R72-95

Reprinted from TEXTILE RESEARCH JOURNAL, Vol. 42, No. 10, October 1972
Printed in U. S. A.

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Crimp and Cover Factor of Maximum Weavable Fabrics as a Function of Displacement Ratio

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ABSTRACT

This paper contains a sample condensed table and an example which illustrates its use.

KEYWORDS

Maximum weavable fabrics. Over-all warp crimp; filling cover factors; warp displacement; filling spacing; local warp crimp; local filling crimp; filling displacement.

A simplification of the procedure for designing fabrics of maximum tightness was described in a handbook [1] published in 1970. The handbook presented in tabular form, the solutions of the maximum weavability equations for the plain, oxford, 3-, and 4-harness twills, and 5-harness satin in terms of warp and filling cover factors and yarn number ratio *Beta* for fabrics made from all fiber species and from blends. The tables provide the necessary information needed by the designer to produce reasonable designs of textile fabrics woven to maximum or to a certain percentage of maximum compactness.

To supplement this handbook there is now available an additional set of tables which provides values of over-all warp and filling crimp and warp and filling cover factor in terms of displacement ratio h/D, spacing ratio p/D, and local crimp c for a broad range of yarn balance ratios *Beta* and for the basic weave types—plain, twills, and satin. These tables are based on the equations of Peirce [2] as modified by Love [3]. The tables are arranged in terms of h/D for values ranging from 0.02 to 1.00 in intervals of 0.02 units and for yarn balance ratios *Beta* ranging from 0.5 to 2.0 in intervals of 0.1 units.

To the fabric designer, the tables are useful in facilitating the estimation of fabric thickness and crown height from loom design considerations. To the fabric analyst, the tables provide a readily available source of values of the geometric parameters which characterize maximum weavable constructions for the various weave types.

The complete set of tables (32 pages) with a detailed derivation of the equations upon which the tables are based and an illustrative example of their use are contained in U. S. Army Natick Laboratories Textile Series Report No. 182 titled "Crimp and Thickness Relationships in Maximum Weavable Fabrics."[1]

A condensed version of the table for the 3-harness weave (warp and filling variables) is shown here to illustrate its use by a sample problem.

Let us consider the case of a three-harness fabric woven to maximum weavability with nominal 11s yarns in the warp and 9s in the filling. What combination of warp and filling crimp will lead to an over-all thickness of 0.025 in. with the warp crowns projecting above the filling?

The predicted thickness from warp data would be $h_1 + d_1$ and for filling data $h_2 + d_2$. The approximate diameter d for cotton yarns is $0.0359/\sqrt{N}$. Therefore, $d_1 = 0.011$ in. and $d_2 = 0.012$ in. $D = 0.023$ in. and *Beta* = 1.1. For the warp system, in order to obtain at thickness of 0.025 in.

$$h_1 = 0.025 - 0.011 = 0.014$$

and

$$h_1/D = 0.61$$

Entering the table for the three-harness weave at a *Beta* value of 1.1 and h_1/D of 0.61[2] yields a warp crimp of 0.220 or 22.0%.

For the filling system,

$$h_2 = 0.025 - 0.012 = 0.013$$

and

$$h_2/D = 0.56$$

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[1] Available under No. AD740161 from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

[2] Interpolate linearly.

TABLE OF VALUES OF OVERALL WARP CRIMP AND FILLING COVER FACTOR
FOR MAXIMUM WEAVABLE FABRICS HAVING SPECIFIED WARP DISPLACEMENT
FILLING SPACING AND LOCAL WARP CRIMP

(3-HARNESS WEAVES)

			BETA															
H1/D	C1	P2/D	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
.10	.035	.436	.027	.026	.025	.025	.024	.024	.024	.023	.023	.023	.023	.022	.022	.022	.022	.022
			24.7	27.0	29.0	30.6	32.0	33.3	34.4	35.3	36.2	36.9	37.6	38.2	38.8	39.3	39.8	40.2
.20	.073	.600	.060	.058	.057	.056	.055	.055	.054	.053	.053	.052	.052	.052	.051	.051	.051	.050
			19.2	21.1	22.7	24.1	25.3	26.4	27.3	28.2	28.9	29.6	30.2	30.8	31.3	31.7	32.1	32.5
.30	.114	.714	.096	.094	.093	.091	.090	.089	.088	.088	.087	.086	.086	.085	.085	.084	.084	.083
			16.6	18.3	19.8	21.0	22.1	23.1	23.9	24.7	25.4	26.0	26.6	27.1	27.5	28.0	28.4	28.7
.40	.159	.800	.137	.134	.132	.131	.129	.128	.127	.126	.125	.124	.123	.122	.122	.121	.120	.120
			15.0	16.6	18.0	19.2	20.2	21.1	21.9	22.6	23.2	23.8	24.4	24.8	25.3	25.7	26.1	26.4
.50	.209	.866	.182	.179	.176	.174	.172	.171	.169	.168	.167	.165	.164	.164	.163	.162	.161	.161
			14.0	15.5	16.8	17.9	18.9	19.8	20.5	21.2	21.8	22.4	22.9	23.4	23.8	24.2	24.5	24.8
.60	.265	.917	.232	.228	.225	.223	.220	.218	.216	.215	.213	.212	.211	.210	.209	.208	.207	.206
			13.4	14.8	16.0	17.1	18.1	18.9	19.6	20.3	20.9	21.4	21.9	22.3	22.7	23.1	23.5	23.8
.70	.327	.954	.288	.283	.280	.277	.274	.271	.269	.267	.265	.264	.262	.261	.260	.259	.258	.257
			12.9	14.3	15.5	16.5	17.5	18.3	19.0	19.6	20.2	20.7	21.2	21.6	22.0	22.4	22.7	23.0
.80	.398	.980	.351	.346	.341	.338	.334	.331	.329	.326	.324	.322	.321	.319	.318	.316	.315	.314
			12.6	14.0	15.2	16.2	17.1	17.9	18.6	19.2	19.8	20.3	20.7	21.2	21.6	21.9	22.3	22.6
.90	.478	.995	.422	.416	.411	.407	.403	.399	.396	.393	.391	.389	.387	.385	.383	.381	.380	.378
			12.4	13.8	15.0	16.0	16.8	17.6	18.3	19.0	19.5	20.0	20.5	20.9	21.3	21.7	22.0	22.3
1.00	.571	1.000	.505	.498	.491	.486	.481	.477	.473	.470	.467	.464	.462	.460	.458	.456	.454	.452
			12.4	13.7	14.9	15.9	16.8	17.6	18.3	18.9	19.4	19.9	20.4	20.8	21.2	21.6	21.9	22.2

H/D=NORMALIZED DISPLACEMENT, C=LOCAL CRIMP, P/D=NORMALIZED SPACING
ALTERNATE ROWS OF TABLE - FIRST LINE=OVERALL CRIMP, SECOND LINE=COVER FACTOR

TABLE OF VALUES OF OVERALL FILLING CRIMP AND WARP COVER FACTOR
FOR MAXIMUM WEAVABLE FABRICS HAVING SPECIFIED FILLING DISPLACEMENT
WARP SPACING AND LOCAL FILLING CRIMP

(3-HARNESS WEAVES)

			BETA															
H2/D	C2	P1/D	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
.10	.035	.436	.022	.022	.023	.023	.024	.024	.024	.025	.025	.025	.026	.026	.026	.026	.026	.027
			40.2	38.6	37.1	35.7	34.5	33.3	32.2	31.1	30.1	29.2	28.4	27.6	26.8	26.1	25.4	24.7
.20	.073	.600	.050	.051	.052	.053	.054	.055	.055	.056	.056	.057	.057	.058	.058	.059	.059	.060
			32.5	31.1	29.8	28.6	27.4	26.4	25.4	24.5	23.7	22.9	22.2	21.5	20.9	20.3	19.7	19.2
.30	.114	.714	.083	.085	.086	.087	.088	.089	.090	.091	.092	.093	.093	.094	.095	.095	.096	.096
			28.7	27.4	26.2	25.1	24.0	23.1	22.2	21.4	20.6	19.9	19.3	18.7	18.1	17.6	17.1	16.6
.40	.159	.800	.120	.122	.123	.125	.126	.128	.129	.130	.131	.132	.133	.134	.135	.135	.136	.137
			26.4	25.1	24.0	22.9	22.0	21.1	20.3	19.5	18.8	18.2	17.6	17.0	16.5	16.0	15.5	15.0
.50	.209	.866	.161	.163	.165	.167	.169	.171	.172	.173	.175	.176	.177	.178	.179	.180	.181	.182
			24.8	23.6	22.5	21.5	20.6	19.8	19.0	18.3	17.6	17.0	16.4	15.9	15.4	14.9	14.5	14.0
.60	.265	.917	.206	.209	.212	.214	.216	.218	.220	.222	.223	.225	.226	.227	.229	.230	.231	.232
			23.8	22.6	21.5	20.6	19.7	18.9	18.1	17.4	16.8	16.2	15.6	15.1	14.6	14.2	13.8	13.4
.70	.327	.954	.257	.260	.263	.266	.269	.271	.274	.276	.278	.279	.281	.283	.284	.285	.287	.288
			23.0	21.9	20.9	19.9	19.1	18.3	17.5	16.9	16.2	15.7	15.1	14.6	14.1	13.7	13.3	12.9
.80	.398	.980	.314	.318	.322	.325	.328	.331	.334	.336	.339	.341	.343	.345	.346	.348	.349	.351
			22.6	21.4	20.4	19.5	18.6	17.9	17.1	16.5	15.9	15.3	14.8	14.3	13.8	13.4	13.0	12.6
.90	.478	.995	.378	.383	.388	.392	.396	.399	.402	.405	.408	.411	.413	.415	.417	.419	.421	.422
			22.3	21.2	20.2	19.2	18.4	17.6	16.9	16.3	15.7	15.1	14.6	14.1	13.6	13.2	12.8	12.4
1.00	.571	1.000	.452	.458	.464	.469	.473	.477	.481	.484	.488	.491	.493	.496	.498	.501	.503	.505
			22.2	21.1	20.1	19.2	18.3	17.6	16.9	16.2	15.6	15.0	14.5	14.0	13.6	13.2	12.8	12.4

H/D=NORMALIZED DISPLACEMENT, C=LOCAL CRIMP, P/D=NORMALIZED SPACING
ALTERNATE ROWS OF TABLE - FIRST LINE=OVERALL CRIMP, SECOND LINE=COVER FACTOR

Entering the table for the three-harness weave at a *Beta* value of 1.1 and h_2/D of 0.56 yields a filling crimp value of 0.201 or 20.1%.

For the warp yarn crowns to project above the filling yarns, the loom take-up would be set to produce a crimp of 22.1%. The filling crimp would then assume a value according to the solution of the equation

$$h_1/D + h_2/D = 1$$

$$h_2/D = 1 - 0.61 = 0.39$$

which from the tables[2] corresponds to a filling crimp of 0.125 or 12.5%.

A 2/1 left twill woven to maximum tightness with a texture of 87.5 × 56.2 and actual yarn numbers of 10.9 by 8.8 was found to have measured crimps of 24.6% × 8.8% which correspond to the predicted 22.1% × 12.5%, and a measured thickness of 0.0256 in. which corresponds to the thickness of 0.025 in. assumed in the problem. If the design goal had been set at 0.026 in., the predicted crimps would be 24.2% × 10.9% compared to the actual of 24.6% × 8.8%.

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Manuscript received November 24, 1971.