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To Calculate the Validity of Alternate Formula for Production Rate to Design for Un-Paced Production Line When Unbalancing the Workloads

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Abstract – In this study we find out the validity of Alternate formula for production rate. We check how much Error occur from actual Production rate to alternate formula rate Say the correction factor (CF). If we apply the Correction Factor (CF) added/ subtract from Alternate Formula we Found the near about actual Production Rate. After this we apply the formula for computing the large (more than 5 station un-paced production) un-paced production line easily. There for we check the variation from mean values of correction factor to correction Factor (Σ CF/n-CFi)and also found the Standard deviation From actual production rate (R) to Alternate Formula Production rate(AFR) i.e. Correction Factor.

Keywords- Un-paced production line, Correction Factor (CF), actual production rate (R), Alternate Formula Production rate (AFR), Correction Factor variation (Σ CF/n-CFi) Standard deviation (σ), work station

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INTRODUCTION

In the Industry, Now a day Utilize the Computer Integrated Manufacturing (CIM) or flexible Manufacturing System. Therefore we required to design that type of System a production line which production rate is high or suitability of work. This production line is Design according to work (different interval of time) of on each Machine (say work station) in Un-paced line or forced to work for Equal interval of time in Paced production line. In this strategy we use Un-paced production line where the Interval of time for each work station are different. We set time to each work station according to these strategies and find out the production rate. We find the production rate (Jamali, 2015) for 5- work station then we calculate the Alternate formula for Production Rate[5] which is simple for designer to calculate the production rate without use of computer. Now we see how much this formula is valid. We check it through correction factor (CF), variance with mean value of Correction Factor and standard deviation. Here we found that our formula is correct if we add the correction factor in this formula for production rate.

THEORY

Here we Know the interval of time From previously we find out the actual production rate Stretegies (Jamali, 2015. Hiller and So, 1993. Jamali, 2016. Jamali & Suhail, 2016. Jamali, 2002). Know we calculate the Correction Factor, variance with mean value of Correction Factor (Σ CF/n-CF_i), standard deviation σ. We define here each function.

Here D= Highest work load (Time) distribution in work station – Lowest work load (time) distribution in work station

Correction Factor = Production Rate (R) - Alternate formula for Production Rate (AFR)

Alternate formula Rate = (μ1 + μ 5)/ total time in production line

Here μ1, μ2, μ3, μ4, μ5 is work load (time) distribution on work station (Jamali, 2015. Hiller and So, 1993. Jamali, 2016. Jamali & Suhail, 2016. Jamali, 2002)

Mean value of Correction Factor = Σ CF/n

Variance with Mean vale Of Correction Factor (Σ CF/n-CF_i) here i indicate that S.NO.

For example , for S. No.1, 3 ,……..30,35…… 59, 60 means Σ CF/n – CF1, Σ CF/n – CF3, Σ CF/n – CF5……., Σ CF/n – CF30, Σ CF/n – CF35…….. Σ CF/n – CF55, Σ CF/n – CF60

Where standard deviation σ = Sqrt (Σ (Σ CF/n-CFi)^2)/n Here i indicate that S. No. and n =total S.No.= 14

For example, for S. No.1, 3, ……. 30, 35 …… 59, 60 means Sum (S) =(Σ CF/n- CF1)^2 + (Σ CF/n- CF3)^2 +……+(Σ CF/n- CF30)^2+(Σ CF/n-CF35)^2+……..(Σ CF/n- CF59)^2+(Σ CF/n-CF60)^2

From these formula we calculated the Alternate formula Production Rate, Correction Factor, Variance with Mean vale Of Correction Factor, Standard deviation and found the graph of each values of variance to S. No. and analyze that our study is correct or not. These values are given in tabulated form given below.

Tables and graph-

Table 1. Alternate formula rate, Production Rate when work load distribution linear are D= 1.8

S. No.	Mu 1	Mu 2	Mu 3	Mu 4	Mu 5	R	AFR	CF	Σ CF/n-CFi	(Σ CF/n-CFi)^2
1	1.45	0.55	1	0.1	1.9	0.436	0.67	-0.234	0.2397	0.05746
3	1.45	1	0.1	0.55	1.9	0.4308	0.67	-0.2308	0.236479	0.05592
5	1	1.45	0.55	0.1	1.9	0.428	0.58	-0.152	0.157679	0.02486
10	1.9	0.1	1	1.45	0.55	0.4187	0.49	-0.0713	0.076979	0.005926
15	1	1.9	0.55	0.1	1.45	0.4128	0.49	-0.0722	0.07788	0.006065
20	1.45	0.1	1	1.9	0.55	0.4079	0.4	-0.0079	0.01358	0.000184
25	0.1	1.45	0.55	1	1.9	0.4027	0.4	-0.0027	0.00838	0.00007
30	1	1.9	0.55	1.45	0.1	0.3928	0.22	0.1728	-0.16712	0.02793
35	1.45	1.9	0.1	1	0.55	0.3876	0.4	-0.0154	0.021079	0.000444
40	0.55	1.9	1.45	0.1	1	0.3846	0.31	0.0746	-0.06892	0.00475
45	1.45	1	1.9	0.55	0.1	0.3826	0.31	0.0726	-0.06692	0.004478
50	1	1.45	1.9	0.1	0.55	0.3747	0.31	0.0647	-0.05902	0.00348
55	0.1	1	1.45	1.9	0.55	0.3717	0.13	0.2417	-0.23602	0.0557
60	0.55	1.45	1.9	1	0.1	0.3694	0.13	0.2394	-0.23372	0.05463
								Σ CF/n= 0.005679		**S=0.301897**

σ = Sqrt (sum)/n =0.039247

Table2 Alternate formula rate, Production Rate when work load distribution linear are D=1.2

S. No.	Mu 1	Mu 2	Mu 3	Mu 4	Mu 5	R	AFR	CF	Σ CF/n-CFi	(Σ CF/n-CF)^2
1	1.6	0.4	1	0.7	1.3	0.469	0.58	-0.111	0.13345	0.017809
3	1.3	1	0.4	0.7	1.6	0.4661	0.58	-0.1139	0.13635	0.018591
5	1.6	0.4	0.7	1.3	1	0.4623	0.52	-0.0577	0.08015	0.006424
10	1.6	0.4	1	1.3	0.7	0.4544	0.46	-0.0056	0.02805	0.000786
15	1.6	0.4	1.3	1	0.7	0.4504	0.46	-0.0096	0.03205	0.001027
20	1.3	0.4	1	1.6	0.7	0.4451	0.4	0.0451	-0.02265	0.000513
25	1.6	1	0.7	1.3	0.4	0.441	0.4	0.041	-0.01855	0.000344
30	0.7	1	0.4	1.3	1.6	0.4367	0.47	-0.033	0.05545	0.003075
35	0.4	1	1.6	0.7	1.3	0.4314	0.34	0.0914	-0.06895	0.004754
40	1	0.4	1.3	1.6	0.7	0.4288	0.34	0.0888	-0.06635	0.004402
45	1.3	1.6	0.7	1	0.4	0.4244	0.34	0.0844	-0.06195	0.003838
50	0.7	0.4	1.6	1.3	1	0.4208	0.34	0.0808	-0.05835	0.003405
55	0.4	0.7	1	1.6	1.3	0.4155	0.34	0.0755	-0.05305	0.002814
60	0.4	1	1.6	1.3	0.7	0.4131	0.275	0.1381	-0.11656	0.013586
								Σ CF/n= 0.02245		**S=0.081368**

σ = Sqrt (sum)/n =0.020375

Table 3 Alternate formula rate, Production Rate when work load distribution linear are D=0.3

S. No.	Mu 1	Mu 2	Mu 3	Mu 4	Mu 5	R	AFR	CF	Σ CF/n-CFi	(Σ CF/n-CF)^2
1	1.075	1	0.85	0.925	1.15	0.4906	0.445	0.0456	0.03696	0.001366
3	1.15	0.85	0.925	1	1.075	0.4901	0.445	0.0451	0.03746	0.001403
5	1.15	1	0.925	0.85	1.075	0.4894	0.445	0.0444	0.03816	0.001456
10	1	1.15	0.85	0.925	1.075	0.4863	0.415	0.0713	0.01126	0.0001267
15	1.15	0.85	1	1.075	0.925	0.4853	0.415	0.0703	0.01226	0.0001503
20	1	0.925	1.15	0.85	1.075	0.4841	0.415	0.0691	0.01346	0.0001812
25	1.075	0.85	1	1.15	0.925	0.4829	0.4	0.0829	0.00034	0.0001184
30	1	1.150	0.85	1.075	0.925	0.4821	0.385	0.0971	-0.01454	0.000211
35	0.85	1.15	1	0.925	1.075	0.4808	0.385	0.0958	-0.01324	0.0001756
40	0.85	1	0.925	1.15	1.075	0.4796	0.385	0.0946	-0.01204	0.00014496
45	0.85	1.075	0.925	1.15	1	0.4787	0.37	0.1087	-0.02614	0.0006833
50	1	0.925	1.075	1.15	0.85	0.4776	0.37	0.1076	-0.02504	0.000627
55	0.85	0.925	1.15	1.075	1	0.4756	0.37	0.1056	-0.02304	0.0005308
60	0.925	1.075	1.15	1	0.85	0.474	0.355	0.119	-0.03635	0.001328
								ΣCF/n= 0.00568		**S=0.008502**

σ = Sqrt (sum)/n = 0.0461

Table 4. Alternate formula rate, Production Rate when work load distribution linear are D= 0.1

S. No.	Mu 1	Mu 2	Mu 3	Mu 4	Mu 5	R	AFR	CF	ΣCF/n-CFi	(Σ CF/n- CF)^2
1	1.05	0.975	0.95	1	1.025	0.4882	0.415	0.0732	0.010979	0.00012
3	1.05	0.95	0.975	1	1.025	0.4879	0.415	0.0729	0.011279	0.000127
5	1.025	0.975	1	0.95	1.05	0.4878	0.415	0.0728	0.011379	0.000129
10	1.05	1.025	0.975	0.95	1	0.487	0.41	0.077	0.007179	0.0000538
15	1.025	1.05	0.95	0.9751	1	0.4866	0.405	0.0816	0.002579	0.0000066
20	1.05	0.95	1.025	1	0.975	0.486	0.405	0.081	0.003179	0.00000101
25	1.05	1	1.025	0.95	0.975	0.4858	0.405	0.0808	0.003379	0.00001142
30	1.05	0.975	1	1.025	0.95	0.4854	0.4	0.0854	-0.00122	0.00000149
35	0.95	0.975	1	1.025	1.05	0.4851	0.4	0.0851	-0.00092	0.00000085
40	0.95	1	0.975	1.05	1.025	0.4847	0.395	0.0897	-0.00552	0.0000305
45	0.95	1.05	0.975	1.025	1	0.4842	0.39	0.0942	-0.01002	0.0001004
50	1.025	1	1.05	0.975	0.95	0.484	0.395	0.089	-0.00482	0.0000232
55	0.975	1.025	1	1.05	0.95	0.4832	0.385	0.0982	-0.01402	0.000197
60	0.95	1	1.05	1.025	0.975	0.4826	0.385	0.0976	-0.01342	0.0001801
								Σ CF/n = 0.084179		**S=0.00098237**

σ = Sqrt (sum)/n =0.002239

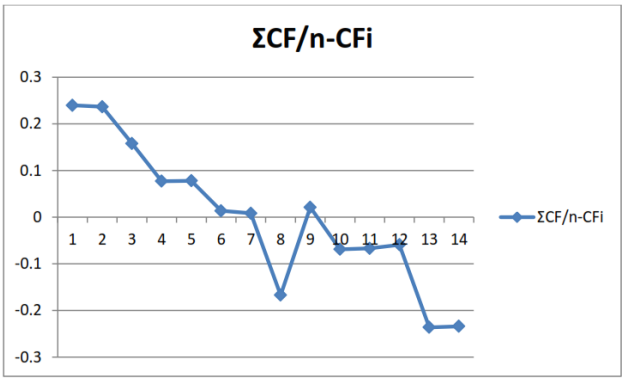
Table 5Alternate formula rate, Production Rate when work load distribution random are D= 1.9

S. No.	Mu 1	Mu 2	Mu 3	Mu 4	Mu 5	R	AFR	CF	ΣCF/n-CFi	(Σ CF/n-CF)^2
1	2	0.3	0.6	0.1	2	0.4022	0.8	-0.3978	0.3914	0.1219
3	2	0.1	0.3	0.6	2	0.3992	0.8	-0.4008	0.35214	0.124
5	2	0.3	0.1	0.6	2	0.3984	0.8	-0.4016	0.35294	0.1246
10	0.6	2	0.1	0.3	2	0.3878	0.52	-0.1322	0.08354	0.00679
15	2	0.3	0.6	2	0.1	0.3805	0.42	-0.0395	-0.08456	0.00715
20	0.6	0.3	2	0.1	2	0.3711	0.52	-0.1489	-0.1024	0.01005
25	0.6	2	0.1	2	0.3	0.3669	0.18*	0.1869	-0.23566	0.0555
30	0.1	2	0.3	2	0.6	0.3632	0.14*	0.2232	-0.21719	0.07391
35	0.1	2	0.6	2	0.3	0.356	0.08*	0.276	-0.32466	0.1054
40	0.3	0.6	0.1	2	2	0.3328	0.46	-0.1272	0.07854	0.0062
45	2	2	0.3	0.6	0.1	0.3321	0.42	-0.0879	0.03924	0.00154
50	0.3	0.1	0.6	2	2	0.3297	0.46	-0.1303	0.08164	0.006665
55	0.3	0.6	2	2	0.1	0.3296	0.08*	0.2496	-0.2983	0.08895
60	0.1	0.6	2	2	0.3	0.3293	0.08*	0.2493	-0.29796	0.08878
								Σ CF/n = -0.04866		**S = 0.82144**

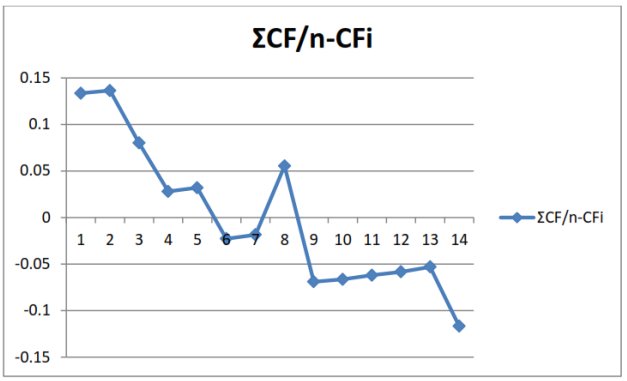
σ = Sqrt (sum)/n=0.06474

*value of last station and first station are very low therefore the AFR are very low

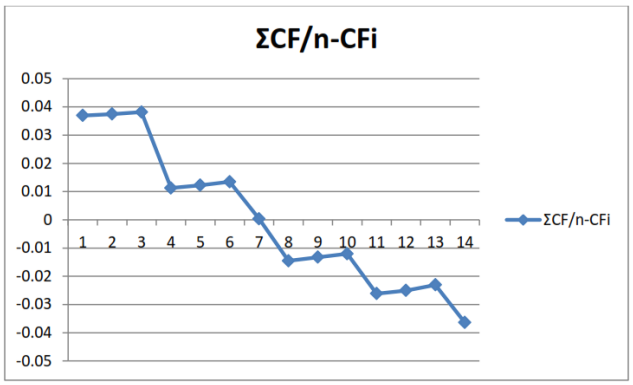
Table 6. Alternate formula rate, Production rate when work load distribution random are D= 0.4



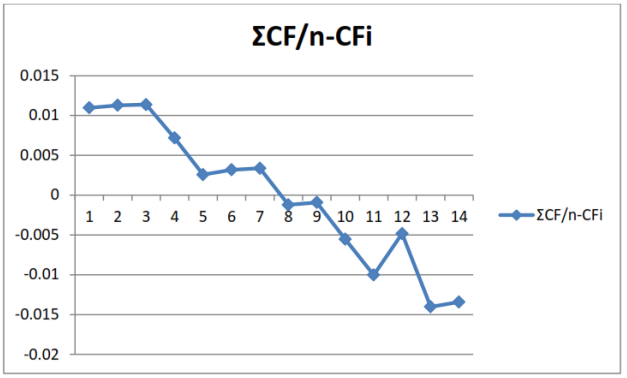
Variance with Mean vale of Correction Factor (Σ CF/n-CFi) VS S. No. When D= 1.8 linear



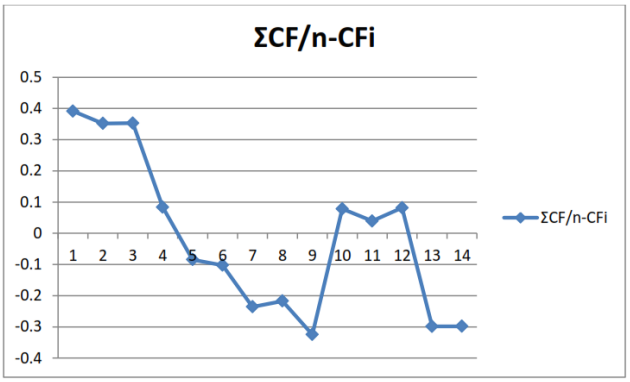
Variance with Mean vale of Correction Factor (ΣCF/n-CFi) VS S. No. When D= 1.2 linear



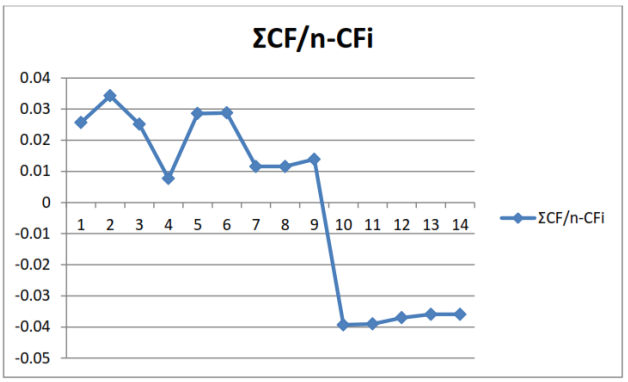
Variance with Mean vale of Correction Factor (ΣCF/n-CFi) VS S. No. When D= 0.3 linear



Variance with Mean vale of Correction Factor (ΣCF/n-CFi) VS S. No. When D= 0.1 linear



Variance with Mean vale of Correction Factor (ΣCF/n-CFi) VS S. No. When D= 1.9 Random



Variance with Mean vale Of Correction Factor (ΣCF/n-CFi) VS S. No. When D= 0.4 Random

RESULTS

When we analyze the Result From Graph and Table we see that, Variance with Mean vale Of Correction Factor (ΣCF/n-CFi) and standard deviation σ is D=1.8 linear (+0.2397, -0.234) σ=0.0393, D= 1.2 linear(+0.133, -0.116) σ=0.0204, D=0.3linear (+0.037, -0.036) σ=0.0461, D= 0.1linear (+0.011, -0.0134) σ 0.00224, D= 1.9 Random (+0.3914, -0.298) σ = 0.0647 D= 0.4 Random (+0.0256, -0.036) σ=0.0077

When we see the graph of each table, we say that the trends of correction factor to mean value is

same for positive as well as negative to mean value just like normal distribution curve. And that does be very near to the -3 σ to + 3 σ. Therefore we see that the formula is valid and the revised formula is Adding CF to the AFR.

Therefore we say that Actual production rate (R) = AFR + CF for Calculation of CF for bigger production line we develop CF= Constant X Standard Deviation

CONCLUSION

After finding out these results we conclude that

1. Alternate Production Rate formula (AFR) is easy to calculate the production rate for developing the un-paced production line for Industrial Engineer. And the formula is vlaid for 5- Station production rate.

2. They also set the machine in a proper way in Production line when the Emphasis given on best production rate or worst production rate or the according to preference given to the work (load) in production line.

3. We say that these formulas are valid even for calculating higher work station production rate.

FUTURE SCOPE

This formula is also

1. Useful for Long Un-paced production line like more than 5- station or more like 7-work station.

2. To calculate the exact formulas for Production rate with have very less error from actual production rate.

3. Useful when the set up and operation time we know then we calculate the how much product is produced in assembly line when jobs designs are change.

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