of this paper has been to nature out the furthermost vital and usually acknowledged philosophies and applications of curved monitor replacing flat monitor. Another objective is to consider the core features and the most ideal appliances of the curved monitor comparing with flat monitor.

2. Materials and Methods
The questionnaires were prepared to investigate, using Rasch Model Analysis, to find the benefit of curved monitor related with eye ergonomic and human factor. Rasch Analysis was used to estimate internal test reliability mainly consider the two formulae of common usage of the Kuder-Richardson formula 20 (KR20) and Cronbach’s alpha. In the end of the research would premised that curved monitor better than flat monitor with the mean score and finding out the each item analysis on visual ergonomic and human factor interaction

The survey would be directed to DCS operators pursuing chance to use curved monitor to replace the flat monitor. The DCS room must therefore be designed with curved monitor accordingly with reliable scientific proven better than normal flat monitor. The human factor element defines the human overall performance in interface with the surrounding environment, and the abilities and its functions. It’s far directly united to the term ergonomics which may be described as the technology of human in work, and the interaction between the person and his apparatus

Rasch Analysis (RA) is accepting for questionnaire method because it offers influential insight into internal reliability and the aiming of items to subjects (the extent to which item difficulty suits population ability) [10]. Consequently, this research established and validated questionnaires, using Rasch analysis, for the measurement of the efficiency of ergonomic and human factor between curved monitor and flat monitor. A Rasch model analysis piloted with computer programs Ministep Winsteps Rasch 4.0.1
software. It will assess how fine data fits the Rasch model with the situation that items are representative a common hypothesis. Examining data conforming to the Rasch model, that is, showing a Rasch analysis, gives a range of facts for checking whether or not adding the scores is justified in the data. This is named the test of fit amid the data and the model. If the invariance of answers through diverse sets of people does not embrace, then enchanting the total score to illustrate a person is not acceptable.

The preliminary data from contributors are age 20-50 years, male only and DCS operator in oil, gas and petrochemical manufacturing in United Arab Emirates. The researcher uses simulator for Boiling Water Reactor (BWR) Plant Technology Education Simulator (Figure 1). BWR reactor simulator is free software available to download and install in two PC, each connecting with flat monitor and curved monitor. The researcher uses media for experiment into two types using Video about BWR training and curved monitor. The researcher uses media for experiment into two types using Video about BWR training and curved monitor.

Proper base for testing statistical significance states that there is association or positive effect that curved panel monitor better than flat panel monitor. Faster response, safe operation and relax would be the advantages after using curved panel monitor in terms of ergonomic and human factors. By Rasch Analysis to estimate internal test reliability mainly consider the two formulae of common usage of the Kuder-Richardson formula 20 (KR20) and Cronbach’s alpha. In the end of the research will premise that curved monitor better than flat monitor with the mean score and finding out the each item analysis on visual ergonomic and human factor interaction.

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Rasch analysis that was achieved in order to response the research questions managing this exploratory study. New findings are provided, such as Visual eye ergonomics – how the curved monitor to ease working in DCS panel and watching visual content better than flat monitor; and Human factor performance – which parameters influence interaction on curved monitor better than flat monitor. Data was collected from 25 participants. Based from the questionnaires, DCS operators in this research mostly have experiences more than 15 years. Working as DCS operators in front monitor panel for 16 years with ages commonly at 45-54 years old. Most of them are ever or having experiences with curved panel or television as a new technology.

The questionnaires cover the certain scale to measure compliance with perceived conditions.

3. RESULTS AND DISCUSSIONS
DCS operators expressed their concern for curved monitor to display information that is interested to them. The information in the questionnaires is relevant with their concern about visual ergonomic. According to the DCS operators, monitor is the most important to know general parameters in the process. These parameters are not demonstrating only one part of the process, nevertheless are composed from different ones. Illustrations of such parameters are: reactor and water temperatures, produced effect, and reactor containment pressure. The choice provides a general illustration, which covers the complete status of the process, and is therefore motivating to DCS operator. The data research in mean
score users on the curved monitor will gain more localized detail-level insights with higher mean score items than flat monitor. The research that have shown the mean score for curve 95.6 and flat 82.1 in Part 3 - Visual Ergonomic Analysis and for curve 90.6 and flat 79.2 in Part 4 – Human Factor Interaction Analysis.

A low standard deviation tells that most of the records are very close to the average. A high standard deviation tells that the numbers are diverge. P. SD is its standard deviation assuming that this sample of the statistic for entire population. P. SD for Curved Monitor is lower P. SD Flat which better. The research that have shown the P. SD for curved 0.57 lower than flat 0.87 in Part 3 - Visual Ergonomic Analysis and for curved 0.75 lower than flat 0.86 in Part 4 – Human Factor Interaction Analysis. We observed this tendency in our own treatment of the monitor, and required to examine the issue experimentally. The graphs Map Variable Wright has hypothesized that users on the curved monitor will gain more comforts in Part 3 - Visual Ergonomic and Part 4 – Human Factor Interaction Analysis. Right-hand column traces the item difficulty dealings along the variable. Whereas, users on the curved monitor will gain rare/less difficulties for items visual ergonomic and human factor interaction, meaning participants more comfortable with curved than flat. Items arranged by measure the hierarchy of item names to spell out a meaningful construct from easiest at the bottom to hardest at the top.

The aim was to replace the flat monitor, with curved monitor displays to make a fully computer-based DCS Room. For several reasons all of those objectives were accomplished in visual ergonomics, and the result was a control room with curved monitor show in computer-based workplaces. Some DCS operators conveyed that there would be some conceivable advantages to the control room if more curved monitors had been included.

Table 1. Table Score Comparison Part 3 - Visual Ergonomic

| Item Visual Ergonomic      | Flat Monitor | Curved Monitor | Difference in % |
|----------------------------|--------------|----------------|-----------------|
| Blurred vision             | 79           | 95             | 16.84           |
| Burping                    | 98           | 100            | 2.00            |
| Difficulty concentrating   | 83           | 94             | 11.70           |
| Difficulty focusing        | 77           | 92             | 16.30           |
| Dizziness with eyes closed | 74           | 93             | 20.43           |
| Dizziness with eyes open   | 73           | 97             | 24.74           |
| Eye strain                 | 64           | 94             | 31.91           |
| Fatigue                    | 68           | 90             | 24.44           |
| Fullness of the head       | 87           | 91             | 4.40            |
| General discomfort         | 76           | 95             | 20.00           |
| Headache                   | 85           | 95             | 10.53           |
| Nausea                     | 92           | 100            | 8.00            |
| Salivation increasing      | 91           | 98             | 7.14            |
| Stomach awareness          | 92           | 100            | 8.00            |
| Sweating                   | 89           | 95             | 6.32            |
| Vertigo                    | 85           | 100            | 15.00           |
| Mean Score                 | 82.1         | 95.6           |                 |

Table 1. was taken from the research by Rasch Analysis, showing that curved better than flat monitor as a total count on the score. Mean Score for Curve is 95.6 and better than Flat Monitor, 82.1. Table also showed the comparison score data extracted from the analysis score, was showing that 10 items had shown more than 10 % better performance in item visual ergonomic.

For the most part of the time trends of some critical parameters are displayed on the curved monitor, and the DCS operator has a central role of monitoring those. The DCS operators were of the opinion
that all of the operators can support and contribute to the monitoring task focusing in Human Factor Interaction. This would not have been possible if the overview were displayed with better monitor.

Table 2. Score Comparison Part 4 - Human Factor Interaction

| Item Human factor Interaction | Flat Monitor | Curved Monitor | Difference in % |
|--------------------------------|--------------|----------------|----------------|
| Time to learn                 | 80           | 91             | 12.09          |
| Speed of performance          | 77           | 92             | 16.30          |
| Rate of errors                | 82           | 88             | 6.82           |
| Subjective satisfaction       | 81           | 89             | 8.99           |
| Retention of over time        | 76           | 93             | 18.28          |
| Mean Score                    | 79.2         | 90.6           | 12.50          |

Table 2. shows the research by Rasch Analysis, showing that curved better than flat monitor as a total count on the score. Mean Score for curve monitor is 90.6 and better than flat monitor, 79.2. Table also showed the comparison score data extracted from the analysis score, was showing that almost each item scored higher in curved monitor. 3 items had shown more than 10 % better in item human factor interaction analysis on Time to learn, Speed of performance, and Retention over time. And 2 rest items lower than 10 % are item “Rate of errors” and item “Subjective satisfaction”, that we could assumed no difference between human interaction factor for flat and curved monitor.

The result agreed with Linacre (2006) [9] that the possibility of each answer is exposed transversely the dimension variety. It can be distinct by the option of any specific reaction is the alteration among the mark of the person and the standardisation of the item. The vertical "+" characters resemble to integer predictable scores, and the "|" characters resemble to half-point predictable marks. The interludes amid the Rasch-half-point beginnings can be supposed of as the interludes corresponding to the investigational groups. For the purposes of implication, relatives in the zone on the x-axis between ‘|’ and ‘|’ resemble, on average, to the score specified on the ‘y’ axis, ‘score’. Correspondingly ratings on the y-axis can be expected of as compatible to measures in the equal zone on the x-axis. Figure 2 shows the expected score in items Part 3 – Visual Ergonomic and Figure 3 shows the expected score in items Part 4 – Human interaction factor illustrations that more score liking for curved monitor, scale going to higher score. The right-most area matches to the maximum item category.

![Figure 2. Part 3 – Flat (up) and Curved (down) Expected Scores – Visual Ergonomic](image-url)
The technique to this shortcoming with flat monitors and software was large reveal partitions. Finally, here turned into a way to update the monitor with a digital model that might display the total system review with help for adjustments. It was even possible to use part of the massive reveal as a DCS monitors. Flat monitor like those are nonetheless commonly located, mainly on top of things rooms in sectors like Petrochemical, Oil & Gas and Utilities.

Many issues can be eliminated as a finding from this research in control rooms for display the condition of the plant. In the future with new design of Curved Monitor to replace Flat Monitor in Control Room will help better DCS control room as ergonomic and human factor interaction benefits.

4. Conclusion
The graphs Map Variable Wright have postulated that users on the curved monitor will gain more comforts in visual ergonomic and human factor interaction. Whereas, users on the curved monitor will gain rare difficulties for items visual ergonomic and human factor interaction. Graphs have shown more participants have a tendency comfortable with curved monitor than flat monitor. Mean score for visual ergonomic was showing that curved better than flat. Mean score for curved monitor is 95.6 and better
than flat monitor, 82.1 for visual ergonomic. 10 items from total 16 had shown more than 10% better in item visual ergonomic on item Blurred vision, Difficulty concentrating, Difficulty focusing, Dizziness with eyes closed, Dizziness with eyes open, Eye strain, Fatigue, General discomfort, Headache and Vertigo.

Mean score for human interaction factor was showing that curved better than flat. Mean score for curved monitor is 90.6 and higher than flat monitor, 79.2. 3 items from total 5 had shown more than 10% better in item human factor interaction analysis on item Time to learn, Speed of performance and Retention over time. The last finding for liking analysis, for the structure calibrations for visual ergonomic and human factor interaction, had found that curved monitor liking better flat monitor. Then probability had showed the expected score in items visual ergonomic (None effect) and human interaction factor (Very good effect) illustrations that more score liking for curved monitor, scale going to higher score. The right-most area corresponds to the highest item category.

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