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CRITICAL ANALYSIS OF PRESS MAKE-READY TIME IN MULTI-COLOUR SHEET FED OFFSET PRESSES AND POSSIBLE REDUCTION OF PRESS SET-UP TIME THROUGH INTRODUCTION OF DIFFERENT TECHNOLOGY IN VARIOUS UNITS OF THESE PRESSES

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Abstract
Sheet fed offset printing is a mature form of printing and is widely used all over the world due its high level of print quality, successfully being able to print on a wide range of printing substrates and high speed of operation. In the recent years, multi-colour sheet fed offset presses are being manufactured to reduce press set-up time, so that a greater number of jobs, especially short run length jobs can be printed effectively within the press hours. Technology has certainly played a major role in terms of increasing press speed, minimizing the press set-up time, reducing raw material wastage, minimizing human touch during the press operation, possible reduction of wastage and maximizing profit. In this research work, the make-ready time of the multi-colour sheet fed offset presses with different levels of press automation is analysed and in the second step is aimed at to find out the possible impact of different technology on press set-up time of these presses.

Keywords
Lithography, Sheet fed offset, Make-ready, Technology, Infeed Unit, Printing Unit, inking unit, Dampening unit, Delivery unit, Press set-up time.

Introduction
Printing means presentation. It is basically presentation of our ideas, thoughts, expression and knowledge to the mass people. It is rightly said that printing is considered as one of the most influential or valuable invention to the human civilization, till date (Baral, 2010).

In the year 1796, Lithography printing system was invented by Alois Senefelder with a sole purpose of printing theatrical piece work in a much lower cost than that of the letterpress printing technique. In a more refined form lithography is still the dominant printing technique today. Invention of lithography is considered to be one of the turning points in the fields of printing technology (Science Photo Library, 2016). History indicates that two eminent personalities contributed to the development of lithography; which includes, Robert Barclay of England in the year 1875 for printing on tin substrate and subsequently for printing on the paper substrates by Washington Rubel of the United States in the year, 1904. Both these developments helped the lithography printing to develop and succeed in the subsequent years (Britannica, 2016).

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Lithography-offset printing technique relies on the principles of mutual repulsion of ink and water and hence it is basically a chemical process of printing; both the image/print and non-image/white areas essentially lie on the same plane. It is a direct printing technique and lithography further transformed into offset printing technology, which is an indirect process of printing technique. The image areas on the plate surface are applied with a thin and even layer of greasy/oil-based printing ink and the non-image/white areas are covered with a thin and even layer of water. Accordingly, the image areas which receives the ink layer is then transferred onto an intermediate cylinder, which is popularly known as the blanket cylinder and in the final step, the inked image from the blanket cylinder is transferred onto printing substrate or paper along with the impression cylinder.

A sheet-fed offset press consists of five units; in-feed unit, printing unit, inking unit, dampening unit and delivery unit. The configuration or structures of typical sheet-fed offset presses are divided into; single colour offset press, multi-colour sheet-fed presses and convertible printing press (Nandakumar & Uthanu Mallayan, 2019*).*

Multi-colour sheet-fed offset printing machines are capable of printing in several colours, typically up to six or eight colours. This allows for the production of high-quality, full-colour printed materials. Multi-colour sheet-fed offset printing presses essentially use the very principles of offset printing technology, which essentially involves transferring ink from a metal plate to a rubber blanket, and then onto the paper. This results in high-quality prints with sharp, clean lines and vibrant colours. Multi-colour sheet-fed offset printing machines often include automated features such as colour registration, ink level monitoring, and sheet feeding, which help to improve print quality and reduce the risk of errors. These machines are capable of printing on a wide range of paper stocks and other materials, including coated and uncoated papers, cardstock, and plastics, making them suitable for a variety of applications.

Among all the printing techniques available today, offset-lithography process of printing is very common and useful printing and it is basically used for the printing of; books, newspapers, journals, magazines, trade catalogues, brochures, stationery, books, posters and packaging printing applications. It is equally good to print low run length as well as high print run jobs with highest achievable print quality. These machines are robust and easy to operate and maintain (Prepressure, 2017).

Today, the share of printed materials being printed by the offset printing technique all over the world is estimated in-between forty per cent to forty five per cent. After the World War II, the per cent contribution of this particular printing technology was around fifty per cent, but during the last few years, it was being replaced by other printing technologies, such as flexographic printing, gravure printing, etc. (Offset printing technology, 2019). Press make-ready is defined as the process of organizing the press ready for printing, matching to the reference print or “OK” sheet or the originals. The set of activities the machine operator to follow and execute, so that the machine is readily available for printing for the customer to have acceptable print output. (Hird, 2010).

The make-ready process in a multi-colour sheet-fed offset press involves a series of steps to prepare the press for printing. Here are the basic steps involved in a make-ready operation: The first step is to prepare the press for the specific job. This involves selecting the appropriate printing plates, ink colours, paper stock, and other materials. The prepared image carrier or the plate is subsequently fixed onto the plate cylinder of the machine. Proper care must be observed, so that proper positioning of the plate around the plate cylinder is carried out for accurate colour registration during printing cycle. Proper inking and dampening adjustments have to be carried out so that thin and even layers of ink and fountain solutions are applied in the subsequent printing cycle onto the plate. This will essentially result into proper ink density on the printed sheets.

The paper feeding system is set up to ensure proper feeding of the paper into the press. The paper guides, registration sensors, and other components are adjusted to ensure accurate positioning and alignment of the paper. A series of test prints are made to check the possible colour registration, ink density, and overall print quality. Adjustments are made to the press settings as needed to achieve the desired print quality. A final inspection of the printed sheets is conducted to ensure that the job meets the required quality standards. Any necessary adjustments are made to the press settings before the final production run. These steps are repeated for each colour used in the print job until all colours are printed and the job is completed. The make-ready process is critical in achieving high-quality printed materials, and experienced press operators can perform these steps quickly and efficiently to minimize downtime and increase productivity.

Review of literature

Author (Forrester, 2020) explained that, from the days of Gutenberg's letterpress to digital printing systems, the very aim and purpose of strengthening the mass communication medium still serves the purpose very effectively and efficiently.

Author (Webtech, 2018) critically pointed that, there are four distinct steps which made this particular printing process useful and progressive; invention of lithography by Alois Senefelder and the very use of this printing technique during the early days, introduction & applications of reproduction photography to the lithography-offset printing, subsequent successful addition of offset printing press to the printing technique and revolution of image carrier or the lithographic printing plate.

Author (Offset printing technology, 2019) pointed out that, the construction of sheet fed offset printing presses can vary from a single colour press to a multi-colour press, for printing of single to multi-colours in single pass feeding of the printing substrate. In single colour press, only one printing station is being built to print one colour at a time. Likewise, additional printing units can be added to the press ranging from one unit to ten units as per the requirement, so that one can print ten colours in the single pass of paper into the printing machine.

Authors (Verma & Lal, 2019) explained that, in recent years sheet fed offset presses are manufactured with lot of advanced technology into its various units to take care of speed and

ease of operation of the press. These machines are specially designed for reducing the possible wastage of resources and at the same time improving press productivity coupled with environmental concerns.

Authors (Bellandur, et.al., 1997) explained that, the printing industry more specifically the graphic arts production segment is following the footsteps of other progressive manufacturing industries with an emphasis of clear-cut adoption of technology for streamlining the complete production system. Printing industry constitutes very high percentages of small printers and they basically operate like a traditional handicraft industry and need to adjust themselves with the newer machines which comes with a bundle of technology incorporated into them to take care of production and environmental aspects.

Research objective

Offset printing process is a popular form of printing and even the introduction of digital printing has not affected the market share of offset printing much in the recent times. New generation sheet fed offset presses are equipped with latest technologies in various units, which is helping the press to suitable for both the short run jobs and as well as high volume print jobs. Press set-up time is a major part of print production system and in recent years, focus is given to reduce the make-ready time as low as possible, so that a higher number of jobs can be printed within the stipulated time, effectively. The basic objectives of this research work are to analyse and study the impact of various technologies being incorporated in multi-colour sheet fed offset presses and how it is going to affect the press make-ready time.

Research methodology

Three multi-colour sheet fed offset presses with different levels of automation were selected for the research work. These machines are manufactured at different point of time and accordingly technology in these presses is also from semi-automatic to advance machines. Production data for complete one year of these three presses were taken into consideration for research work. Numbers of make-ready, make-ready times, time available for actual production and the printed sheets were the basis for fulfilling the purpose of the particular research work. Machine one, (M-I) is with high level of automation, machine two, (M-II) is with medium level of press automation and machine three, (M-III) is with low level of automation

Data collection & analysis

Data of all the three multi-colour sheet fed offset presses were collected on day basis for one complete year and being noted down and presented in suitable table format. Month wise and finally the complete year data relating to number of make-ready and total make-ready time and average make-ready time for each press were collected and analysed in different tables and graphs shown in subsequent pages of data collection and analysis section.

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Table 1, Performance of Machine-I, Machine-II & Machine-III

	Machine-I		Machine-II		Machine-III	
Month	**Average MR Time (Min.)**	**Average Press Speed (SPH)**	**Average MR Time (Min.)**	**Average Press Speed (SPH)**	**Average MR time (Min.)**	**Average Press Speed (SPH)**
Month1	60.7	7988.4	56.63	6064.78	66.23	5018.9
Month2	62.38	7242.93	58.75	6316.92	73.76	4664.74
Month3	65.42	7131.56	60.24	6427.81	65.82	4731.76
Month4	57.85	7424.11	76.62	6813.84	79.08	4446.27
Month5	65.05	7653.13	64.66	6108.02	69.34	4483.11
Month6	59.9	7515.13	58.96	6690.38	61.51	4603.19
Month7	61.29	6646	58.2	6931.94	74.77	4726.6
Month8	60.08	6754.32	65.2	6781.53	78.37	5029.16
onth9	58.78	7086.93	58.67	7100.86	73.95	4862.76
Month10	60.51	7292.86	62.85	6876.02	72.39	5046.75
Month11	55.52	7294.85	62.36	6785.55	70.92	4617.91
Month12	60.26	7466.42	66.01	7398.81	73.38	4736.48

Table 1, indicates the month wise average make-ready (MR) time in minutes (Min.), average press speed, sheets per hour (SPH) of the three machines; Machine-I, Machine-II and Machine-III, respectively. Machine-I, representing the sheet fed offset press with highest level of automation, Machine-II with medium level of press automation followed by Machine-III with low level of automation. Table indicates press with high level technology results into low make-ready time and high level of average press speed, followed by Machine-II and Machine-III, respectively.

Table 2, Performance of Machine-I, Machine-II & Machine-III (Average, Maximum, Minimum & Standard Deviation)

	Machine 1		Machine 2		Machine 3	
	Average MR Time(min.)	**Average Press Speed (SPH)**	**Average MR Time(min.)**	**Average Press Speed (SPH)**	**Average MR Time(min.)**	**Average Press Speed (SPH)**
Average	60.65	7291.39	62.43	6691.37	71.63	4747.30
Maximum	65.42	7988.4	76.62	7398.81	79.08	5046.75
Minimum	55.52	6646	56.63	6064.78	61.51	4446.27
Standard Deviation	2.65	352.33	5.19	380.21	4.96	196.16

Table 2, represents the average, minimum, maximum and standard deviation of make-ready (MR) time in minutes (Min.), average press speed, sheets per hour (SPH) of the three machines; Machine-I, Machine-II and Machine-III, respectively. Machine-I, representing the sheet fed offset press with highest level of automation, Machine-II with medium level of press automation followed by Machine-III with low level of automation.

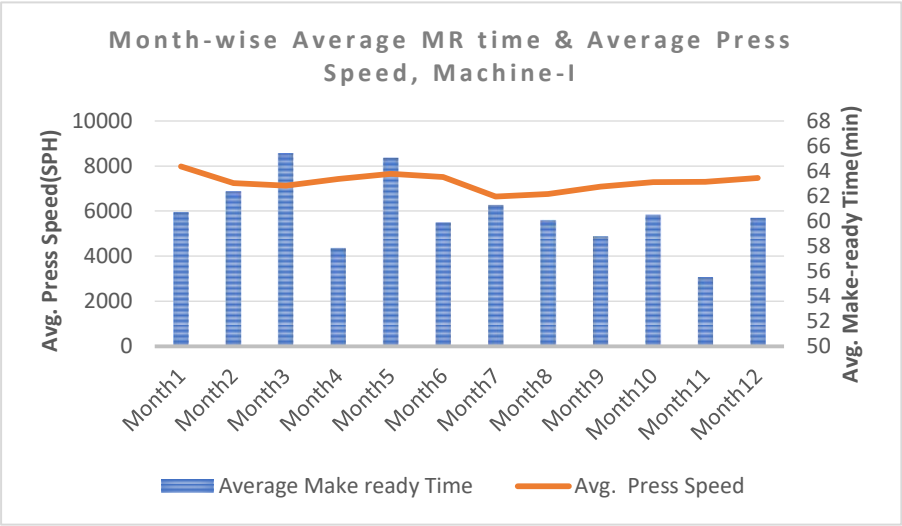

Fig. 1, Month-wise Average MR time & Average Press Speed, Machine-I

Figure 1, represents the average press speed in sheets per hour, average make-ready time in minutes of Machine-I, which is equipped with high level of automation. The average make-ready time is in-between 55.52 minutes to 65.42 minutes and the press speed is in-between 6646 to 7988.4 sheets per hour.

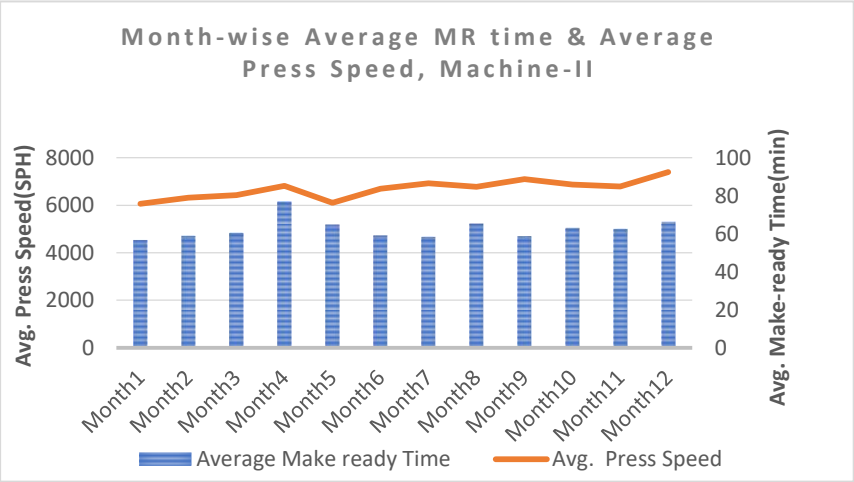

Fig. 2, Month-wise Average MR time & Average Press Speed, Machine-II

Figure 2, represents the average press speed in sheets per hour, average make-ready time in minutes of Machine-II, which is equipped with medium level of automation. The average make-ready time is in-between 56.63 minutes to 76.62 minutes and the press speed is in-between 6064.78 to 7398.81 sheets per hour.

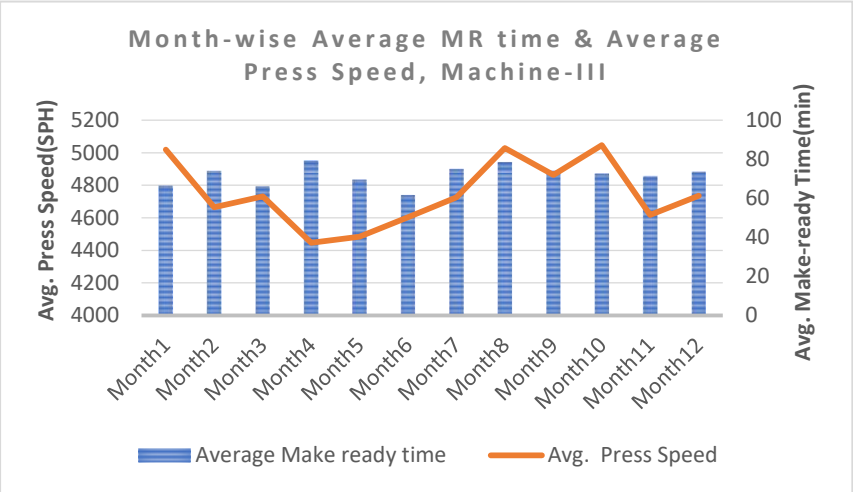

Fig. 3, Month-wise Average MR time & Average Press Speed, Machine-III

Figure 3, represents the average press speed in sheets per hour, average make-ready time in minutes of Machine-III, which is equipped with low level of automation. The average make-

ready time is in-between 61.51 minutes to 79.08 minutes and the press speed is in-between 4446.27 to 5046.75 sheets per hour.

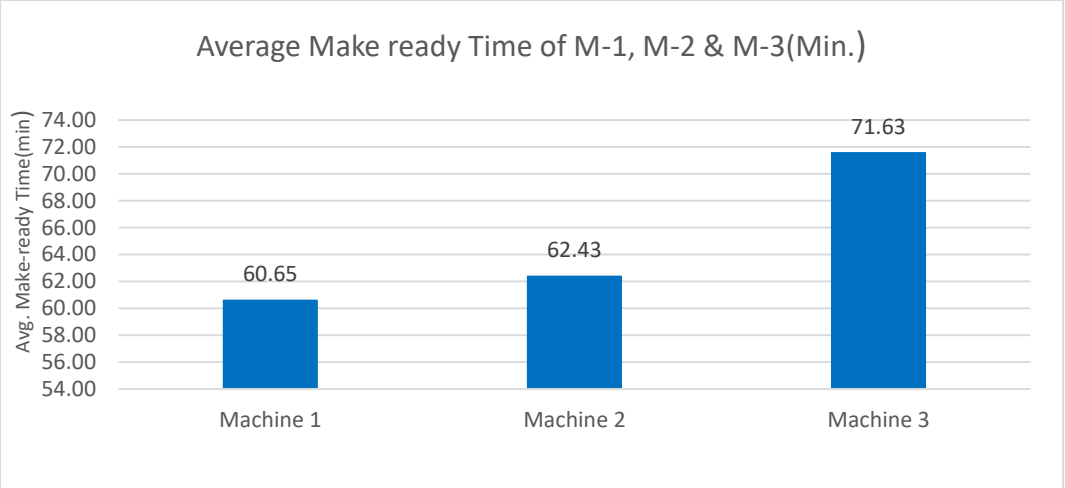

Fig. 4, Average MR time in minutes, Machine-I, Machine-II and Machine-III

Figure 4, represents the average make-ready times in minutes of Machine-I, Machine-II and Machine-III. Machine-I is having 60.65 minutes average make-ready followed by Machine-II is having 62.43 minutes and Machine-III is having 71.63 minutes. This indicates machines with high level automation results into low make-ready time and vice-versa.

Result & Discussion

Sheet fed offset printing presses are very common in the marketplace due it's speed of operation, constructional features, high print quality and being compatible to print on a wide range of printing substrates. It occupies a major percentage of market share in the printing industries. Three multi-colour sheet fed offset presses (M-I, M-II and M-III) of six colours were taken into consideration with high level of automation to low level of press automation, with varying speed of operations. M-I and M-II presses operates with a maximum speed of 15000 sheets per hour and M-III being an old age of manufacturing configuration than M-I & M-II, operates at a maximum speed of 13000 sheets per hour.

It is being observed and found out that, the press make-ready time is highly dependent on the level of automation being incorporated into the particular sheet fed offset press. M-I being the high level of automation, like automatic registration control system, pre-set infeed system, automatic plate loading, etc. shows a substantial reduction of make-ready time than the M-II and M-III. Some of the factors that contributes to the optimization of multi-colour sheet fed offset press make-ready time could be; number of colours to be printed, the criticality of the job, the size of the printed sheet, nature & characteristics of the substrates and level of automation in all the five units (infeed unit, inking unit, dampening unit, printing unit and delivery unit) of the printing press.

Conclusion

In the last two decades printing industry has undergone tremendous changes and developments and one of them is the successful introduction and adoption of advanced technology into sheet fed offset presses. Staring form the pre-set infeed unit to automatic plate loading, automatic plate, blanket and impression cylinder cleaning, automatic inking and dampening roller cleaning, automatic plate loading, automatic plate loading, automatic dampening solution circulation and adjustment, ink temperature control, automatic colour registration, automatic ink control systems to printed sheet curing to CIP 4 complementing the press to reduce the press set-up time, reduction of resource usage and producing the print output which are not only environmental friendly but also sustainable, finally leading to generating more profit margin. This research work clearly indicates that certainly exists the impact of technology in multi-colour sheet fed offset presses towards reducing the press make-ready time effectively.

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